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# THE PLANT DISEASE REPORTER

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UNITED STATES DEPARTMENT OF AGRICULTURE

RECENT STUDIES ON VIRUS DISEASES  
OF APPLE IN THE UNITED STATES AND CANADA

Supplement 254

February 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

RECENT STUDIES ON VIRUS DISEASES OF APPLE IN THE UNITED STATES AND CANADA

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# OBSERVATIONS IN MAINE ON "STEM PITTING", A VIRUS DISEASE OF APPLE

R. C. McCrum and M. T. Hilborn<sup>1</sup>

The stem pitting disease of apple has only recently been described. In 1954 Smith (6)<sup>2</sup> described the disorder in such body stocks as Virginia and Florence crabs growing in New Hampshire. Later Miller (3) in Nebraska and Tukey et al. (7) in Indiana noted a similar disorder in Virginia Crab. Tukey et al. (7), Smith (6), and Millikan and Guengerich (4) suggested that a virus may be involved. Early in 1956 Millikan and Guengerich (5) showed that the virus would cause leaves of Amelanchier to become dwarfed and rugose when diseased buds of Virginia Crab were inserted. Later that same year Guengerich and Millikan (1) were able to transmit the stem-pitting factor from diseased to healthy Virginia Crab trees by inserting diseased buds.

Hilborn and Hyland (2) demonstrated certain anatomical changes in stem-pitted wood and bark. Some of the cambial initials become multinucleate and the nuclei are distorted. The cambial derivatives become abnormal, resulting in the disorientation of xylem elements and phloem rays. Large "islands" of parenchymatous cells occur in the xylem, and the xylem rays may be multicelled. In the phloem the sieve tubes quickly degenerate and become non-functional, sieve areas and companion cells are lacking, and the phloem becomes completely disoriented.

From 1941 to 1951 various body stocks for apples were obtained through the courtesy of the Division of Plant Exploration and Introduction, Glenn Dale, Maryland. These were planted in an experimental orchard at Highmoor Farm in Monmouth, Maine, the experimental fruit farm of the Maine Agricultural Experiment Station. The planting was established in an attempt to find body stocks hardy enough to avoid the trunk and crotch type of winter injury that is so prevalent in Maine. As Virginia Crab trees were used as the standard for comparison in this planting there was an excellent opportunity to make preliminary studies on the host range of this virus within some apple varieties. The trees were examined during July and August, 1958, for the presence of stem pitting. The following information includes the observations and data taken during this survey.

Two V-shaped cuts were made in the bark of each tree examined, one at the soil line and one 3 feet above the soil line. The bark was then pulled downward and the sapwood examined for pitting. No attempt was made to evaluate the degree of pitting, a variety being recorded as pitted whenever any pitting was observed. This approach was made with the attitude that for this type of preliminary survey a positive reading would have more value than a negative reading. This means, of course, that some of the pitting noted may not have been caused by the virus, but may be due to other unknown factors.

Two general types of pitting were observed. In one the sapwood was uniformly pitted with short longitudinal depressions in the wood. The bark on such trees had corresponding extensions that fitted into the depressions in the wood. The bark was also very thick and brittle, and yellow in color. The second type of pitting exhibited a very fine, knitted pattern in slightly raised, narrow, grayish areas parallel to the stem. The bark was not so thick as with the first type, and it was not brittle and yellow.

Readings were also taken of the relative overgrowth of the top-worked scion variety at the union on the scaffold branches of the stock and the scion. A reading of 0 indicates that there was no overgrowth at this point and a smooth union existed. A reading of 2.5, for example, shows that considerable overgrowth occurred at the union.

Table 1 includes body stock varieties in which some form of pitting was found, Table 2 those in which no pitting was observed.

<sup>1</sup>Assistant Plant Pathologist and Plant Pathologist, respectively, Maine Agricultural Experiment Station

<sup>2</sup>For references see page 7 in article following).

Table 1. Apple body stock varieties in which some form of pitting was found.

Body stock	No. trees examined		: Scion : variety : top-worked : on scaffold : Branches	No. trees pitted		: Relative overgrowth : of scion variety on	
	trees	No. trees pitted		Soil	3-foot	Pitted body stock	Non-pitted body stock
				Line	level		
Anis, 113472	4	1	Baldwin	1	0	3.0	1.8
Antonovka (Orono) <sup>a</sup>	5	1	Baldwin	1	0	3.0	1.1
Antonovka Shafron, 107197	4	1	Baldwin	1	0	1.0	1.0
Bedford	3	1	Baldwin	1	0	1.5	3
Belfer Foenicks, 107232	13	4	Baldwin	3	1	1.2	1.2
Belfer Kitaika, 90524	7	1	Baldwin	1	1	1.0	0
Bessemianka, 107202	5	1	Baldwin	1	0	0.5	0.25
Calros, 15153	7	2	Baldwin	1	1	3.0	2.5
	3	3	RedDelicious	3	2	3.0	
Charlamoff	9	1	Baldwin	1		3.5	2.0
Columbia, 123988	4	1	Baldwin	1	0	2.0	1.5
Dabinett, 150648	2	2	RedDelicious	2	2	1.7	
Dudley	4	3	Baldwin	3	2	3.1	2
Erickson, 148422	6	1	Baldwin	1	0	1.5	1.7
	4	2	RedDelicious	1	2	1.2	1.7
Flava, 107212	6	6	Baldwin	6	6	3.6	
Garnet	1	1	Baldwin	1	1	3	
Gros Frequin, 131105	4	1	RedDelicious	1	0	2	2.1
Harbin Selection, 161091	7	0	Baldwin	0	0		1.1
	7	1	RedDelicious	0	1	2	1.9
Hibernal	4	0	Baldwin	0	0		2.1
	2	0	Red Delicious	0	0		1.0
	4	1	Cortland	1	0	1.0	0.5
Krasnoznamennoie, 107227	5	2	Baldwin	1	1	1.5	2.0
Kulon Kitaika, 107229	4	2	Baldwin	2	0	0.5	0
	25	11	Cortland	4	8	1.4	.85
Kurosh's Renette, 136118	4	3	Baldwin	3	0	2.8	3
Lennoxville, 151643	4	0	Baldwin	0	0		1.1
	2	2	RedDelicious	1	2	1.5	
Malus wisantowoye, 104998	3	1	Baldwin	1	0	.5	1.5
M. mandshurica x White							
Astrachan, 154329	5	3	Baldwin	3	0	2.8	3.0
	4	2	RedDelicious	0	2	2.0	2.8



Table 1. (Continued)

	:	:	: Scion	:	:	: Relative overgrowth	
	: No.	:	: variety	:	No. trees	: of scion variety on	
	: trees	: No.	: top-worked	: pitted	Pitted	: Non-pitted	
	: exam-	: trees	: on scaffold	: Soil: 3-foot	body	: body	
Body stock	: ined	: pitted	: branches	: line: level	: stock	: stock	
N. Queen x Cranberry							
Pippin, 141870	3	0	Baldwin	0	0	0	2
	3	3	Red Delicious	0	3	2.3	
Olga, 127702	5	5	Baldwin	5	5	4.0	
Osman, 123995	3	1	Baldwin	1	1	3	3.5
Pippin Shaffron, 104995	5	2	Baldwin	2	0	0	.3
Printosh, 144088	5	4	Baldwin	4	4	3.1	2.5
Robin, 144025	5	2	Baldwin	2	0	3	2.5
	4	3	Red Delicious	3	3	2.8	2.5
Rosilda, 123915	4	0	Baldwin	0	0		1.7
	2	1	Red Delicious	1	0		1.5
Rubiniwoe, 107244	4	4	Baldwin	4	4	3.8	
Severn, 144030	8	7	Golden Del.	0	1	1.0	1.8
Sissipuk, 148500	4	4	Red Delicious	4	4	3.3	
Sugar Crab, 143974	7	7	Baldwin	7	7	3.5	
	3	3	Golden Del.	3	3	3.5	
Toschprince, 148487	5	4	Golden Del.	1	0	2.5	2.3
Virginia Crab	6	6	Baldwin	6	6	3.2	
	11	10	Red Delicious	10	9	1.75	2
	3	3	Golden Del.	3	3	2.0	
Wallace Hybrid, 143920	5	5	Baldwin	5	5	3.3	

<sup>a</sup>Propagated at Orono from an unknown bud source.

Table 2. Apple body stock varieties in which no pitting was found.

Body stock	No. trees examined	Scion variety top-worked on scaffold branches	Relative overgrowth of scion variety
Anaros, 139664	5	Baldwin	1.2
Antonovka Zheltaia, 107310	9	Baldwin	1.7
Arrow, 148703	4	Golden Delicious	2.7
Atlas, 143889	4	Baldwin	1.0
Beauty, 139665	3	Baldwin	2.0
Cestra Belfer Kitaika, 107204	4	Baldwin	0
Chinese Shampainen, 107206	4	Baldwin	2.0
Glen Dale, 171460	1	Baldwin	2
Izo Crab, 127696	4	Baldwin	.5
Mecca, 148480	7	Golden Delicious	0.85
McPrince, 113483	5	Baldwin	1.3
Redman, 148482	2	Baldwin	2
Toba, 151645	5	Golden Delicious	2.0
Tony, 148486	4	Baldwin	2.1
	3	Golden Delicious	1.5

MAINE AGRICULTURAL EXPERIMENT STATION, ORONO  
(Plant Disease Reporter Supplement 254. 1959)

SOME OBSERVATIONS ON THE EFFECT OF SCION ROOTING IN VIRGINIA CRAB  
INTERMEDIATE APPLE STOCK IN REGARD TO STEM PITTING

R. C. McCrum

Smith (6) reported that Virginia Crab and Florence Crab used as body stocks for apple varieties may not develop stem pitting when scion rooting occurs. The observations in Maine agree with this statement. Out of 88 Virginia Crab body stock trees in the hardy stock orchard at Highmoor Farm only eight were found to be free from stem pitting. All eight non-pitted trees were found to be scion rooted. This orchard contained trees top-worked to Baldwin and McIntosh but the eight trees free from pitting were top-worked to the Baldwin variety.

As a result of the preliminary survey in the fall of 1957 it was decided to examine at random a comparable number of pitted Virginia Crab body stock trees for the presence of scion rooting. Two groups of pitted versus non-pitted trees in commercial apple orchards were also examined to determine whether scion rooting of the Virginia Crab body stock could be correlated with the stem-pitting factor.

Results of these observations carried out in the summer of 1958 are recorded in Tables 1 and 2.

Table 1. Scion roots on pitted Virginia Crab body stock

Scion variety top-worked on scaffold branches	Number trees examined	Number trees scion rooted	Number trees not scion rooted	Number trees with pitted scion roots
<sup>a</sup> McIntosh	4	4	0	4
<sup>a</sup> Baldwin	4	3	1	3
<sup>b</sup> Golden Delicious	5	3	2	3
<sup>b</sup> McIntosh	5	2	3	2

<sup>a</sup>Trees at Highmoor Farm

<sup>b</sup>Trees in commercial apple orchards

Table 2. Scion roots on non-pitted Virginia Crab body stock

Scion variety top-worked on scaffold branches	Number trees examined	Number trees scion rooted	Number trees not scion rooted	Number trees with pitted scion roots
<sup>a</sup> Baldwin	8	8	0	0
<sup>b</sup> Golden Delicious	5	5	0	0
<sup>b</sup> McIntosh	5	5	0	0

<sup>a</sup>Trees at Highmoor Farm

<sup>b</sup>Trees in commercial orchards

Table 1 shows that scion rooting did occur on the pitted Virginia Crab body stock. Scion roots on these pitted trees, however, were small and deeply pitted. All trees in this pitted group were poorly rooted and showed symptoms of decline. A few had only the small pitted scion roots for support, the seedling roots having been completely rotted away.

Table 2 indicates that all of the non-pitted Virginia Crab body stock trees in this study were scion rooted. Scion roots on these trees were free from pitting. These trees were far superior to the pitted scion rooted trees. They were larger in trunk diameter and had better root systems.

## DISCUSSION

A preliminary survey has shown that some apple varieties being used as body stocks remain free of stem pitting under orchard conditions even though growing in close proximity to diseased trees in the same orchard. Stem pitting is not restricted to those varieties that are typically crab apple, but also occurs in some varieties whose ancestry shows only one-fourth

crab apple parentage. Other varieties that are typically crab apple have remained free to date of any symptoms of the virus.

These observations indicate that scion rooting in Virginia Crab body stock trees will not in itself suppress the stem-pitting factor. It does raise an interesting question in regard to scion rooting: that is, would the stem-pitting factor occur if the Virginia Crab were not top-worked until after scion rooting had been established? Studies of the growth rings in trees at the experimental farm at Highmoor show that the top-worked Virginia Crab trees began to exhibit anatomical symptoms of stem pitting about 1945. Most of these trees were planted in 1940 and the topworking was done in 1942-1944. Possibly in the trees examined in this study the pitted scion roots were formed after the anatomical changes occurred in the Virginia Crab stem. Thus scion roots produced afterwards could develop the same anatomical pattern. Longitudinal sections made through two pitted scion roots attached to their stems indicated that the roots originated in the same year that pitting occurred in the stem.

At the present stage of our knowledge it is impossible to distinguish cause from effect. The fact that the non-pitted trees were all scion rooted does not necessarily mean that the scion rooting prevented the pitting symptom from appearing. There is a possibility that a body stock tree affected with the pitting factor may not have the vigor to develop scion roots.

Experiments are now being carried out to determine whether scion rooting and time of topworking can be used to control stem pitting in Virginia Crab intermediate stock.

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MAINE AGRICULTURAL EXPERIMENT STATION, ORONO, MAINE  
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THE OCCURRENCE OF STEM-PITTING AND DAPPLE APPLE  
VIRUS DISORDERS IN AN ORCHARD PROPAGATED WITH  
KNOWN SOURCES OF VARIETAL SCIONWOOD<sup>1</sup>

J. G. Barrat, W. W. Smith, and A. E. Rich<sup>2</sup>

Abstract

The occurrence and distribution of the stem pitting and dapple apple virus disorders were recorded in an orchard originally designed for a test of winter hardiness of apple body stocks. The stem pitting disorder occurred in the body stocks Virginia Crab, Florence Crab, and Red River Crab. The dapple apple disorder occurred in the varieties Cortland and McIntosh. Theories for the occurrence of both disorders in the same orchard and their association with the body stock Virginia Crab are proposed.

INTRODUCTION

In an effort to counteract injury and death to apple trees due to winter injury, a study was undertaken in an experimental orchard in Gilford, New Hampshire, to determine the desirability of using body stocks in the areas of the framework of the tree (trunk and major branch crotches) which are most susceptible to winter injury (5). The body stocks Virginia Crab and Florence Crab have been used as hardy interpieces (3) and were compared in this study with varietal trunks on seedling and Malling IV rootstocks. The apple varieties used were McIntosh (Rogers strain, and trees J-2 and B. F. 224), Northern Spy (B. F. 52), Red Spy (Farley strain), and Cortland (3).

MATERIALS AND METHODS

Trees for the experimental orchard were obtained or propagated in the following manner: The Rogers strain of McIntosh and the Farley strain of Red Spy were purchased from nurseries and were on seedling roots. The varieties McIntosh, Northern Spy, and Cortland were propagated on Malling IV and seedlings in the orchard nursery. Two trees, J-2 and B. F. 224, at the University of New Hampshire orchard were used as scionwood sources for the McIntosh variety. One tree, B. F. 52, was used as scionwood source for the Northern Spy, and one tree, also in the University orchard, was used as a scionwood source for the variety Cortland.

Virginia Crab and Florence Crab trees were purchased as 2-year-old stock and set in the orchard. These plants, once established, were whip-grafted on the scaffold limbs to the varieties McIntosh (J-2 and B. F. 224), Northern Spy (B. F. 52), and Cortland (from one tree).

The experimental part of the orchard was designed to include 10 rows with 30 trees in each row. Each of four groups of understocks was replicated 15 times within the 10 rows. There were six replicates per row. Nine of the 10 rows were designed so that two rows of each variety were adjacent to each other, and the single rows of each variety were not adjacent to a row of the same variety. The first row consisted of 10 trees of Cortland followed by 10 trees of McIntosh and 10 trees of Red Spy. The rootstocks of this row were planned with the regular series across the orchard. See Figure 1 for the experimental plan of the orchard.

The orchard was planted in 1941. During subsequent years some of the trees died and were replaced with other body stocks and rootstocks not in sequence with the original plan. However, the varieties were maintained. By 1957, 71 of the 300 original trees had been replaced.

The roughened bark surface of trees infected with the stem-pitting virus (2, 3) is not sufficient by itself to determine the presence of the disorder. In the experimental orchard all Virginia Crab and Florence Crab body stocks were examined by cutting through the bark and examining the surface of the xylem and inner phloem at the cambial area. Many seedling and Malling IV roots were examined in a similar manner, but no pitting was observed in these.

<sup>1</sup> Published with the approval of the Director of the New Hampshire Agricultural Experiment Station as Scientific Contribution No. 234.

<sup>2</sup> Formerly Graduate Research Assistant in Botany, Associate Horticulturist, and Plant Pathologist, respectively, New Hampshire Agricultural Experiment Station.

Tree Number	Row									
	D	E	F	G	H	I	J	K	L	M
7	4	V	4	V	4	4	V	4	V	4
8	C4	V	4	V	4	4	V	4	V	4
9	o4	V	4	V	4	4	V	4	V	4
10	r4	V	4	V	4	4	V	4	V	4
11	t4	V	4	V	4	4	V	4	V	4
12	lS	F	S	F	S	S	F	S	F	S
13	aS	F	S	F	S	S	F	S	F	S
14	nS	F	S	F	S	S	F	S	F	S
15	dS	F	S	F	S	S	F	S	F	S
16	<u>S</u>	F	S	F	S	S	F	S	F	S
17	MV	4	V	4	V	V	4	V	4	V
18	cV	4	V	4	V	V	4	V	4	V
19	IV	4	V	4	V	V	4	V	4	V
20	nV	4	V	4	V	V	4	V	4	V
21	tV	4	V	4	V	V	4	V	4	V
22	oF	S	F	S	F	F	S	F	S	F
23	sF	S	F	S	F	F	S	F	S	F
24	hF	S	F	S	F	F	S	F	S	F
25	F	S	F	S	F	F	S	F	S	F
26	<u>F</u>	S	F	S	F	F	S	F	S	F
27	<u>V</u>	V	4	V	4	4	V	4	V	4
28	RV	V	4	V	4	4	V	4	V	4
29	eV	V	4	V	4	4	V	4	V	4
30	dV	V	4	V	4	4	V	4	V	4
31	V	V	4	V	4	4	V	4	V	4
32	SF	F	S	F	S	S	F	S	F	S
33	pF	F	S	F	S	S	F	S	F	S
34	yF	F	S	F	S	S	F	S	F	S
35	F	F	S	F	S	S	F	S	F	S
36	F	F	S	F	S	S	F	S	F	S
	M	C	S	M	M	C	C	S	S	M
	i	o	p	c	c	o	o	p	p	c
	x	r	y	l	l	r	r	y	y	l
	e	t		n	n	t	t			n
	d	l		t	t	l	l			t
		a		o	o	a	a			o
	R	n		s	s	n	n			s
	o	d		h	h	d	d			h
	w									

### Legend

F = Florence Crab

V = Virginia Crab

S = Seedling (Malus sylvestris)

4 = Malling IV

FIGURE 1. Rootstock, interpiece and varietal plan of experimental orchard

Tree Number	Row									
	D	E	F	G	H	I	J	K	L	M
7	CRA	CV	Y4	MVP	M4	C4	CVA	Y4	YV	M4
8	C4	CVP	Y7	MS	M4	C4	CV	YV	YV	M4
9	CR	CV	Y4	MVPA	M4	C4	CVA	Y7	YV	M4
10	CR	CVP	Y7	MVP	M4	C7	CV	Y4	YVP	M4
11	CR	CVA	Y4	MVP	M4	C4	CVA	Y4	YVP	M4
12	CDA	CF	YS	MF	MSA	CS	CF	YS	YF	MS
13	CS	CFPA	YS	M7	MSA	CS	CF	YS	YFP	MS
14	C7	CFP	YS	MF	MS	CS	CF	YS	Y7	MS
15	CS	CF	YS	MR	MS	CS	CF	YS	YF	MS
16	C7	CR	YS	MR	MS	CS	CF	YS	YF	MS
17	MVP	C4	YVP	M7	MVP	CVPA	C4	YVP	YR	MVP
18	MVP	CRA	YVP	M4	MVP	CV	C4	YVP	Y4	MVP
19	MVP	CRA	YVP	M4	MVP	CV	C4	YVP	Y4	MVP
20	MR	C4	YVP	M4	MVP	CVA	C7	YV	YR	MVP
21	MKA	C4	YV	M4	MVP	CVP	C4	YV	YR	MVP
22	MK	CS	YF	MS	M7	CFPA	CS	YF	YS	MDP
23	MK	CS	YF	MS	MR	CFPA	CS	YFP	YS	MK
24	MR	CS	Y7	MDP	MR	CF	CS	YR	YS	MF
25	MS	CS	YF	MS	MV	C7	CS	YK	YS	M7
26	MVP	CS	YF	MS	MK	CF	CS	YR	YS	MDP
27	YVP	CV	Y7	VM	M4	C4	CVP	Y7	YVP	M4
28	YV	CR	Y4	MV	M7	C4	CVP	Y7	YV	MDP
29	YV	CVPA	Y4	MV	MK	C4	CVP	Y4	YV	M7
30	YVP	CVPA	Y7	MV	MR	C4	CVPA	Y4	YVP	M4
31	YVP	CRA	Y4	MV	M4	C4	CVPA	Y4	Y7	M4
32	YR	CF	YS	MF	MS	CS	CR	YS	YF	MS
33	YFP	CF	YS	MS	MS	CS	CR	YS	YF	MS
34	YR	CF	YS	MFP	MS	CS	CR	YS	YF	MS
35	YS	CF	YS	MR	MS	CS	CR	YS	YF	MS
36	YS	CS	YS	MF	MS	CS	CF	YS	YF	MS

#### Legend

A = Dapple apple  
 C = Cortland  
 D = Red River Crab  
 F = Florence Crab  
 K = Malus sikkimensis  
 M = McIntosh  
 P = Malus stem-pitting

R = (Malus)robusta V  
 S = Seedling (Malus sylvestris)  
 V = Virginia Crab  
 Y = Northern or Red Spy  
 4 = Malling IV  
 7 = Malling VII

FIGURE 2. Experimental orchard indicating variety, interpiece or rootstock and disorder, 1957.



There were 69 trees with a body stock of Virginia Crab in the experimental block at the time of inspection. Forty-four trees or 63.7 percent expressed symptoms of stem pitting. Thirty-nine trees remained of the original 75 trees with Florence Crab as an interpiece, and six or 15.3 percent of these showed symptoms of stem pitting. Four of the five Red River Crab replacement trees showed stem pitting symptoms. See Figure 2 for the occurrence of stem pitting.

Dapple apple (1, 4) was first noted about 1951, when a few boxes of fruit showing the symptoms were observed in the packing shed. During the following years tree records were kept as the fruit was picked, and the position of several trees that produced fruit with dapple apple symptoms was recorded. In 1954, when a general survey was made, 11 affected trees were located in the experimental block. All but two trees were on Virginia Crab body stocks; these two were replacement trees on Robusta V rootstock. The scionwood for these two trees is thought to have come from an infected tree. In addition, all affected trees were of the Cortland variety, except for three McIntosh trees which, it is suspected, may have had some Cortland scionwood grafted into them. In 1956 and 1957 additional surveys were made and 22 trees showing dapple apple symptoms on mature fruit were located in the experimental block. See Figure 2 for the occurrence of dapple apple infected trees.

## DISCUSSION AND CONCLUSIONS

The experimental portion of the orchard was designed for a body stock study. The investigation of the virus disorders which appeared in the trees was incidental to the main purpose of the experiment but proved to be most interesting. Several features of the tree structure in the orchard made this study possible and suggested reasonable theories for disease occurrence.

The foremost feature was that all scionwood of each variety came from known sources of that variety. In the case of the variety Cortland all scionwood came from one tree. With this knowledge as basis the opportunity presented itself for tracing and understanding the sources of infection.

Stem pitting occurred in the Virginia Crab body stocks in all apple varieties regardless of the source of scionwood. That pitting did not occur in all the Virginia Crabs from any one source of apple variety scionwood indicates that the virus was not initially present in the scionwood. If not present in the varietal scionwood, then the virus must have been present in the Virginia Crab or in the seedlings upon which the body stock was originally propagated. More than 60 percent of the Virginia Crabs remaining in the experimental orchard were infected with the stem pitting disorder. It seems improbable that apple seedlings would be so highly infected with a single virus. There is no information concerning the seed transmissibility of this virus. The most reasonable conclusion is that the stem-pitting factor was present in body stocks when they were propagated. Since these body stocks were propagated in large quantities their source must necessarily be from many scionwood trees, some of which may be infected while others are not. The erratic distribution of the affected trees in the experimental orchard would tend to bear out this assumption. The stem-pitting virus (or viruses) is perpetuated with the infected scions during propagation of the body stocks.

The theory is proposed that the disorder dapple apple results from a complex of two viruses which, when coming together in one apple tree, cause the symptoms of dapple apple. Either virus alone within a single plant is latent. Dapple apple first occurred in Cortland trees which had Virginia Crab as their body stocks. It has not been observed to occur spontaneously on any other variety that is not suspected of having been grafted with infected material. The fact that it occurred originally and only on the Cortland variety, and only when the body stock was Virginia Crab, indicates an interaction of some sort between these two units. However, dapple apple does not occur on all Cortland-Virginia Crab combinations. Since we know that the Cortland scionwood was taken from one tree we can say with some assurance that the virus content for the Cortland variety is the same throughout the orchard. This, then, leaves the Virginia Crab as the variable factor. Some of the scionwood source trees used to propagate the Virginia Crab may contain one component, while the Cortland source tree contains the other component. When they are brought together in one tree, dapple apple symptoms are expressed. Seedlings can be eliminated as the perpetuating agent since the disorder has not been observed on other Cortland trees where seedlings have been used. The viruses causing the stem pitting and dapple apple disorders occur independently of each other.

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NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION  
(Plant Disease Reporter Supplement 254. 1959)

PRELIMINARY EVALUATION OF SOME RUSSIAN APPLE VARIETIES  
AS INDICATORS FOR APPLE VIRUSES<sup>1</sup>

Gaylord I. Mink and J. R. Shay<sup>2</sup>

Summary

The Russian apple variety R12740-7A and several of its seedlings have been shown in preliminary tests to be of value for use as indicators of apple mosaic and stem-pitting viruses. A new disease called chlorotic leaf spot was induced in the Russian indicators used to index trees with known virus infection and varieties selected at random. Both chlorotic leaf spot and stem pitting symptoms developed on indicator trees used to index 27 of 36 trees representing 23 varieties. Further work is needed to determine the relationship between these two diseases.

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The apple variety designated R12740-7A<sup>3</sup> was produced at the University of Illinois from seed received from Russia and has been used as a source of scab resistance in a cooperative apple breeding program. Selections from crosses of R12740-7A with various commercial apple varieties were distributed, along with other scab resistant items, to a number of co-operators in the United States and in Europe for field tests against prevailing strains of *Venturia inaequalis* (Cke.) Wint. One of the authors (Shay) examined an orchard at Elste, Holland in 1955 in which some 22 different scab resistant selections had been topworked into young trees showing symptoms of apple mosaic virus. Eight of these selections were seedlings of R12740-7A. All eight had either failed to grow following top-working or were growing abnormally. Apparently, these selections were sensitive either to the apple mosaic virus or to some other virus present in the stock trees. The leaves of affected shoots were unilaterally distorted and flecked with circular chlorotic spots not typical of apple mosaic variegation.

This paper reports the results of preliminary tests to evaluate R12740-7A and selected seedlings as indicator varieties for apple viruses.

MATERIALS AND METHODS

The variety R12740-7A and certain of its seedlings were used to index apple varieties known to be infected with a virus and varieties of unknown virus content. Isolates of apple mosaic and other viruses were collected from foreign apple varieties growing in experimental apple orchards of Purdue University at Lafayette, Indiana and from collections of Professors D. Cation of Michigan State University, H. H. Thornberry, University of Illinois, and D. F. Millikan, University of Missouri, and designated as follows:

Apple Mosaic Virus Sources:

- ApM-1 From D. Cation. Received as scions of Snow variety and budded on seedling rootstocks.
- ApM-2 do., except Red Astrachan variety.
- ApM-3 From H. H. Thornberry. Received as scions of Hyslop (VC 52-3A) and budded on seedling rootstocks.
- ApM-4 do., except Hyslop (VC 52-3B).
- ApM-5 do., except Golden Delicious (VC 54-4).
- ApM-6 Fraas Kalvill P. I. 104787.
- ApM-7 Antonovka Funtovaja P. I. 231925.

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<sup>1</sup> Journal Paper No. 1353 of the Purdue University Agricultural Experiment Station, Lafayette, Indiana.

<sup>2</sup> Graduate Research Assistant and Professor of Plant Pathology respectively, Department of Botany and Plant Pathology.

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ApM-8 Perzikrode Zommerapple. Received from Holland, 1956.

ApM-9 Ejbij. Received from Holland, 1956.

#### Stem-pitting Virus Sources:

- SP-2 Severely pitted Virginia Crab sprout from the roots of severely pitted, own-rooted Virginia Crab tree at Purdue University Horticulture Farm.
- SP-6 Red Delicious (HV 6-5) from D. Millikan showing stem pitting and fruit symptoms (Possibly scar skin).
- SP-7 Red Delicious (SP 8-4) from D. Millikan showing stem pitting.

Apple varieties of unknown virus content were collected from various Indiana orchards as dormant scions in the spring of 1956. These were grafted on whole roots of seedlings purchased from the Milton Nursery, Milton, Oregon and planted in the nursery.

The indicator varieties used included R12740-7A and its seedlings and Virginia Crab. In 1956, only three seedlings of R12740-7A were available in sufficient numbers for testing. These were 27-69, 27-202, and 65-105. They had been propagated by budding on seedling rootstocks in 1952 and planted in the nursery.

The Virginia Crab clone used as an indicator variety was obtained from a 25-year-old tree growing at the Horticulture Farm, Purdue University, and designated K6. This tree, examined repeatedly since 1956, showed no evidence of pitting and trees propagated from it on seedling rootstocks have likewise remained free from pitting symptoms.

### RESULTS

In the first experiment, buds from five virus sources (ApM-1, ApM-2, SP-2, SP-6, SP-7) were placed into 5-year old trees of the Russian seedlings 27-69, 27-202, and 65-105 in August 1956. One or two trees of each variety were inoculated with each virus source and two trees of each variety were left as unbudded controls. No symptoms were observed until May 1958, when leaf symptoms began to develop on inoculated trees. Final readings were taken in July, 1958, and the results are recorded in Table 1. Typical mosaic symptoms appeared in two of the three indicator varieties inoculated with the ApM-2 source. None of the varieties has as yet developed typical mosaic symptoms from the ApM-1 source. In all cases of inoculation with stem pitting sources the indicator varieties showed the stem pitting symptoms in one or both trees by July, 1958. In addition, stem pitting symptoms appeared in the trees of two of the indicator varieties inoculated with the ApM-2 source and one variety inoculated with the ApM-1 source.

A third disease syndrome was transmitted to one or more of the three indicator varieties from all virus sources. The symptoms were similar to those observed in the top-worked scions in the orchard in Elste, Holland. Young leaves developed pale yellow spots of varied sizes that persisted throughout the season. Affected leaves in most cases were small and moderately to severely distorted. The leaf spotting and distortion were less pronounced on leaves formed later in the season until finally the later summer leaves were largely symptomless. This syndrome was designed "chlorotic leaf spot" (CLS).

In a second experiment, carried out in the spring and summer of 1958, apple seedlings with a viable dormant bud that had been inserted the previous summer from one of three Russian varieties were used as indicator varieties. The seedlings were pruned to the inserted bud, potted in 6-inch pots and forced in the greenhouse in April. At budbreak a single bud from each of nine apple mosaic virus sources was inserted into the seedling stock below the indicator variety bud. Six trees of each indicator variety were used for each virus source and six trees remained uninoculated as controls. The trees were transplanted to the outdoor nursery in June and final readings of symptom development in the growing shoot of the indicator variety were made in July. The results are presented in Table 2. During the 4-month period, four of the apple mosaic virus sources had induced apple mosaic symptoms in one or more of the indicator varieties; five had induced stem pitting symptoms and all had induced chlorotic leaf spot symptoms. The uninoculated controls developed normally.

In the third trial, a random collection of apple varieties from several Purdue orchards and commercial orchards in Indiana were indexed on two of the Russian seedlings and on Virginia Crab K-6. As stated earlier, the K-6 clone of Virginia Crab has remained free from symptoms of stem pitting. First-year grafts of the varieties growing in the nursery row were

Table 1. Symptoms expressed by 5-year-old apple varieties of R12740-7A parentage, 2 years after bud-inoculation with known apple virus sources.

Virus Source	Symptoms expressed on stated Russian variety <sup>a</sup>		
	65-105	27-69	27-202
ApM-1	0	CLS, SP	CLS
ApM-2	M, SP	CLS, SP	M
SP-2	CLS, SP	CLS, SP	CLS, SP
SP-6	CLS, SP	-	CLS, SP
SP-7	-	CLS, SP	-
Control <sup>b</sup>	0	0	0

<sup>a</sup> - = not tested, 0 = no reaction, CLS = chlorotic leaf spot, SP = stem pitting, M = typical apple mosaic.

<sup>b</sup> No buds inserted in indicator trees.

Table 2. Symptoms expressed within 4 months on indicator trees after inoculation at budbreak with one of nine sources of apple mosaic virus.

Virus Source <sup>a</sup>	Symptoms expressed on Russian indicator variety <sup>b</sup>		
	R12740-7A	65-105	45-39
ApM-1	M, CLS, SP	CLS, SP	CLS, SP
ApM-2	CLS, SP	M, CLS, SP	CLS, SP
ApM-3	M	M, CLS	0
ApM-4	0	M, CLS	0
ApM-5	CLS	CLS	CLS, SP
ApM-6	0	0	CLS
ApM-7	CLS	CLS, SP	CLS
ApM-8	CLS	CLS, SP	SP
ApM-9	CLS	CLS	0
Control <sup>c</sup>	0	0	0

<sup>a</sup> See text for description and origin of virus source.

<sup>b</sup> 0 = no reaction, CLS = chlorotic leaf spot, SP = stem pitting, and M = typical apple mosaic.

<sup>c</sup> No buds inserted in indicator trees.



Table 3. Summary of results from indexing single trees of a number of apple varieties on Russian varieties 45-39 and 65-105 and on K-6 clone of Virginia Crab.

Variety Indexed in 1956 <sup>a</sup>	Orchard	Symptom development by July, 1958 on indicator varieties		
		Russian varieties <sup>b</sup>		Virginia Crab K-6 <sup>c</sup>
		Chlorotic leaf spot	Stem pitting	Stem pitting
Virginia Crab K-6	Purdue-Hort., 51	-	-	-
Antonovka Shafran	Purdue-O'Neal	-	-	-
Belle de Pontoise	" "	+	+	-
Blackjon	" Hort.	+	+	+
Cortland	Smith	+	+	-
Delicious	Purdue-Hort.	+	+	+
"	Smith	+	+	-
"	"	+	+	+
" ,Richared	Purdue-Hort.	+	+	-
" ,Starking	" "	+	+	-
Early Victoria	Purdue-O'Neal	-	-	-
Fredrick von Boden	" "	+	+	+
Gallia	Smith	+	+	+
Golden Delicious	Purdue-Hort. 51	+	+	+
" "	Purdue-Hort. 53B	+	-	+
" "	Smith	+	+	+
" "	Doud	+	+	-
Grimes	Purdue-Hort.	-	+	-
Hyslop	Hobbs	-	-	-
Jonathan	Smith	+	+	-
"	Doud	+	-	+
Lord Suffield	Purdue-O'Neal	+	+	-
McIntosh	Smith	+	+	-
Malling I	Doud	+	+	-
Malling II	"	+	+	-
Malling VII	"	+	+	-
"	"	+	+	-
"	"	+	+	+
Mantovana	Purdue-O'Neal	+	-	-
Rome	Purdue-Hort.	+	+	-
"	Doud	+	+	+
Staymen	Purdue-Hort.	-	-	+
Turley	Smith	+	+	-
Virginia Crab	Purdue-Hort. 51	+	+	+
" "	Purdue-Hort. 52	+	+	+
Winesap	Purdue-Hort.	-	+	-

<sup>a</sup> Indicator bud placed in two 1-year-old grafts of the variety to be indexed in August.

<sup>b</sup> The results obtained on the two Russian varieties 45-39 and 65-105 are grouped; if symptoms appear on one of the indicator trees used, a "+" is recorded in the column below.

<sup>c</sup> If stem pitting was found on one or both of the indicator trees used, a "+" is recorded in the column below.

budded in the scion portion with a bud of one of the indicator varieties in August, 1956. Two to four trees of each variety to be indexed were budded with one of each of the Russian seedlings 45-39 and 65-105 and with the K-6 clone of Virginia Crab. Examinations for leaf symptoms were made during the second year of growth of the indicator variety (1958) and for the stem pitting symptom in July, 1958. The results are summarized in Table 3. Thus far, only four varieties have failed to induce chlorotic leaf spot and/or stem pitting symptoms on one or more of the indicator trees. These are Antonovka Shafran, Early Victoria, Hyslop, and Virginia Crab K-6. Most of the varieties induced both chlorotic leaf symptoms and stem pitting symptoms on one of the Russian seedlings. A greater proportion of the varieties indexed positive for the stem-pitting virus on the Russian seedlings than on Virginia Crab K-6.

#### DISCUSSION

The Russian varieties used in these tests are worthy of further trials as sensitive indicators of the stem-pitting virus. In the experiment recorded in Table 2 the stem pitting symptoms appeared in the Russian indicators within 4 months after inoculation. In the indexing trial of 36 trees recorded in Table 3 the Russian seedlings expressed the stem pitting symptoms only in 15 cases. Further, the Russian seedlings are the only known indicators of the chlorotic leaf spot syndrome.

In the results recorded in Table 3 the chlorotic leaf spot and stem pitting symptoms are associated (either in presence or absence) in 32 of the 36 cases. The two syndromes were associated in indicator trees inoculated with buds of 27 of the 36 trees indexed. Experiments designed to elucidate the relationship between these two diseases are in progress.

PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION, LAFAYETTE, INDIANA  
(Plant Disease Reporter, Supplement 254. 1959)

# A SURVEY FOR STEM PITTING IN INDIANA APPLE VARIETIES<sup>1</sup>

Gaylord I. Mink and J. R. Shay<sup>2</sup>

## Summary

A visual survey of commercial apple varieties revealed a range of 0 to 90 percent of trees showing stem pitting symptoms. Virginia Crab showed the most severe form of pitting of all varieties examined. A similar range in incidence of pitting was found in a visual survey of 6- to 8-year-old seedling trees. A limited survey of apple varieties for the stem-pitting virus by indexing on sensitive indicator hosts revealed that symptomless trees induced stem pitting symptoms in the indicator hosts in five of six cases. Therefore, a visual survey is not reliable as a sole means of determining the presence of the stem-pitting virus.

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Stem pitting symptoms have been transmitted by grafting from pitted apple varieties to non-pitted Virginia Crab<sup>3</sup> and to other varieties<sup>4</sup>. It is of interest to know the extent of natural occurrence of the stem pitting symptoms on apple varieties and seedlings of bearing age. For this purpose, a general survey of varieties and seedlings was made in the Purdue University experimental orchards at Lafayette and Bedford, Indiana. The visual examination was supplemented by indexing in the cases of a few orchard trees.

## MATERIALS AND METHODS

In the general survey, both commercial varieties and seedling trees were observed. The varieties consisted of bearing trees ranging from 10 to 35 years old. They were examined by making a V-shaped cut in the bark near the base of the tree. The bark was lifted and both xylem and phloem tissues examined. Preliminary examinations indicated that if pitting symptoms were mild they could be detected only at or near ground level. All trees on which data were collected were examined first at ground level. Trees on which no pitting symptoms were found were examined in two or more places. Pitted trees were classified into three classes of symptom severity: mild, moderate and severe.

The seedling trees were 6 to 8 years old and on their own roots. They had fruited and had been discarded from the apple breeding program. They were examined shortly after having been uprooted by a tractor. In these cases, the entire tree trunk was examined for stem pitting. All trees found to be pitted were classified into one of seven classes of symptom severity as follows:

- Class 1 -- Shallow pits at or near ground level.
- Class 2 -- Deep pits at or near ground level.
- Class 3 -- Shallow pits in the trunk from ground level to a height of at least 3 feet. No pits on the lower limbs.
- Class 4 -- Deep pits in the trunk from ground level to a height of at least 3 feet. No pits on the lower limbs.
- Class 5 -- Combination of shallow and deep pits over the entire trunk and on basal portions of the lower limbs.
- Class 6 -- Pitting generally more severe than Class 5.
- Class 7 -- Compound pits present in large numbers on stems and twigs over the entire tree. Some pits visible on the stem and larger limbs without removal of the bark.

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<sup>1</sup> Journal Paper No. 1354 of the Purdue University Agricultural Experiment Station, Lafayette, Ind.

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<sup>3</sup> Guengerich, H. W., and D. F. Millikan. 1956. Transmission of the stem pitting factor in apple. *Plant Disease Repr.* 40: 934-938.

<sup>4</sup> Mink, Gaylord I., and J. R. Shay. 1959. Preliminary evaluation of some Russian apple varieties as indicators for apple viruses. *Plant Disease Repr. Suppl.* 254: 13-17.

A severity index for each cross was calculated as follows:

$$\frac{(\text{Number of trees in each class}) \times (\text{Class value})}{\text{Number trees classified}}$$

In the survey by indexing, individual trees were indexed for the stem-pitting virus by the use of three indicator varieties: 65-105, 45-39, and Virginia Crab K-6<sup>4</sup>. Buds from one of each of these indicators were inserted into the scion portion of two young grafts of each tree to be indexed. The indicator buds were inserted in August 1956, and final readings were taken on shoots from these buds in July 1958.

## RESULTS

The results of a visual survey for incidence and severity of stem pitting symptoms in trees located on the Purdue experimental farms are presented in Tables 1, 2, and 3. Stem pitting symptoms were found in nine of the ten scion varieties examined (Table 1). The incidence ranged from none in Stayman Winesap to approximately 90 percent infection in the case of Delicious. With one exception, pitting in scion varieties was found to be mild and confined to relatively small portions of the tree. However, in the case of Virginia Crab, three trees out of 13 examined were found pitted over most of the above-ground portion of the trees. When Virginia Crab was used as an understock (Table 2) the incidence of pitting was found to be generally greater than when the variety was used as a scion. Seedling understocks did not appear to be so severely pitted as Virginia Crab understocks.

It was of interest to determine the occurrence of pitting symptoms on seedling trees that had never been united by graft with other varieties. Presence of virus in such trees must be attributed to an introduction by natural means. Data from a visual survey of nearly 900 6- to 8-year-old seedlings are presented in Table 3. There was a range from 16 percent to 90 percent of trees showing symptoms among the different crosses. There appear to be no differences in incidence or severity of stem pitting symptoms among crosses involving *Malus atrosanguinea* (Spaeth.) Schneid., *M. floribunda* Sieb., *M. prunifolia* (Willd) Barkh., and *M. pumila* Mill. In progeny of the cross Starking x *M. baccata jackii* Rehd., however, only four trees of the 26 examined showed pitting symptoms. The most severe pitting was found on triploid seedlings resulting from crosses of diploid selections with tetraploid McIntosh.

Table 1. Incidence and severity of stem pitting symptoms in apple varieties of bearing age in Purdue University orchards at Lafayette and Bedford, Indiana, 1957 and 1958.

Variety	: Number : Percent : Classification of pitted trees <sup>a</sup>				
	: trees	: trees	: Mild	: Moderate	: Severe
	: examined	: pitted	: Percent	: Percent	: Percent
Delicious	94	89	48	52	0
Turley	14	50	29	71	0
Starking Delicious	12	42	60	40	0
Virginia Crab	13	38	0	40	60
Gallia	32	34	73	27	0
Golden Delicious	63	33	71	29	0
Grimes	204	23	89	11	0
Winesap	22	23	100	0	0
Red Rome	9	22	0	100	0
Stayman Winesap	10	0	--	--	--

<sup>a</sup> Mild = Pits shallow and infrequent. Present only at ground level or near graft union.

Moderate = Both shallow and deep pits present in abundance near ground level or near graft unions.

Severe = Pits primarily deep and present in large numbers over the trunk and scaffold limbs.



Table 2. Incidence and severity of stem pitting symptoms in understocks of trees of bearing age in Purdue University orchards at Lafayette and Bedford, Indiana, 1957 and 1958.

Understock	Height : grafted	: Number : trees : examined	: Percent : trees : pitted	: Classification of pitted trees <sup>a</sup>		
				Mild	Moderate	Severe
				: Percent	: Percent	: Percent
Virginia Crab	12-15"	47	98	2	9	89
Virginia Crab	Approx. 3' <sup>b</sup>	143	80	11	21	68
Seedling	10-12"	97	80	67	33	0
Clark Dwarf	<sup>c</sup>	43	74	23	54	23
Virginia Crab	10-12"	9	11	0	0	100

<sup>a</sup> Mild = Pits shallow and infrequent. Present only at ground level or near graft union.

Moderate = Both shallow and deep pits present in abundance near ground level or near graft union.

Severe = Pits primarily deep and present in large numbers over the trunk and scaffold limbs.

<sup>b</sup> The top variety was grafted on scaffold branches of Virginia Crab at points about 1 to 3 feet from the trunk.

<sup>c</sup> Consisted of a 4 inch interpiece between Virginia Crab rootstock and the scion variety.

Table 3. Incidence and severity of stem pitting in stems of 6- to 8-year-old apple seedlings, Lafayette, Indiana, 1957 and 1958.

Female parent	Male parent	Trees examined	Trees pitted	Severity index <sup>a</sup>
		No.	%	
McIntosh	Wolf River x 804 <sup>b</sup>	35	71	1.4
Wolf River x 804	Jonathan	21	67	1.1
Jon x 26830-2 <sup>c</sup>	Delicious	54	91	1.4
Macoun	Jon x 26830-2	10	50	1.4
McIntosh	Gal. Del. x 26829-2-2 <sup>c</sup>	14	64	1.0
McIntosh	Jon x 26830-2	87	76	1.5
4N McIntosh	26829-2-2	64	83	3.3
McIntosh	19651 <sup>d</sup> x 20 oz.	34	76	1.3
Starking	19651 x 20 oz.	14	71	1.6
McIntosh	Jon x R12740-7A <sup>e</sup>	17	76	1.0
McIntosh	R12740-7A x Del.	60	70	1.1
McIntosh	R12740-7A x 20 oz.	28	68	1.0
McIntosh	Wealthy x R12740-7A	96	53	1.1
4N McIntosh	R12740-7A	63	83	2.4
R12740-7A x Del.	Jonathan	38	69	1.0
R12740-7A x 20 oz.	Delicious	16	88	1.2
R12740-7A x 20 oz.	McIntosh	13	69	1.2
Wealthy x R12740-7A	Delicious	119	80	1.3
Geneva	Atlas	15	80	1.1
Geneva	Melba	14	93	1.1
Starking	Alexis	36	97	1.9
Starking	<u>Malus baccata jackii</u> Rehd.	26	16	1.0
Starking	Jonsib Crab	17	35	1.5

<sup>a</sup> See text for description of infection classes and formula for calculating severity index.

<sup>b</sup> Malus atrosanguinea (804)

<sup>c</sup> 26829-2-2 and 26830-2 are F<sub>2</sub> seedlings from a cross Rome Beauty x M. floribunda (821)

<sup>d</sup> M. prunifolia variety 19651

<sup>e</sup> M. pumila R12749-7A



Table 4. Transmission of stem pitting symptoms from pitted and non-pitted trees to three sensitive indicator varieties.

Variety <sup>a</sup> and rootstock of trees indexed 1956	Pitting in scion and rootstock portions of tree indexed	Symptoms on indicator varieties, July 1958 <sup>b</sup>		
		65-105	45-39	K-6
Virginia Crab K-6/unkn	None/none	0	0	0
Virginia Crab/unkn	None/none	0	+	+
Golden Delicious/unkn	None/none	0	+	+
Rome/unkn	None/none	0	0	+
Richared Delicious/Va.Crab	None/none	+	+	0
Starking Delicious/Va.Crab	None/none	+	+	0
Virginia Crab on own roots	Severe	+	+	+
Blackjon/Va. Crab	None/severe	+	+	+

<sup>a</sup> Buds for indexing were collected from the scion portion of each.

<sup>b</sup> 65-105 and 45-39 are seedlings of the Russian variety 12740-7A. Virginia Crab K-6 was observed for 3 years and found to be free from stem pitting symptoms.

Unfortunately, there was an insufficient number of indicator trees available to index the seedling trees examined for the stem pitting symptoms. Consequently, it is not known whether the large number of symptom-bearing trees would actually have transmitted the stem-pitting virus. However, there were enough trees available of three indicator varieties to index a limited number of apple varieties. These results are presented in Table 4. Five trees that did not display stem pitting symptoms in routine examinations induced stem pitting symptoms on one or two of the three indicator hosts. These data suggest that visual examination of trees for pitting symptoms is not reliable as a sole means of selecting clones free from the stem-pitting virus.

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# VIRUS STEM PITTING OF APPLE BODY STOCKS IN BRITISH COLUMBIA

F. W. L. Keane<sup>2</sup> and Maurice F. Welsh<sup>3</sup>

## Abstract

Trees of 27 apple and crabapple varieties that are in use or under test as body stocks in British Columbia have been examined for stem pitting symptoms. Symptoms have been found in body stocks of Beauty Crab, Columbia Crab, Hyslop Crab, Malus robusta No. 5, Robin Crab and Virginia Crab. Stem pitting has been found also in top-worked limbs of Golden Delicious.

## INTRODUCTION

The stem pitting disease has seriously impaired the performance of Virginia Crab as a body stock in British Columbia as in other areas (1, 3, 4, 5). All available information on the effect of this disease on other hardy varieties used as body stocks is of value. Surveys in plantings of a number of these varieties in British Columbia have provided an opportunity to obtain such information.

The testing of hardy varieties as apple tree body stocks was initiated by Mr. A. J. Mann of the Summerland Experimental Farm in the years 1938-41 (2). Promising hardy varieties were propagated on seedling and clonal rootstocks, and supplied to orchardists in areas with histories of cold injury. After 2 to 3 years the trees were top-worked with scionwood some of which was supplied from the Experimental Farm by Mr. Mann. The scion variety was budded or grafted on framework branches 18 inches or more from the trunk. Several additional blocks of Virginia Crab and Hibernial were set out by nurserymen or orchardists in 1941 and 1942, and these were top-worked with commercial varieties by the owners. Many plantings remain, and are fully mapped, providing excellent opportunities for the recording of stem pitting occurrence.

## PROCEDURE

In 1955, following a discussion of stem pitting with Mr. H. W. Guengerich, surveys for the disease were initiated in all surviving plantings of trees on hardy body stocks. Most of the survey was completed in 1955. Several additional plantings were surveyed in 1957 and 1958. All trees were 16 to 19 years old when surveyed, except those with Malus robusta No. 5 frameworks which were 6 to 7 years old.

Following preliminary surveys of Virginia Crab plantings, the characteristics of frameworks affected by stem pitting were established. The most reliable symptom is the presence of pits in sapwood matched by projections from the inner surface of the bark. These pits may be isolated and shallow. In severely affected frameworks they may develop into densely arranged deep longitudinal grooves. Gross tree characteristics associated with stem pitting include dwarfing; a low-spreading and open-centre growth habit; reduced diameter of trunk and limbs; longitudinal depressions in the trunk, sometimes extending into the limbs; overgrowth of the top-worked variety at the unions; reduced production of watersprouts from the affected body stock, and abundant production of suckers from the rootstock below.

In earlier phases of the survey stem pitting was assessed by raising inverted V-shaped flaps of bark in the scaffold branches, and at the base of the trunk within 12 inches of ground level. As the survey progressed, modifications were made in this procedure. "V" cuts were made at the base of the trunk of all body stock varieties for which limited numbers of trees were available. In large blocks of trees for which all body stocks were of a single variety,

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Table 1. Body stock varieties inspected for occurrence of stem pitting.

Framework variety	Number of plantings inspected	Number of trees inspected	Number of trees pitted
Anis	1	1	0
Antonovka	4	20	0
Atlas	2	9	0
Beauty Crab	1	3	3
Bedford Crab	2	6	0
Canada Baldwin	3	15	0
Charlamoff	6	111	0
Columbia Crab	1	2	1
Dolgo Crab	2	8	0
Florence Crab	1	5	0
Haas	1	4	0
Haralson	5	179	0 <sup>a</sup>
Hibernal	11	975	0 <sup>a</sup>
Hyslop Crab	2	12	5
Lobo	1	13	0
<u>Malus baccata</u>	3	11	0 <sup>a</sup>
<u>Malus robusta</u> No.5	4	45	11
Melba	2	9	0
McIntosh	2	10	0
Olga Crab	2	10	0
Osman Crab	4	23	0
Pioneer Crab	1	1	0
Robin Crab	1	5	5
Tony Crab	3	10	0
Transcendent Crab	1	4	0
Virginia Crab	11	1,534	1,310
Winter St. Lawrence	2	3	0

<sup>a</sup> One or more trees with trace of atypical stem pitting.

especially Charlamoff and Hiberna, that had proved consistently free from stem pitting, the bark cuts were made only in a sampling of trees that included all those with gross tree characteristics that rendered them subject to suspicion. Also, in large blocks of Virginia Crab the trees that displayed severe gross symptoms were recorded as diseased without recourse to bark cuts.

## RESULTS

The number of trees of each variety examined, the number of plantings in which observations of each were made, and the number of trees of each body stock variety in which pitting was found, are listed in Table 1.

Bark cutting was practised on a sampling of commercial varieties growing on various body stocks. Stem pitting was found in three Golden Delicious top-worked on Haralson, three Golden Delicious top-worked on Malus robusta No. 5, and three Golden Delicious top-worked on pitted Virginia Crab. No typical stem pitting was found on other commercial varieties, in occasional examinations that were made in main limbs, as close as possible to their junctions with affected Virginia Crab frameworks.

Traces of possible pitting were found in three Haralson body stocks, one Hiberna body stock, and one Malus baccata body stock. The pitting was not considered sufficiently severe or characteristic to be listed as a positive reading.

## DISCUSSION

These surveys obviously give only an indication of the reactions of the various body stock varieties to stem pitting. Varieties such as Charlamoff, Haralson, and Hiberna for which large numbers of trees showed no symptoms, are undoubtedly unaffected, or affected so mildly that effects are not evident. This conclusion is fortified when such body stocks are interplanted with pitted Virginia Crab and have been top-worked with the clones of commercial varieties that are top-worked on the pitted Virginia Crab body stocks also.

In those body stock varieties for which small numbers of trees in a limited number of plantings were available for observation, there remains considerable doubt whether negative survey results are significant.

Throughout this survey rather rigid specifications were required for the recording of positive readings of stem pitting. Two types of pitting were found that were deemed atypical: one a "reverse pitting", with pegs of wood extending into the bark; the other a fine continuous longitudinal grooving in the wood, with corresponding fine continuous ridges on the inner surface of the bark. Both types of symptoms were found in varieties top-worked on both pitted and non-pitted Virginia Crab frameworks, and were therefore considered unassociated with presence of stem-pitting virus.

For all body stock varieties that are at present recommended for British Columbia, or that show sufficient promise to suggest possible future recommendations, transmission tests with the stem-pitting virus are in progress.

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# PRELIMINARY RESULTS IN THE INDEXING OF APPLE IN BRITISH COLUMBIA

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## Abstract

Representative trees of commercial and body stock varieties grown in British Columbia are being indexed for virus infection. Positive results in 1958 suggest that the viruses of rubbery wood and of stem pitting are distinct, and show that each of these viruses is being carried in trees of several varieties. An apparently unrecorded virus transmitted from Rome Beauty causes stunting and decline of Virginia Crab. Foliage symptoms have appeared in Prunus tomentosa seedlings following inoculations from Virginia Crab trees with and without stem pitting. Attempted inoculations with the stem-pitting virus have not yielded symptoms in West Indian lime seedlings.

## INTRODUCTION

Within the last several years there has appeared strong need to assess the prevalence and importance of viruses in British Columbia apple plantings. The only apple virus demonstrated in British Columbia Interior plantings before 1956 was that of apple mosaic, found in a single Delicious tree and transmitted to one tree each of Delicious and McIntosh (2). In 1957 the virus nature of the leaf pucker disease in McIntosh and Spartan was reported (6). No information has been available on the extent to which other viruses are carried in the trees of commercial orchards or in scion source trees at the Experimental Farm.

Accordingly, in 1956, materials were assembled for the initiation of an indexing program. The immediate objectives were, first, to assess the prevalence in commercial varieties of the viruses responsible for stem pitting and rubbery wood, by sampling various clones of these varieties; and, secondly to determine the effects of these viruses on the commercial and body stock varieties commonly grown in British Columbia orchards or currently recommended for planting.

## MATERIALS AND METHODS

Lord Lambourne apple was used as the standard indicator host for rubbery wood, and Virginia Crab for stem pitting. Limited trials were made of two other plants as indicator hosts for stem pitting. One of these was Prunus tomentosa, reported by Millikan and Guengerich (3) as a host that develops foliage symptoms when inoculated with pitted Virginia Crab. Tests were also made of the suitability of West Indies lime seedlings as indicators. The use of these was suggested by their ability to develop stem pitting symptoms when inoculated with the tristeza virus (5).

All test apple trees used in the indexing experiments were grown on Malling II rootstocks propagated by the East Malling Research Station from stools indexed for freedom from viruses recognized in England. Healthy Virginia Crab materials propagated on these stocks have been consistently symptom-free, indicating that the clone is free from stem-pitting virus also. The clone of Lord Lambourne used for indexing of rubbery wood was obtained from the East Malling Research Station, where it had been indexed for freedom from virus. The source of Virginia Crab for all test trees used in the indexing of stem pitting was a symptom-free tree E. F. 9J-P30 on the Summerland Experimental Farm.

Test apple trees were created by the simultaneous summer budding of Malling II rootstocks with two inoculum buds that were applied at the base of the trunk, and with two buds of the

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indicator variety applied to the trunk immediately above. Growth of the upper buds was forced. Only cambial union was demanded for the inoculum buds, although many of them originated growing shoots. All inoculations were made into paired trees, with a single uninoculated tree serving as a check.

Rubbery wood readings were made in midsummer by the hand bending method (4) and by observation of the growth habit of test trees (Fig. 1). Stem pitting readings were made by lifting large flaps on the trunks, immediately above the union of indicator and rootstock, and by stripping bark of lateral branches of test trees.



FIGURE 1. Rubbery wood in Lord Lambourne. Apple tree at right received buds from Delicious E.F. 9D-90910. Tree in centre is uninoculated check.

*Prunus tomentosa* seedlings were grown in 1-gallon cans in the greenhouse, inoculated by summer budding when approximately 2 feet high, and headed back immediately to a height of 12 to 15 inches, to force new growth. Ten test trees received buds from a pitted Virginia Crab tree (Splett 1); four received buds from a non-pitted Virginia Crab tree (Hait BB-22); and four received buds from the non-pitted source tree E.F. 9J-P30. Symptom readings were made at intervals during 8 months after inoculation.

West Indian lime seedlings were grown in cans in the greenhouse, from seeds supplied by Dr. J. M. Wallace. They were treated in July, when they were approximately 10 inches high. The methods attempted for their inoculation were: (a) the insertion, beneath the bark through T-shaped cuts, of cambium pieces from apple source trees; (b) the rubbing of young lime leaves with the inner surface of freshly removed apple bark; (c) leaf grafting, by inserting apple leaves into clefts made at leaf axils of the lime seedlings, a slight adaptation of the method described by Bringham and Voth (1); and (d) approach grafting from apple shoots held in beakers of water. The three Virginia Crab trees used as sources for *Prunus tomentosa* tests were used in the attempts to inoculate lime seedlings. Observations were made at intervals during a period of 11 months.

## RESULTS AND CONCLUSIONS

All positive results are recorded in Table 1. Negative results have been omitted, because additional positive results on Lord Lambourne and Virginia Crab are expected in ensuing years. This expectation is supported by a small proportion of negative readings in 1958 for perpetuation of both stem pitting and rubbery wood, and in various tests that involved transmission of the viruses of these diseases from known infected sources. All recorded results were given by both trees of the inoculated pair. The check tree for each test gave a negative reading for the virus concerned in that test.

Table 1. Virus indexing of apple varieties; positive results obtained in 1958.

Source Tree	Stem Pitting	Rubbery wood	Virginia Crab decline	<u>Prunus tomentosa</u> leaf mottle
Tree 1 (E.F. 9D-90910, <u>Delicious</u> )	x	x		
Tree 2 (Hait U-7, <u>Delicious</u> on pitted <u>Virginia Crab</u> )	x			
Tree 3 (Hait GG-13, <u>Delicious</u> on non-pitted <u>Virginia Crab</u> )		x		
Tree 4 (9D-91912, <u>Winesap</u> on pitted <u>Virginia Crab</u> )	x	trace		
Tree 5 <sup>a</sup> (Hait V-12, <u>Spartan</u> on pitted <u>Virginia Crab</u> )	x			
Tree 6 (Skelly H-20, <u>Golden Delicious</u> on pitted <u>Virginia Crab</u> )	x			
Tree 7 (Evans 1, <u>Golden Delicious</u> )	x			
Tree 8 (E.F. 3-17-1, <u>Rome Beauty</u> )	x	trace	x	
Tree 9 (Hait BB-22, non-pitted <u>Virginia Crab</u> )				x
Tree 10 (Splett 1, pitted <u>Virginia Crab</u> )				x

<sup>a</sup> The Spartan and the Virginia Crab portions of this tree were applied separately to indicator trees. Results were the same.

Significant information provided by the 1958 results of indexing is as follows:

1. Rubbery wood virus has been demonstrated present in two 16-year-old indexed Delicious trees, neither of which displays any obvious abnormalities. Tree 1 is known to be a Turner Red Delicious. Tree 3 is a red strain of Delicious, believed to be Turner Red. One Secando Winesap tree and one Rome Beauty tree, apparently normal in growth habit, have indexed as strongly suspicious for rubbery wood. These are the first demonstrations of the occurrence of rubbery-wood virus in British Columbia apple plantings.
2. The stem-pitting virus has been demonstrated present in Delicious, Spartan, and Winesap clones growing on pitted Virginia Crab body stocks; and in Delicious, Golden Delicious, and Rome Beauty clones that have had no known contact with Virginia Crab. This substantiates considerable circumstantial evidence for the common occurrence of the virus in clones of commercial apple varieties.
3. The rubbery-wood virus has been demonstrated present in one tree that also carries stem pitting, and is strongly suspected in two additional trees that carry stem pitting. However, rubbery-wood virus has been demonstrated to be present also in one clone of Delicious growing on Virginia Crab body stock that shows no suspicion of stem pitting, and that has not perpetuated or transmitted stem pitting in three separate tests. These results provide limited but strong evidence that the viruses of rubbery wood and stem pitting are distinct.
4. None of the young Lord Lambourne indicator trees, whether inoculated from stem pitting sources or not, showed typical pitting symptoms in 1958. However, almost all Lord Lambourne trees showed a "reverse pitting" with pegs of wood tissue penetrating into the inner tissues of the bark. The significance of this symptom is difficult to assess.
5. A tree of Rome Beauty in Experimental Farm plantings, showing no gross symptoms, has not only indexed positive for stem pitting, and strongly suspicious for rubbery wood, but has caused a striking dwarfing and decline of Virginia Crab. This decline (Fig. 2) appears to be far more severe than the usual effect of the stem-pitting virus. By mid-Aug-



FIGURE 2. Dwarfing and decline of Virginia Crab. Tree at left received buds from Rome Beauty E.F. 3-17-1. Tree at right is uninoculated check.



ust of the year following inoculation, the trunk diameters of inoculated trees were approximately one-half the diameter of the check tree. Inoculated trees had a weeping growth habit. Their foliage was pale green, with about one-quarter of the leaves turning yellow from the margin, and dropping. The fruits were about one-half normal size and ripened prematurely, with flesh water-soaked from the core outwards. There appears justification for ascribing this decline to a virus distinct from those causing stem pitting and rubbery wood.

6. In *Prunus tomentosa*, foliage mottling resembling that described by Millikan and Guengerich (3) has been induced. The symptoms developed in six trees that received buds from the pitted Virginia Crab tree Splett 1, two of those that received buds from non-pitted Virginia Crab tree BB-22, and none of those that received buds from non-pitted Virginia Crab tree E.F. 9J-P30. Thus the *P. tomentosa* symptoms have followed inoculation from pitted and from apparently non-pitted Virginia Crab. Tree Hait BB-22 which is 16 years old, has shown no evidence of stem pitting after very careful examination. The results therefore suggest that the symptoms in *P. tomentosa* are caused by a virus distinct from that of stem pitting.
7. Attempts to inoculate a total of 44 lime seedlings by the four described techniques, 28 of these with material from a pitted Virginia Crab tree, and eight with material from each of two non-pitted trees, have induced neither foliage nor stem pitting symptoms in the test seedlings. Six leaf inserts remained green for 3 weeks or more, and a small proportion of the approach grafts and cambial insertions made definite union. Therefore the opportunity for virus transmission was provided, and evidence was yielded that the virus of apple stem pitting does not cause stem pitting in lime seedlings.

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BOTANY AND PLANT PATHOLOGY DIVISION, SCIENCE SERVICE, CANADA DEPARTMENT OF AGRICULTURE  
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# REACTION OF OWN-ROOTED TREES OF SPY 227 AND VIRGINIA CRAB TO INFECTION WITH THE STEM-PITTING VIRUS<sup>1</sup>

H. W. Guengerich and D. F. Millikan

## Abstract

The apple rootstock clone, Spy 227, appears to be a good indicator for apple viruses. Inoculation with an isolate of the stem-pitting virus caused severe stem pitting of Spy 227. Own-rooted Spy 227 trees were killed by the same isolate. This suggests that the previously reported lethal rootstock-scion combinations may have been due to infection with the stem-pitting virus.

## INTRODUCTION

In 1948, Weeks (4) published the third of a series of papers concerning the uncongeniality associated with combination between scion varieties and the USDA rootstock, Spy 227. The possibility that a virus infection was associated with the lethal action was considered in this report and evidence was presented showing that this uncongeniality of one clone could be transferred to a non-lethal clone. Previous tests (2) showed that Spy 227 on seedling roots developed pitting on the wood following inoculation with buds from scion sources known to contain the stem-pitting virus. These reports, and an earlier one by Tukey and Brase (3) concerning the uncongeniality of McIntosh on Virginia Crab prompted the authors to compare Spy 227 with Virginia Crab as an indicator.

## EXPERIMENTAL METHODS AND RESULTS

Spy 227 scionwood was received in August 1954, from C. P. Harley of the United States Department of Agriculture. The clone was increased by budding into domestic seedlings. In 1956, softwood cuttings of a single Spy 227 tree were rooted under intermittent mist. Virginia Crab from a single tree known to be free from infection with the stem-pitting virus was increased by both softwood cuttings and bench-grafting to domestic seedlings. These were lined out in the spring of 1957 and inoculated the subsequent August.

Two sources of inoculum were used in the study. One, GD-A, was a single tree increase from a parent Golden Delicious tree showing no pitting on the Virginia Crab stem. The other source, GD-C, was a bearing tree showing a severely cracked and pitted Virginia Crab stem. One half of the test plants were inoculated with the infected source, GD-C, and the other half were budded with clone GD-A. In April 1958 one half of the trees inoculated from a diseased source were cut back so that the inoculum tissue dominated. Trees budded from the disease-free source were treated in a similar fashion and observations were made beginning in July and terminating in September. These data are listed in Table 1.

## DISCUSSION

From the date listed in Table 1, it appears that the cause for the uncongeniality of apple lethal to Spy 227 could be the stem-pitting virus. The observation that Spy 227 trees cut back to the inoculating bud and forced are longer lived than Spy 227 not cut back is in agreement with Gardner, Marth and Magness' (1) observation of Rome Beauty worked on Spy 227. Most of the roots on the two surviving trees of the virus-inoculated and forced group were found to be dead at the last inspection. This also agrees with observations of Gardner, Marth and Magness (1).

Own-rooted Virginia Crab and the same clones on seedling roots behaved similarly to trees infected with the stem-pitting virus. However, the pitting on own-rooted trees seemed to be somewhat less severe than that on trees with seedling roots.

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<sup>1</sup>Journal Series Paper No. 1924, approved by the Director of the Missouri Agricultural Experiment Station.



Table 1. Effect of virus infection upon Spy 227 and Virginia Crab clones of apple.

Scion	Rootstock	Inoculum	Number of trees		Reaction	
			Cut back	Not	Date of observation	Type
			to bud and	cut		
			forced	back		
Spy 227	Spy 277	GD-A	3		9/8/58	All alive
Spy 227	Spy 227	GD-A		3	9/8/58	All alive
Spy 227	Spy 227	GD-C	5		7/1/58	1 dead
					8/30/58	2 dead
Spy 227	Spy 227	GD-C		5	9/8/58	3 dead
						2 alive
Spy 227	Spy 227	GD-C		5	7/1/58	1 dead
					8/13/58	2 dead
					9/8/58	5 dead
Va. Crab	Seedling	GD-A	4		9/8/58	None pitted
Va. Crab	Seedling	GD-A		4	9/8/58	None pitted
Va. Crab	Seedling	GD-C	5		9/8/58	All pitted
Va. Crab	Seedling	GD-C		5	9/8/58	All pitted
Va. Crab	Va. Crab	GD-A	2		9/6/58	None pitted
Va. Crab	Va. Crab	GD-A		3	9/6/58	None pitted
Va. Crab	Va. Crab	GD-C	5		9/6/58	All pitted
Va. Crab	Va. Crab	GD-C		5	9/6/58	All pitted

#### SUMMARY

When inoculated with an isolate of the stem-pitting virus the apple rootstock Spy 227 gives a reaction similar to that observed when certain clones of apple are budded to it. The lethal effect of the virus is delayed if the clone is cut back to the inoculated bud and forced. This suggests that the factor responsible for lethal uncongeniality in apple may be the stem-pitting virus, and indicates that Spy 227 may be a good indicator for pome fruit virus studies.

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MISSOURI AGRICULTURAL EXPERIMENT STATION  
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# SOME POMACEOUS INDICATOR HOSTS FOR THE STEM-PITTING VIRUS OF APPLE

D. F. Millikan and H. W. Guengerich<sup>1</sup>

## Abstract

Host range studies involving several pomaceous species revealed indicator hosts for the stem-pitting virus in clones of Malus floribunda, M. platycarpa (B-39478), Crataegus crus-galli, C. mollis, and Amelanchier spp. Clones of M. floribunda and M. platycarpa appear to be particularly promising as indicator hosts.

## INTRODUCTION

The widespread occurrence of stem-pitting virus in our commercial clones and varieties has stimulated a search for an indicator superior to Virginia Crab. Virginia Crab when used as indicator plant requires an incubation period approaching 12 months. In addition, the stripping of the bark necessary to observe the pitting characteristic of infection is laborious and destroys the tree. Consequently several genera and species closely related to apple were collected and inoculated with an isolate of the stem-pitting virus. These host plants were then evaluated on the basis of severity of symptoms.

## EXPERIMENTAL METHODS AND RESULTS

During the first 2 years seedlings of Amelanchier spp., Aronia spp., Cotoneaster spp., Crataegus crus-galli, C. mollis, Malus floribunda, Photinia spp., Sorbus americana, and S. aucuparia were screened by inoculating with the virus and observing the development of symptoms over a 2-year period. Most of these seedlings offered no improvement over Virginia Crab as indicators. On the other hand, certain seedlings of Amelanchier spp., Malus floribunda, Crataegus crus-galli, and C. mollis did show marked foliage symptoms in the spring following August budding.

Tests were then set up to examine these species more critically. These experiments were conducted under field conditions. Every other seedling in a row was inoculated with buds from a tree known to be carrying the stem-pitting virus. Prior to inoculation a bud was taken from the seedling to be inoculated and placed into the adjacent plant, which served as the non-inoculated control and was encouraged to grow so as to provide propagation material if the inoculated test plant proved to be useful. The results of this test are listed in Table 1.

Table 1. Pomaceous hosts showing foliage symptoms following inoculation with the stem pitting virus.

Species	Number plants			
	Showing symptoms			
	Total	None	Mild	Severe
<u>Crataegus mollis</u>	31	27	3	1
<u>C. crus-galli</u>	36	26	8	2
<u>Malus floribunda</u>	5	2		3
<u>M. platycarpa</u> (clone B-39478)	12		12	
<u>Amelanchier</u> spp.	15	13		2

## DISCUSSION

The data listed in Table 1 indicate that some seedlings of both Crataegus mollis and C. crus-galli show foliage symptoms following inoculation with buds infected with the stem-pitting virus. Typical foliar symptoms of stem pitting on Crataegus, shown in Figure 1, consist of a mottled foliage condition generally associated with a pronounced dwarfing of the plant. The

<sup>1</sup>Journal Series Paper No. 1925, approved by the Director of the Missouri Agricultural Experiment Station.



FIGURE 1. Typical symptoms of the stem pitting virus in Crataegus crus-galli. Inoculated clones on left, non-inoculated control on right.



FIGURE 2. Symptoms of the stem pitting virus in Amelanchier spp. Leaves from inoculated plant on left, leaves from non-inoculated control plant on right.

symptoms expressed on Amelanchier following inoculation were essentially those described earlier<sup>2</sup>. Malus floribunda reacted to infection with a marked mottling of the leaves accompanied by a mild rugosity. Generally, the leaves on the inoculated plants were somewhat smaller than those on the control. M. platycarpa showed a mild mottling on the leaves. The single clone of M. platycarpa and all three clones of M. floribunda showed severe wood pitting in addition to the foliage symptoms.

#### SUMMARY

Certain clones of Malus floribunda, M. platycarpa, Crataegus mollis, C. crus-galli, and Amelanchier spp. showed marked foliage symptoms the season following inoculation with the stem pitting virus. These clones are being increased and may be useful as virus indicators for apple virus investigations.

MISSOURI AGRICULTURAL EXPERIMENT STATION  
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<sup>2</sup>Millikan, D. F., and H. W. Guengerich. 1955. Transmission to Amelanchier of an agent causing a disorder in apple. Phytopathology 46: 130.

TOLERANCE OF SOME HARDY APPLE STOCKS TO THE  
STEM-PITTING VIRUS OF APPLE<sup>1</sup>

D. F. Millikan and H. W. Guengerich

Abstract

Experimental inoculations indicate that certain promising hardy body stock clones of apple show no symptoms characteristic of those produced by the stem-pitting virus. The rubbery wood indicator, Lord Lambourne, as well as other body stock clones, show severe pitting similar to that found on Virginia Crab.

INTRODUCTION

Incompatibility between scion varieties Grimes and Delicious, and Virginia Crab was noted as early as 1933 by Lantz (4). Later, Maney (2) reported that Stayman was highly incompatible with Virginia Crab. In 1954, Smith (5), Tukey et al. (6), and Miller (3) listed numerous incompatibilities between scion varieties and Virginia Crab. In 1956 this disorder was shown to be due to a transmissible virus (1). As observations by the authors and others (3, 5, 6) indicated widespread occurrence of this virus throughout North America in many commercial varieties, it seemed advisable to determine the relative tolerance of hardy apple stocks to infection with the stem-pitting virus.

EXPERIMENTAL METHODS AND RESULTS

Several commonly used or potential body stocks collected for increase were bench-grafted to domestic seedlings and lined out in nursery rows. The 1-year budlings were inoculated in August by budding with a source of inoculum known to cause severe pitting on Virginia Crab. Cutting back to the inoculating buds the following spring forced the inserted buds into growth. Observations were made 1 year after inoculation and in subsequent years. Readings were made

Table 1. Tolerance of several body stock clones to infection with the stem pitting virus.

<u>Clones showing pitting</u>	<u>Clones showing no pitting</u>
Delcon	K-14 <sup>c</sup>
Spy 227	K-18
Lord Lambourne <sup>b</sup>	K-24
A-2 (Alnarp A-2)	Rescue <sup>a</sup>
K-29	<u>M. kitaika</u> PI 107219
<u>Malus platycarpa</u> (B-39478)	Columbia
<u>M. kitaika</u> PI 107200	Canada Baldwin <sup>a</sup>
(very mild after 3 yrs.)	Antonovka (Ottawa strain)
<u>M. kitaika</u> PI 154157	Charlamoff
(very mild after 3 yrs.)	Belle de Boskoop <sup>b</sup>
<u>M. floribunda</u> var. Paul's Scarlet	Besseminka
<u>M. sikkimensis</u>	Antonovka zhaltai
<u>M. sikkimensis</u> seedlings	
Hibernal	

<sup>a</sup>One year's observations, only.

<sup>b</sup>Lord Lambourne -- indicator for rubbery wood. Belle de Boskoop -- indicator for rough skin.

<sup>c</sup>K clones - selections of French Crab from Kansas



by stripping the bark from the inoculated trees and comparing the presence or absence of pitting with the pitting found on the inoculated Virginia Crab controls. The results of this study are listed in Table 1.

## DISCUSSION

Considerable variability was noted in the reactions of some commonly used and potential body stocks to infection with the stem-pitting virus. Such stocks as Spy 227 and M. sikkimensis were affected and showed pitting as severely as any Virginia Crab found in our surveys. Other stocks such as M. kitaika PI 107200, M. kitaika PI 154157, and K-29 showed only mild pitting after 3 years. M. kitaika PI 107219, K-14, K-18, K-24, Columbia, and Charlamoff showed no pitting 3 years after inoculation. Additional tolerance or resistance is suggested in the case of Rescue, Mount, Canada Baldwin, and a clone of Antonovka. These clones were free from pitting 1 year after inoculation.

## SUMMARY

Several body stocks were evaluated for freedom from stem pitting following inoculation with the stem-pitting virus. Stocks K-14, K-18, K-24, M. kitaika PI 107219, Canada Baldwin, Antonovka (Ottawa strain), Antonovka zhaltai, Besseminka, and Charlamoff showed no pitting in 1 to 3 years after inoculation. Stocks K-29, M. kitaika PI 107200, and M. kitaika PI 154157 showed mild pitting 3 years after inoculation.

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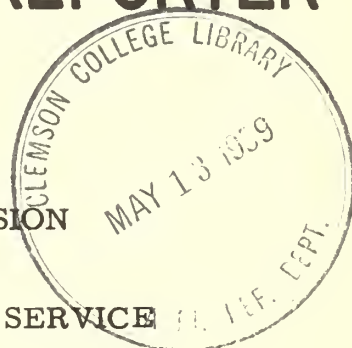
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# THE PLANT DISEASE REPORTER

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UNITED STATES DEPARTMENT OF AGRICULTURE

VERTICILLIUM HADROMYCOSIS OF DECIDUOUS TREE FRUITS

K. G. Parker

Supplement 255

May 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

VERTICILLIUM HADROMYCOSIS OF DECIDUOUS TREE FRUITS

K. G. Parker

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Supplement 255

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# VERTICILLIUM HADROMYCOSIS OF DECIDUOUS TREE FRUITS

K. G. Parker<sup>1</sup>

## Abstract

The literature on *Verticillium hadromycosis* as it affects stone and pome fruits is reviewed and the information discussed as to its bearing on development of the disease and its control. Literature on the disease on other crops is included when the information may help to understand the development and control of the disease on trees.

This disease is world-wide in occurrence on stone fruits and all species grown commercially for fruit crops are susceptible. Among the pome fruits, quince appears to be susceptible, with pears and apples only doubtfully so.

The best control available is rotation with non-susceptible crops. If susceptible crops have been grown on soil where the planting of stone fruits is planned other crops should be grown for several years before the trees are planted. Susceptible weed hosts should be kept down both before and after the trees are planted.

Needs for research are discussed. Cultural treatment as it influences the survival of infected trees is included in the list of factors considered. The influence of soil conditions and antibiosis on the development and maintenance of inoculum seems to offer considerable promise for study.

An interesting relation that is evident in the literature is the rootstock-scion combination. Instances are described in which the top is more susceptible than the rootstock, as with apricot on plum root, and the reverse condition, in which the tree fails because of infection in the root although the scion is only mildly or not at all susceptible, as with pear on quince root.

## INTRODUCTION

Vascular wilt or hadromycosis (104), caused by species of *Verticillium*, affects a wide variety of plants belonging to many genera. Among these the stone fruits stand out as highly susceptible. The literature on the disease as it affects this group has not been reviewed since Rudolph's monograph (104) was published. Using that monograph as a starting point, an attempt is made in the present review to bring together all references to *Verticillium* wilt in the genus *Prunus* not listed by Rudolph and to discuss the disease as it affects members of that genus. Frequent reference is made to the monograph and to the papers cited by Rudolph when necessary to make the discussion complete. The very limited literature on *Verticillium hadromycosis* on pome fruits is reviewed also.

Along with this an attempt is made to discuss the possible pertinence of information obtained in studies on other susceptible crops to *Verticillium* wilt as it affects the tree fruits. This includes primarily epiphytology, and control by sanitation, crop rotation, and soil fumigation. The development of resistant varieties is not discussed because all investigations on resistance have been on cotton, tomato, and other herbaceous or semi-herbaceous plants and are of interest primarily in connection with the particular crops concerned. The toxin hypothesis of causation of wilt has been recently reviewed (21) and is not discussed here.

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<sup>1</sup>The literature reviewed in this paper was read and the first draft of the paper prepared during the winter of 1957-1958 when the author was temporarily on the staff of the State Experiment Stations Division, Agricultural Research Service, United States Department of Agriculture. Grateful acknowledgment is made of the guidance of Dr. C. L. Lefebvre and the suggestions made by various members of the staff of that Division, and of the fine cooperation of the staff of the United States Department of Agriculture Library.

The manuscript was critically reviewed by Dr. W. D. McClellan and Dr. G. C. Kent, to whom the author is grateful.



Chemotherapy is omitted because it does not appear to offer immediate promise of control.

In the discussion that follows the different headings, therefore, are understood to refer to Verticillium wilt and hadromycosis as it affects tree fruits belonging to the genus *Prunus* and to the sub-family Pomideae of the family Rosaceae. The hosts listed conform with the names given in Rehder's Manual and Bibliography (96, 97). Names given by the authors of the papers cited, however, are copied unless changes can be made without chance of error.

The name of the species of *Verticillium* when given is that used by the author of the study referred to. In many cases a species name is not given in the original publication, and no attempt is made to supply one here. This question will be discussed briefly elsewhere in this review.

Literature surveyed: To search for titles the following journals were examined:

Review of Applied Mycology -- Volumes 7 (1928) through 36 (1957).

Biological Abstracts -- Volumes 3 (1929) through 29 (1955).

U. S. Department of Agriculture, Bibliography of Agriculture -- Volumes 19 (1955); 20 (1956); 21 (1957); and 22, no. 1 (January, 1958).

American Journal of Botany -- Volume 40 (1957).

Annals of Applied Biology -- Volume 45 (1957).

Phytopathologische Zeitschrift -- Volume 28, nos. 3 and 4; 29, nos. 1 through 4; and 30, no. 1 (January through October, 1957).

Phytopathology -- Volume 47 (1957).

Plant Disease Reporter -- Volume 41, nos. 1 through 10 (January through October, 1957).

Tijdschrift over Plantenziekten -- Volume 63, nos. 1 through 5 (January through August, 1957).

British Mycological Society Transactions -- Volume 40 (1957).

Zeitschrift für Pflanzenkrankheiten (Pflanzenpathologie) und Pflanzenschutz -- Volume 64 (January through May, 1957)

Inspection of this list will indicate the plan followed. The abstracting journals were examined beginning early enough to furnish references to papers overlapping those cited by Rudolph (104). This was determined by checking for duplications with Rudolph's citations. Biological Abstracts was examined through the last volume that had an index and the Review of Applied Mycology was examined through one additional year (1957). The examination of The Bibliography of Agriculture was started with 1955, to overlap the latest coverage of the abstracting journals. The original journals were examined for the year 1957 in so far as they were available. Complete volumes which coincide with the calendar year are listed as such, and where only part of the volume was seen or where the volume does not coincide with the calendar year the period covered is indicated.

A part or all of the 1957 numbers of a few additional journals were examined but are not listed because no papers on Verticillium wilt were listed in the numbers seen.

## NAMES OF THE DISEASE

The name Verticillium hadromycosis, as explained by Rudolph (104), appears to be the best descriptive brief term available, but the term Verticillium wilt has gained such wide usage that it will be used for the most part in this review, particularly when referring to the work of an investigator who uses the term. It will be understood to include all aspects of the disease: tracheomycosis, hadromycosis, "black heart", defoliation, and yellowing, as well as true wilt.

## SUSCEPTS

An attempt is made in the discussion of each species or group to cite all available information on history and range and to cite all reports of the disease published after those listed in Rudolph's monograph. Symptomatology on the different species of stone fruits will be discussed in a separate section.

### Stone Fruits

All members of the genus Prunus commonly grown for fruit production are susceptible to Verticillium wilt.

Almond (Prunus communis Arcang.). According to Rudolph, the first report of Verticillium wilt on almond was made by Czarnecki from California in 1923, and Dufrenoy and Dufrenoy (38) reported it from France in 1927. The latter authors observed the mycelium in wood vessels and isolated Verticillium dahliae Kleb. but did not describe inoculation experiments. Carter (23) isolated V. albo-atrum Reinke & Berth. from Prunus communis in Illinois, and Brien and Dingley (18) reported V. dahliae on this species in New Zealand.

While there is little question of the pathogenic relation of Verticillium to the disease on almond in the earlier reports it is important that the point be tested. In 1931, Joessel and Bordas (66) reported successful inoculations to 2-year-old almond trees with V. dahliae. Also in France (3), V. dahliae isolated from apricot was successfully inoculated into almond with even more rapid development of decline symptoms than on apricot, the source of the isolate. Hutton and Morschel (57) inoculated tomato plants growing adjacent to almond trees and the disease developed on the trees within 12 months.

Finally, Day (30) reported the disease on apricot nursery trees growing on almond roots, listed in this section because infection probably in most cases is through the roots.

Apricot (Prunus armeniaca L. and P. mume Sieb. & Zucc.). According to Rudolph (104) Verticillium wilt was first reported on apricot in 1916, with definite proof of susceptibility published in 1923. A more recent inoculation test was made by Joessel and Bordas (66) who reported successful inoculations with V. dahliae to 2-year-old apricot trees. Rudolph's reports were from California, and the disease was reported from Canada and from France in 1927. Since that time additional reports have been made from British Columbia, Canada (27, 28), Washington State (14, 46), Italy (15, 29, 47, 77), and from Hungary (11, 56). Additional reports from France will be discussed under the discussion of the relation of Verticillium to apoplexy. The disease has assumed importance in Australasia. Cheney (26) described the disease from Victoria and, although the symptoms differed somewhat from those described in Czarnecki's original description, there appears to be no reason to doubt the authenticity of this report. Later reports were from Victoria (4, 43) and New South Wales (57) on the Australian mainland, from New Zealand (5, 16, 17, 67, 98, 107), and from Tasmania (119).

According to Weiss and O'Brien (120) the disease has been reported on Prunus nune from California, Utah, and Washington.

Day (30) apparently considers the apricot rootstock more susceptible to "blackheart", caused by V. albo-atrum, than other rootstocks of stone fruits used in California.

Many reports have been made from Europe of a serious disease of apricots called "apoplexy". Certain of the more recent reports have indicated Verticillium wilt to be part of this disorder. The chief characteristic of apoplexy is that a part or all of the affected trees dies rapidly.

Joessel (65) found in trees -- in both orchards and nurseries -- in a declining condition, a brown to black discoloration in the wood, and he microscopically identified Verticillium in the tissue. He associated the discolored tissue with mechanical wounds, including in the case of the nursery trees the cut made to remove the portion of the stock above the inserted bud. Curzi (29) referred to Verticillium wilt as described on peach by previous workers as a partial explanation for apoplexy symptoms on apricot in Italy. Sarejanni (105) isolated a micro-sclerotial form of V. albo-atrum from 5- to 7-year-old apricot trees in Greece with symptoms of apoplexy, and has isolated the same form of this fungus from potato in the same area. Potato and other susceptible crops are often planted between rows of apricot. Chabrolin (24, 25) found more discoloration in the inner bark of affected trees than in the woody tissues and, therefore, considers Verticillium unimportant to this disorder. Joessel and Bordas (66) published additional observations indicating a symptomatology similar to that caused by Verticillium and isolated V. dahliae from affected trees.

More recently, Rieuf (100), Delmas (31), and Morvan (90), have published studies indicating a strong belief that Verticillium wilt is one of several causes of apoplexy. Morvan recognizes three forms of apoplexy. One is characterized by necrosis of bark in the crotches of the trees. His photographs resemble at least in part a type of injury usually attributed in the United States to low winter temperatures, particularly on trees that grow late in the autumn and are not fully "matured". Another form is associated with tracheomycosis and Verticillium is isolated from such trees. Affected trees wilt in July and turn pale or yellow, the leaves drop, and the wood is discolored. It occurs where the trees are planted in old lucerne fields



or where potatoes, tomatoes, or strawberries had previously been grown. The third and most important type of apoplexy is associated with necrosis in the bark instead of in the wood, and therefore probably has no relation to the *Verticillium* wilt disease.

At any rate, it appears very likely that *Verticillium* wilt causes a significant part of the disease of apricots generally termed "apoplexy" on the European Continent.

**Cherry (*Prunus* spp.).** Rudolph credits van der Lek (113) in 1918 with the first report of *Verticillium* hadromycosis on cherry, the first definite report of the disease on any kind of stone fruit. He further reviews work by van der Meer (114, 115) in which *V. albo-atrum* and *V. dahliae* were isolated from various species and varieties of cherry and from several herbaceous hosts and cross inoculations were made. Isolates from sour and sweet cherry and from *Prunus mahaleb* L. were successfully inoculated into cherry and into certain herbaceous hosts. Inoculations to cherry with isolates from herbaceous hosts likewise were successful.

At the time Rudolph prepared his monograph the disease was known on cherry in Holland, Czecho-Slovakia, Denmark, France, and Corsica. Since that time it has been reported on sour cherry in Germany (137) and on Morello [sour] cherry in England (138). McKeen (84) observed symptoms on both sweet and sour cherry on the Niagara Peninsula in Ontario, Canada. The disease was reported on both sweet and sour cherry in British Columbia (27, 28) and on sweet cherry in California (132) and in Washington State (14). McIntosh (81) reported a particularly severe occurrence on sweet cherry in British Columbia.

Donandt (36), in a host range study, obtained infection with severe wilt on *P. mahaleb* following artificial inoculation with isolates from several hosts, including certain weeds and *Prunus domestica* L.

Dufrenoy and Dufrenoy (38) isolated the fungus from St. Lucie cherry [*P. mahaleb*], made successful cross inoculations with *V. albo-atrum* from potato and cherry, and obtained infection with the cherry isolate on tomato.

**Peach (*Prunus persica* Batsch.).** Rudolph (104) described experiments in which successful inoculations with *Verticillium* were made from peach to eggplant by C. M. Haenseler in New Jersey, from peach to tomato by M. F. Barrus in New York, and from peach to Myrobalan seedlings, tomato, and raspberry by Rudolph. Apparently no one has successfully inoculated peach. In later reports McKeen (83) made inoculations with isolates from peach and other plants to a host range (not including peach) and obtained infection with the peach isolates on these hosts about equal to that obtained with other isolates.

In addition to the report from New Jersey in 1922, that from New York, and the widespread occurrence in California (104) the disease has subsequently been reported on peach from the following states: New York (88), Oregon (120), and Washington (14). It is known in Canada in Ontario (83, 134, 135) and British Columbia (27, 28). It has been reported from New Zealand (6, 18, 67, 107). In Europe it has been recorded from France (42, 65). From Holland van Koot (117) reported *Verticillium* attack on peach grown under glass in a house where tomato had been attacked by *Verticillium* "sleeping sickness". There is a strong probability that peach is affected by *Verticillium* in Greece (105). Pollacci (93) reports from Italy "tracheomicosi" on peach apparently caused by a species of *Verticillium*. Atanasoff et al. (10) list *V. albo-atrum* from *P. persica* in Bulgaria.

**Plum (*Prunus* spp.).** Rudolph (104) credits Czarnecki with the first report of the disease on plum in 1923, on Myrobalan seedlings, although inoculation experiments were not made until his own work reported later (103). He made successful inoculations to Myrobalan seedlings with isolates from Myrobalan, tomato, apricot, peach, and raspberry. Dufrenoy and Dufrenoy (38) reported successful cross inoculations with isolates from raspberry and plum. They did not specify the kind of plum that was the source of the fungus used but described the disease on *P. domestica* L. It seems, therefore, that pathogenicity of *Verticillium* to the European plum is well established.

Wollenweber (137) in Germany reported the isolation of *Verticillium* from *P. domestica* which showed blackish-brown discoloration in the wood. Curzi (29) in Italy observed partly defoliated trees in which he identified the *Verticillium* fungus in the tracheids, apparently by microscopic examination. Atanasoff et al. (10) isolated *V. albo-atrum* from *P. domestica* in Bulgaria. Pollacci (93), also in Italy, states "tracheomicosi" is equally severe on plum and apricot. Husz (56) in Hungary isolated *V. albo-atrum* from Myrobalan nursery trees with symptoms of wilt and black heart. Marchal (85, 86) in France reports apoplexy rather common on plum with *V. albo-atrum* found associated with it. Van Koot (117) describes the

disease on plums along with peach under glass in Holland. Keyworth (70) described the disease as caused by V. albo-atrum on a single Victoria plum tree in Kent.

Carrera (22) observed wilt on P. domestica in Argentina and isolated Verticillium sp. from affected trees. Day (30) found verticilliosis occasionally on trees on Myrobalan rootstock in both orchard and nursery but stated that it is more severe on apricot rootstock than on Myrobalan, however. Blodgett and Twomey (14) observed wilt on two young trees of Stanley prune (P. domestica).

The disease has been reported from New Zealand on plums (6), but Smith (107) indicates that it is comparatively unimportant.

Goidánich (48) reported the disease on the Burbank variety (P. salicina) near Bologna, Italy, and Gaudineau (42) states that Japanese plums are often attacked in France although it is difficult to determine from her report whether verticilliosis is the primary cause.

While some of the earliest successful inoculation experiments on stone fruits were made on Myrobalan seedlings, apparently plums are generally less susceptible than are apricots. M. Dufrenoy (39) and Rieuf (100) describe apricot on plum rootstock in which the apricot portion of the tree is killed leaving the plum understock comparatively unaffected.

Miscellaneous Species of Prunus. Prunus davidiana Franch resembles peach and is used primarily as an ornamental. Some use is made of it as an understock. Ghillini (44) observed one tree with wilt and with discoloration in the wood, from which he isolated a Verticillium which produced sclerotia in culture. His photographs of a young twig and of a cross section of the lower trunk show clear symptoms usually considered as characteristic of Verticillium hadromycosis.

According to Weiss and O'Brien (120) the disease has been reported on Prunus laurocerasus (Mill.) Ait. and P. lusitanica L., English cherry laurel and Portugal laurel respectively.

Sommer (109) reports the disease on nursery trees of stone fruits but does not name the species.

### Pome Fruits

Rudolph (104) did not describe the disease on pome fruits and, therefore, presumably the earliest reports of Verticillium attack on this group are cited in the present review.

Apple (Malus pumila Mill.) In a list of new records from Bulgaria in 1932, Atanasoff et al. (10) listed V. albo-atrum as found on Pyrus malus, but they did not specify the tissue involved nor describe symptoms. That species is listed, however, in their report along with other hosts known to be susceptibles of this pathogen. Since Verticillium has been isolated from the bark of trees, probably growing saprophytically, Atanasoff and his associates may have obtained the fungus from apple bark and a pathogenic relation is not necessarily indicated.

In a study of decay of apple fruits Huber (55) isolated 58 species or forms of various genera of fungi from the surface of sound fruits, with which he was able to cause decay by artificial inoculation to sound fruits. Of these forms, nine belonging to six genera had not previously been reported as causing decay of apple fruits. Three of the new forms were listed as belonging to Verticillium with no indication of the species. On the other hand, Adams and Tamburo (1), in an extensive study of apple fruit rotting, failed to find any form of the genus Verticillium in naturally-occurring lesions on the fruit. They limited their study to isolates from already-existing lesions on fruits taken directly from the tree or on freshly-harvested fruits on the packing lines. They found representatives of 22 fungous genera capable of causing rot, as based on artificial inoculations, but Verticillium was not among them.

As it stands, further evidence of pathogenicity is required before apple can be considered as a suspect of Verticillium wilt <sup>2</sup>.

Hawthorn (Raphiolepis spp.). Wilhelm et al. (133) in 1955 reported the isolation of V. albo-atrum from the vascular tissue of Raphiolepis indica (L.) Lindl. (India hawthorn) and R. umbellata var. integerrima Rehd. [ R. umbellata f. ovata (Briot) Schneider ] (Yeddo hawthorn).

<sup>2</sup>Since the preparation of this review a report was made that indicates apple may be slightly susceptible. R. W. F. Sewell and H. H. Glasscock (Plant Pathology 7: 76, 1958) isolated Verticillium from apple wood with discolored sectors on trees that bore dead blossom "trusses". Inoculation into young trees caused vascular discoloration but no wilting.



The plants were growing in two areas of the University of California campus at Berkeley and in a private garden. They showed "...unilateral dying of branches, yellowing, browning, and casting of lower leaves, and pronounced brown to black vascular discoloration."

Pear (Pyrus communis L.). In 1933, Wormald and Harris (139) reported that many young pear trees on the quince clonal rootstocks Malling types A and C "failed altogether" or the foliage on them turned yellow and withered. Discolored tissue was present in the wood of the stocks and V. dahliae was isolated from them. They suggest the stocks probably were diseased when they were planted for propagation of the pears but did not make any comment on discoloration in the wood of the scion nor fungous invasion of it. The same workers (140) in a later report described symptoms "characteristic of Verticillium wilt" in the rootstock just above the roots of 2-year-old pear trees on Malling Quince type C rootstock. They describe clearly delimited blue green discolored areas in the wood with fungous hyphae in the vessels and isolated V. dahliae from this tissue. Less than 1 percent of the trees in the nursery where this occurrence was encountered were said to have "succumbed". There is no mention of inoculation experiments in either of these two reports.

In 1931, Montemartini (89) at two sites in Italy observed pear trees on which during the summer the leaves became reddened. From one of these two sites he obtained material for study and found the wood affected by a tracheomycosis and isolated V. albo-atrum from this material. He stated that the fungus was localized in the wood of the main branches which bore the reddened foliage. Apparently, he did not find evidence of the fungus in the wood of the smaller branches. The rootstock on which these trees were propagated is not indicated and one, therefore, wonders whether it may be quince, the infection having originated in quince roots and moved part way up into the pear top. In any case, this appears to be the first report of Verticillium being obtained from pear wood itself.

In a report from Holland (7), the following statement appears "Anatasting door verwelke-ziekte, veroorzaakt door Verticillium dahliae werd constateerd bij perezailingen van het ras Drielse Groen." [Attack by the wilt disease, caused by Verticillium dahliae was diagnosed on pear seedlings of the variety Drielse Groen]. No further explanation is given in this report.

Blodgett and Twomey (14) suggest that Verticillium might be a factor in the very vexing problem of pear decline in Washington State, and Sprague (110) reported the isolation of Verticillium from pear roots. Sprague made isolation attempts by washing root tissue and planting pieces on agar. He considered Pythium debaryanum to be the most likely pathogen obtained. He obtained Verticillium sp. from approximately 10 percent of the samples, but this percentage was approximately the same whether the samples were from trees showing severe decline, moderate decline, or appeared to be healthy. Apparently Sprague did not make inoculations with these isolates and it may be that the isolates of Verticillium obtained were saprophytic forms. The method of isolation used would be likely to select fungi in the outer dead tissue, and according to Isaac (60), weakly pathogenic forms of Verticillium are better saprophytes than are the more strongly pathogenic forms.

Photinia villosa DC. There is a single report from Holland of the isolation of V. dahliae from this species, with no description of symptoms and no statement concerning inoculation tests (7).

Quince (Cydonia oblonga Mill.). In England, Wormald and Harris (139) isolated V. dahliae from discolored wood tissue in "quince layers" with wilting shoots, and, as already discussed, found that young pear trees failed on quince clonal stocks having discolored xylem. In a later report (141) the same workers described "defective" leaf development on Malling Quince C stock plants that had not been budded and observed greenish-black sectors in the wood in cross section. They isolated V. dahliae from this material. They were unable to isolate the fungus from the base of budshoots on budded stock plants similarly affected, but it is not stated whether the budshoots were of quince or pear.

In Belgium, Vanderwalle (116) found a yellowing and defoliation and general sickly condition of quince budlings in their first growing season. The wood was discolored, and a Verticillium was isolated with characters ascribed to V. dahliae. Affected budlings were scattered through the nursery plantings, indicating the possibility of the fungus having been introduced in the budwood. He considered there was evidence that affected material was brought in from France and from Holland, where the disease is known as "het zwart in de kwee" [the black in the quince]. Gaudineau (42) in a general paper on certain diseases of

fruit trees in France describes the disease caused by V. dahliae on cherry, peach, and quince. She states that individual branches wilt suddenly and yellowing and defoliation follow. In cross section, the branches of the trees show reddish-brown color in the vessels, but it cannot be certain that this description in its entirety applies to quince specifically. The paper contains no detailed description of experimental work, but there appears to be no question in the author's mind that V. dahliae causes disease on quince of the hadromycotic type.

Brien and Dingley (19) reported V. dahliae on C. oblonga in New Zealand.

## SYMPTOMS

The description of symptoms to follow refers primarily to stone fruits. For the very meager information available on symptoms on pome fruits the reader is referred to the preceding sections on the various species.

### Morphologic Symptoms

Symptoms on apricot and on peach are much alike and the following general description represents the development of the disease on these two species. Variations from this more usual symptom picture as they occur on other stone fruits will be described later.

Most writers agree that at first symptoms usually appear on only a part of the tree and may be limited to a single branch at that time. J. Dufrenoy (37) states that a tree may bear chlorotic leaves one year and during early summer the following year have large branches dry up one after the other. A sudden wilting early in the summer is common, although this may not occur until late summer (14). The onset of symptoms probably depends primarily on when water stress becomes acute. The leaves at bases of branches wilt, turn yellow and drop, leaving green leaves on the distal portion of the twigs. Most writers describe this as occurring progressively upward through the tree (67), but Hutton and Morschel (57) state that symptoms appear first on the "extremities" of lateral shoots and leaders. Cheney (26) states that in the year following extensive wilt and defoliation buds on affected branches fail to open and the branch dies, or the flower buds open and set fruit but the fruit drops.

Young trees, 1 to 8 years old, are most seriously affected, and rarely is a tree more than 1 year in the orchard killed entirely (67). This statement seems to hold in general, although over a period of years the tree may lose so much bearing surface from progressive death of affected branches that it becomes unprofitable.

On plum, Keyworth (70) observed that if the leaves were older when attacked they withered and turned brown, but the younger leaves wilted and remained green. Hochapfel (52) described the disease on plum, on which there was no wilt but all buds on older parts of the tree failed to open, the only leaves being on the 1-year-old shoots.

On sweet cherry McIntosh (81) describes a wilt on one or more spurs of the leaders, on 1-year-old wood, with the leaves faded green, and infrequent yellowing. This starts in the lower part of the tree and progresses upward and laterally. Blodgett and Twomey (14) describe similar symptoms, and state that they may appear in July or August. The tree becomes unthrifty, off color, has small leaves, poor fruit size, and recovery is less common on cherry than on apricot. Blodgett and Twomey describe considerable dieback and suckering on cherry, but they do not consider wilt and death of spurs in the main framework of the tree symptoms of the disease.

Most writers describe no necrosis in the bark of affected trees, but Curzi (29) indicates that on affected plum (P. domestica) the bark separates from the wood, and Dufrenoy and Dufrenoy (38) note that the bark becomes necrotic on apricot trees on plum rootstock. In these cases mycelium was observed in the xylem vessels, and it seems likely that direct attack by the fungus occurred only in the wood.

### Histologic Symptoms

Most writers agree that there is a brownish-black (greenish on quince) discoloration in the sapwood, in cross section appearing as arcs and dots. Usually more discoloration is observed in the wood of the trunk and main framework than in smaller twigs (57, 107). The discoloration is said to be darker in the older wood than in the young twigs (98).

For a full description of histologic symptoms on stone fruits and their development the reader is referred to Rudolph's monograph (104). Little has been added to our knowledge of the subject since that monograph was published.



## ECONOMIC LOSSES

Judging from the number of reports in the literature, apricot apparently is damaged more by *Verticillium hadromycosis* than is any other tree fruit species. Whether this is because of greater susceptibility or chance of inoculation cannot be determined with the information available. Hutton and Morschel (57) report that the disease was identified in New South Wales first on apricot in an orchard planting of 250 trees and when first determined in 1948, 32 trees had been killed and many more were seriously injured. Renouf (98) in the initial report from New Zealand stated that one-third or more of the trees had been removed in some orchards because of *Verticillium* wilt. Smith (107) indicates that it is increasing in New Zealand since its discovery there in 1945 but that the overall losses are still less than 1 percent. Wade (119) considers the disease serious on apricot in Tasmania.

It appears that generally *Prunus armeniaca* is more susceptible than the commonly used plum rootstocks because of the reports that the apricot top growing on a plum rootstock is killed and the understock continues to grow and produce new shoots. Numerous descriptions of this condition appear in European literature, among them Dufrenoy and Dufrenoy (38).

Mills (88) described an occurrence of *Verticillium* wilt in 2-year-old peach trees in which 32 of 45 trees were affected. June (67) finds the disease widespread on peach in the Hawke's Bay district of New Zealand. Various other reports of the disease on peach either do not emphasize its severity or indicate that it is of minor importance. Day (30) received conflicting reports from different nurseries concerning various kinds of trees growing on peach and other rootstocks. Some reported more *Verticillium* wilt on apricot and peach rootstock than on Myrobalan, while others reported more disease on trees growing on apricot and Myrobalan roots than on peach and almond.

McIntosh (81) described an occurrence of *Verticillium* wilt on 3-year-old sweet cherry seedlings in British Columbia in which 202 of the total of 220 trees in the planting were affected. An interesting feature of this outbreak was that no known susceptible crop had been grown on this land, as it had been maintained as a stone fruit planting with weed ground cover. Wilhelm et al. (132), on the other hand, reported the disease on sweet cherry trees propagated on both Mazzard and Mahaleb rootstock with symptoms similar to those described by McIntosh, but with no instance of concentrated occurrence such as he reported. This was true in spite of the fact that some of the plantings examined had been made where tomato had grown.

Plum rootstock (Myrobalan) apparently is rather susceptible. Rudolph (104) states that this rootstock often is made unfit for propagation purposes by *Verticillium* infection. Yet, although many reports of the disease on plum are found in the literature no clear statement indicating a serious occurrence on any of these species has appeared. Pollacci (93) stated that "tracheomycosis" was severe on plum as well as apricot. We cannot be entirely sure he meant *Verticillium* although this seems likely, and no figures are given. Then there is the statement by Day (30) previously referred to that some nurserymen reported more *Verticillium* wilt on apricot on Myrobalan rootstock than on peach or almond.

A few additional reports are available on the occurrence of the disease in nurseries, such as those of Wollenweber (137) and Day (30), neither of which provides any clear statement as to just how severe the disease may be.

Recovery from *Verticillium* wilt symptom expression appears to be rather common, but cannot be depended upon. Wade (119) suggests severe pruning of affected apricot trees to promote recovery, although the effect may be only temporary. Hutton and Morschel (57) indicate that less severely affected trees of apricot may make partial recovery after removal of affected branches but that their life cannot be predicted. Blodgett and Twomey (14) report that apricot may be killed but usually only part of the branches will be lost and that suckering from lower parts will rebuild the tree. It may be that suitable fertilization might help such trees, as has been reported for maple (111), but in most orchards this does not appear to be promising as a control measure.

Of particular concern is the fact that most reports indicate that it is the young trees -- less than 10 years old -- that are most likely to be affected.

#### Secondary Pathogens Add to the Injury

A discussion of economic losses would not be complete without a statement concerning other pathogens that may be enabled to attack a tree because of previous attack by the *Verticillium* wilt pathogen. M. Dufrenoy (39) in a general discussion of apoplexy of apricot indicated that so long as the cambium remains alive in trees containing infection by *Verticillium* they

can continue to grow. Rapid death of the tree or branches follows loss of the cambium, which may be caused by Verticillium itself or by secondary fungi or by insects that are able to attack because of the weakening by Verticillium. In another report from France (2), some of these secondary fungi are named as Fusarium, Coryneum, and Alternaria.

Willison (134, 135) found that Verticillium infection of peach was one of several factors that provided infection courts for the establishment of cankers caused by two species of Valsa. His data indicate, however, that "verticilliosis" was the least important of the several conditioning factors listed, it being responsible for 3 percent of the cankers examined in 1931 and 5 percent in 1932.

### Verticillium Hadromycosis and Winter Injury

Zeller (142), working with cane fruits, found that plants infected by this disease suffered greater injury because of low temperatures in winter than did uninfected plants. It seems likely, therefore, that diseased trees would suffer from winter injury, and probably that is the chief reason for the failure of buds to open as reported by several workers.

## ETIOLOGY

### Name and Classification of the Pathogen

It is not within the province of this review to attempt to settle the question of classification of the species of Verticillium involved in hadromycosis. Rudolph (104) gives a thorough discussion of the question up to the time of his review.

Most reports of Verticillium hadromycosis of tree fruits list V. albo-atrum or V. dahliae as the cause, with the latter probably being mentioned the more frequently. This question is pertinent because of the importance of microsclerotia to persistence of the fungus in the soil. That is, the chief difference given between the two species is that V. dahliae produces microsclerotia and V. albo-atrum does not (71). Recent workers who have given attention to this question and who favor retaining the species V. dahliae as distinct from V. albo-atrum include Berkeley et al. (12), Isaac (59), and Robinson et al. (102). Papers in which the view supporting combination V. dahliae with V. albo-atrum is expressed include Wollenweber (137), McKeen (83), Wilhelm (122), Presley (94), and Caroselli (21).

The influence of temperature on growth and distribution of the pathogen is significant. Robinson et al. (102) found that the resting-mycelium type had a lower temperature maximum for growth than did the pseudosclerotial type, and that the former was the only form found on potato in Wisconsin and eastern Canada while the latter only was found in Idaho. Previous reports have stated that the forms that produce microsclerotia have the higher temperature relations of the two types (59, 79). Edgington (40) found the same relation.

Reports of differences in pathogenicity among different isolates of Verticillium are frequent in the literature, and these differences often are correlated with differences in the resting bodies, microsclerotia, resting mycelium, and chlamydospores (63, 79, 94). The most recent of these papers, by Isaac (63), presented evidence that V. albo-atrum was the most pathogenic of five species tested, V. dahliae was next, and the other species required special nitrogen nutrition to produce a pathogenic reaction.

This whole question of designating the forms of Verticillium that cause hadromycosis and wilt in tree fruits is of considerable importance because of the differences among them in pathogenic relations, persistence in the soil, and other characters. The factors just mentioned will serve as examples of the need for an adequate and usable means of identification of these different forms. It may make little difference whether they are given specific rank or are described as forms within a single species, as suggested by Presley (94). One of the greatest needs in the study of Verticillium hadromycosis is for a careful, thorough investigation of this question, using controlled cultural conditions. If factors such as temperature, pH, nutrients, and light influence the production of morphological structures of any single form, it seems that with uniform controlled conditions it should be possible to establish procedures for distinguishing the different forms (102). If such a study were made, a means of determining forms whenever the need arises would be available.

### Life History of the Pathogen

Source of Inoculum. Statements in the literature that the disease in tree fruits is associ-



ated with previous or concurrent growing of susceptible herbaceous crops are so numerous that contrary experience is out of the ordinary and worth mentioning. Outstanding among such reports is the one by McIntosh (81), who reported a very severe outbreak on sweet cherry in a field in which no susceptible crop had been grown. The field had been maintained in weed cover, which may account for the high percentage of infection in the trees.

Hutton and Morschel (57) inoculated tomato plants growing adjacent to young stone fruit trees and infection developed on apricot and almond trees within 12 months. The literature contains many references to studies indicating that debris from diseased plants incorporated in the soil will build up inoculum. Blank and Leyendecker (13), for example, applied diseased cotton stalks to the ground at different times of the year and immediately plowed the ground and at the same time plowed adjacent untreated soil. Disease-free cotton seed was planted in April. Up to 95 to 99 percent infection occurred in the ground where the diseased cotton stalks had been plowed under and none occurred in the check plots. Wilhelm (126) failed to find *V. albo-atrum* in the rhizosphere of diseased tomato plants or on the plant roots, but in an earlier study (123) he found that on the death of infected plants the fungus invades the pith and cortical tissue and produces microsclerotia there. He reported survival of the fungus for as long as 14 years in one case in soil that had been continuously planted to grains and pasture, and he suggested that the carry-over probably was in the form of microsclerotia. Keyworth (69), working with hop, incorporated diseased bines and soil from diseased plants in clean soil, then made new plantings. Infection where the diseased bines were used as inoculum was 10 times that where soil from diseased plants was used. Wilhelm (123) and others have suggested that microsclerotia or plant debris -- probably containing microsclerotia -- may be blown about by the wind and infest new areas, or at least new areas within a given field.

**Inoculation.** Surprisingly little study has been made of the natural mode of inoculation and infection with these fungi, particularly on trees. Berend (11) described a small scale experiment in which young apricot seedlings were potted in artificially infested soil and later wounded (method not described), with other seedlings planted similarly but not wounded. Infection developed only in the wounded trees. It is significant that most reports of *Verticillium* hadromycosis state that infections usually occur in young trees, up to 10 years old but mostly within the first 2 or 3 years from planting. It seems probable that many of the infections are the result of invasion through wounds present on the trees at planting time. It is common practice to make fresh cuts on many roots at the time the trees are planted, to remove dead and broken roots and to shape the root system. This may not be good practice. In fact, it has been found experimentally with another pathogen, the crown gall organism (54), that less infection results if any root-pruning needed is done before time to plant and time is allowed for healing before the trees are planted.

On the other hand, Isaac (58), working with *Verticillium* infection in sainfoin [*Onobrychis viciaefolia*], obtained evidence that artificial wounds may not be necessary. He inoculated unwounded roots of small seedlings growing in nutrient culture and studied the development of infection microscopically. He illustrates apparently direct mechanical penetration into root hairs, through the root-cap region into the vascular tissue, and through wounds made by the emergence of lateral roots. He did not follow development of the infection further and there may be some doubt whether extensive invasion of the plant occurs by this means. Furthermore, there is no assurance that infection would occur in this manner under field conditions.

Hutton and Morschel's experiment already described (57) indicates that symptoms may develop on apricot within 1 year or less of the time of inoculation with *V. dahliae*. Since trees are known to recover from symptom expression it would not be surprising, on the other hand, for a delay to occur in the initial expression of symptoms.

**Propagation with Diseased Material.** Vanderwalle (116) suggested that the *Verticillium* hadromycosis pathogen may be carried over into new quince trees in the scionwood. Apparently he did not test the point experimentally, and while other reports of the disease in nursery trees exist no others encountered in this study suggest this means of increase.

Working with roses, Dimock (33) obtained ample evidence that infection on rose plants may be readily obtained by budding with budwood from affected plants. One bud developed into a shoot after serving as inoculum for the plant. Raabe and Wilhelm (95), also working with rose, obtained comparatively high percentage infection by budding with a contaminated knife. A lower percentage infection was obtained by brushing the wound made in removing the stock above the inserted bud 1 month after budding. Likewise, a low percentage of infected plants resulted from the use of buds from infected plants for propagation. More study is needed on

this point, but according to present evidence some possibility exists that fruit trees might be infected if buds for propagation are taken from affected trees.' The relative importance of this source of infection remains to be determined. The question is sufficiently important that a study should be made, taking into account the fact that preventing this means of transmission in nursery practice might add to the expense, and nurserymen cannot afford to follow expensive unnecessary practices.

Inoculation in Pruning. Dochinger (34, 35) was able to transfer the fungus from diseased to healthy maple trees by pruning, with 10 percent infection. Joessel (65) found discolored wood tissue associated with the cut made in removing the top of the stock in nursery trees and isolated *Verticillium* from this tissue. It will be recalled, however, that Raabe and Wilhelm (95) obtained comparatively high percentage infection by budding with a contaminated knife and a low percentage infection by inoculating the lopping cut. The difference may be because the wound made in budding is covered and wrapped to prevent drying out whereas the lopping cut is left open, as in ordinary pruning.

Saprogenesis. McKay (82) found that the fungus lived for 1 year in potato tops buried in soil, but did not obtain evidence of longer persistence. It took more than a 2-year rotation, however, to obtain effective control. Zeller (142), working with raspberry, obtained evidence that infection would progress down the row by root contact after there was time for infected roots to die. Citing McKay's (82) demonstration that roguing of potatoes increased infection on the remaining healthy plants, Zeller postulated that this was because live infected roots were broken in the roguing process. Because the broken roots died more quickly the fungus was able to grow out of them sooner than from intact diseased roots. Keyworth (68) found that the pathogen produced spores in abundance on leaves, stems, and branches of "moribund" plants.

Roberts (101) made an experimental investigation of the hypothesis that the fungus remains within the host plant until after death of the plant. He planted a diseased tomato plant in the center of a crock with four healthy plants around it. After the plants were established he ringed the stems of the diseased ones in part of the crocks. Symptoms appeared sooner in the originally healthy plants in these pots, and a higher percentage eventually became infected than in the pots with the non-ringed diseased plants. He stated that all ringed diseased plants died, but did not comment on the non-ringed ones; presumably they survived.

Luck (78) found that in muck soil the fungus persists at least 4 years (the length of the study) in the absence of known hosts. He reported greenhouse studies showing that survival is not due to saprophytic growth of the fungus but to persistence of microsclerotia. The mycelium and spores did not persist for longer than 5 months. Wilhelm (128) found a light "infection index" in soil from a field planted to tomato once, then to grains and pasture for 8 consecutive years. After 6 additional years, he still was able to demonstrate the presence of the fungus in the soil.

Isaac (60) made an interesting study on the question of survival of different forms in the soil. He added pure cultures grown on wheat grain to the soil and made isolations at intervals. The more pathogenic forms were not recoverable after 6 months, while less pathogenic forms were recovered after about twice as long a period. His suggestion that the more pathogenic forms could not compete with the other soil microorganisms, whereas the less pathogenic forms were better able to compete and to grow saprophytically, seems reasonable. It was interesting that in comparable isolations after long periods in the soil the pathogenic forms took longer to produce measurable growth in the cultures than did the less pathogenic forms. This longer growth period corresponded with the time it took for growth from microsclerotia, and Isaac suggested that the pathogenic forms were present in a resting stage only, whereas the less pathogenic forms occurred in the resting stage and also in the mycelial and conidial stages, having continued to grow saprophytically.

## EPIPHYTOLOGY

Soil Factors. Isaac (62) made a thorough literature review on soil factors, particularly moisture, pH, and plant nutrient supply. He concluded that the moisture relations are "very obscure", but his own studies in pot culture with *Antirrhinum* indicated strongly that in dry soil infection is less than in moist or wet soil. Isaac inoculated his plants by adding inoculum to the soil. Caroselli (21), using a more artificial method of inoculation, one that should be more likely to furnish 100 percent infection, obtained more wilt with a lower water content in



the soil than with more moisture. In Caroselli's experiments the influence of soil moisture probably was on development of wilt in the diseased tree whereas in Isaac's work there may have been more influence on the initiation of infection. Nelson (91), working with mint planted in pots in infested soil, obtained a particularly interesting result. With the soil moisture content maintained at a pre-determined level by weight, he obtained more severe disease development at 70 and at 100 percent water-holding capacity than at the intermediate level of 80-85 percent.

Isaac (62) found less disease development with additions of potassium and with the use of ammonium sulfate as the nitrogen source. Caroselli (21), working with maple trees, obtained less disease with use of all forms of nitrogen except sodium nitrate, ammonium sulfate being the most effective. It seems possible that this effect might have been due to a pH relation, since a substantial body of experience indicates less disease on acid soils, although Wilhelm (124) concluded that the disease was not greatly affected by pH within the usual range in California soils. Haenseler (50) working with eggplant, obtained less disease development with the application of sulfur to the soil, without evident injury to the plant, but stated that he did not consider this a practical method of control because the required pH level is too low.

Temperature appears to be rather important, with little or no development at a soil temperature of 85° F or above (106). Wilhelm (123) stated, however, that in unpublished work James Howard, working at the University of California, determined that microsclerotia could withstand a temperature of 120° F for several months. Edgington (40) found a slightly lower temperature range for the non-microsclerotial type than for the microsclerotial type. He indicated that soil temperature was more important than air temperature. For that reason, it seems unlikely that temperature will reach a high enough point to prevent, or perhaps even retard, development of the disease in fruit trees in the Northeast. At the level of most tree roots the temperature has been found rarely, if ever, to reach 85° F even in the hottest days in unusually warm seasons. On the other hand, the higher temperatures and brighter light during the summer create a greater demand for water and, therefore, wilt is more likely to develop in middle or late summer than in early summer.

Antibiosis. Along with several other fungi, Ark and Hunt (8) found that V. albo-atrum may be antagonized by Bacillus vulgatus and an unidentified bacterium in pure culture. Arnstein et al. (9) found that musarin, an antibiotic produced by actinomycetes, inhibits V. albo-atrum and V. dahliae at very high dilution. Leben et al. (75) prevented growth of V. albo-atrum in culture with helixin extracted from an actinomycete in the soil. Holmes (53) inhibited growth of Verticillium sp. in culture with eight of 16 antibiotics tested.

Nelson (91) found that when the fungus was permitted to colonize sterilized soil it caused more wilt in mint planted in the soil than when it was added to natural soil, and he suggested an antibiotic relation. Wilhelm (127) found that several fungi, including Gliocladium roseum, added to sterilized soil checked the growth of Verticillium or destroyed it. Wilson (136) found V. albo-atrum to be a very poor competitor in muck soil, and obtained control of the disease on tomato with antagonistic fungi. Isaac (61) obtained Blastomyces luteus as a contaminant in isolating Verticillium, and was able to reduce infection by adding Blastomyces to the soil which was later infested with Verticillium as a means of inoculating plants. Caroselli (21) extracted metabolites that were antagonistic to V. albo-atrum in culture from a soil actinomycete and from Bacillus subtilis, a common inhabitant of soil.

Wilhelm (125) obtained a lessened disease development by addition of various amendments to the soil, including ammonium sulfate and organic nitrogen sources, and also barley straw. He suggested that, since microsclerotial production is greater in winter when conditions are unfavorable for activity of soil microflora, the pathogen is most vulnerable to competing organisms when the soil temperature is high. The same author (127) was able to inhibit establishment of Verticillium by colonizing other fungi on the tomato straw used as a substrate.

Verticillium Hadromycosis and Nematodes. McClellan et al. (80), working in a field heavily infested with the root-knot nematode (Meloidogyne), fumigated the soil with a moderate dosage of ethylene dibromide and obtained improved growth of cotton, apparently as a result of nematode control, but observed no influence on Verticillium infection. The incidence of wilt was about equal in treated and untreated plots, approximately 80 percent. De Segura and Aguilar (32) found that in an area with a light infestation of root-knot nematodes substantial reduction in growth of cotton occurred if V. albo-atrum was present along with the nematodes. They do not comment on the influence of the nematodes on fungous infection, however, and the difference in growth found may be due primarily to an additive effect of the two organisms.

McKeen and Bosher (84) controlled *Verticillium* wilt on strawberry by fumigation with methyl bromide but failed with ethylene dibromide. They were working in an area where root lesion nematodes were present, but did not comment on nematode control. When they autoclaved the soil and added *Verticillium* inoculum to the soil, infection was readily obtained without wounding the plant roots.

There seems to be no evidence, therefore, that lesions made by nematodes provide infection courts for the *Verticillium* wilt fungus, although damage to the plants by the two types of organism may be additive. The results of McClellan and his associates constitute evidence that there is no synergism such as, they point out, has been shown for nematodes and *Fusarium* wilt of cotton.

Special Case of Alfalfa. Alfalfa has been included in lists of crops that may be used in rotations to reduce soil infestation with *Verticillium*. Morvan (90) associated *Verticillium* sp. with apoplexy of apricot in trees planted in old lucerne fields as well as where potatoes, tomatoes, and strawberries had been grown. Wollenweber (137) named a new form, *V. albo-atrum* var. *chlamydosporae* f. *angustum*, obtained from alfalfa. Various reports indicate that *Verticillium* wilt is of some importance in lucerne, it having been described further in Germany (99, 121), in Holland (7, 112), and in England (92). Isaac (64) considers that both *V. albo-atrum* and *V. dahliae* may attack lucerne, and Richter and Klinkowski (99) inoculated lucerne successfully, but none of these reports contain any reference to cross-inoculations of lucerne with isolates from other plants. There still is some question, therefore, whether the fungus attacking lucerne is the same one that attacks other hosts.

Soloveva and Polyarkova (108) observed that cotton following lucerne was affected less by *Verticillium* wilt than when growing under other conditions, but found cereals to have a similar effect. These workers suggest it is merely a matter of the lucerne not being susceptible. They did not find the disease on lucerne planted in infested soil.

Kononenko (72) presented strong evidence that *V. dahliae* could be lysed by bacteria obtained from many soils or by bits of the soil itself. Brodsky (20) found a high population of infusoria in lucerne soils and was able to prevent growth of *V. dahliae* by adding the infusoria to the cultures. Lysis of the fungus resulted in cultures where the fungus was allowed to grow before adding the infusoria. Control experiments with infusoria added to culture solutions and to soil gave favorable results. There seems to be some question whether this effect is caused by the infusoria or by bacteria that accompany them, but tests with the bacteria alone were not so favorable as when the infusoria were included with the bacteria, or when infusoria were added and an attempt was made to exclude the bacteria. Verner et al. (118) present evidence that *V. dahliae* and other fungi are reduced in soil by infusoria and bacteria.

Leont'ev (76) watered chrysanthemum plants with nutrient solution containing the infusorian *Colpoda saprophila*, the common one in lucerne soils, and obtained complete protection against infection with *V. dahliae*. The addition of bacteria to this material had no added effect, but control with the infusoria alone was complete.

Kublanovskaia (74) found that under cotton culture *Verticillium* accumulated in the soil and the development of mycolytic bacteria was suppressed, and that alfalfa had just the opposite relation.

## CONTROL

### Cultural Methods and Care of Trees

Rotation and Sanitation. The prevention of infection by sanitation measures is the most effective means at our disposal for control of this disease in fruit trees. Since the fungus is very generally distributed (87) in the soil, and since apparently a substantial build-up in inoculum is necessary before a significant number of infections are to be expected, avoiding the growing of susceptible crops before or after planting the trees appears to be very effective under most conditions. Many, and probably most, writers on the subject suggest that this be done, and the most common crop listed to be avoided is tomato. In fact, Hesse (51), who lists other susceptibles as well, in writing about apricots makes the statement that certain other crops named are less dangerous than is tomato because they "seem to develop strains of *Verticillium* which are not likely to cause black heart." In the present state of knowledge, however, it is not safe to plant stone fruits after or concurrently with any crop that is susceptible to *Verticillium*. Those most likely to be encountered in northeastern United States include tomato, potato, pepper, eggplant, strawberry, and raspberry. The host range is so wide that it



would not be feasible to make a complete list.

Unfortunately, severe outbreaks have occurred in the absence of other susceptible crops (81), and the writer has encountered the disease on a number of occasions in trees interplanted in old orchards. Weeds appear to be the most likely cause of the build-up of inoculum in these cases. Smith (107) lists Chenopodium album as common in affected orchards, particularly orchards where tomato had not been grown. He implied that this weed most likely had served to build up the inoculum.

For orchard conditions, Smith (107) recommends that clean cultivation be practiced to keep down weeds and that cereals, grains, and clover be used as cover crops. Also, of course, he cautions that susceptible crops should not be grown as intercrops in the orchard. He further suggests that an area known to be infested be sowed to grass 2 to 4 years before planting again to a susceptible tree species, such as apricot or peach. He suggests that when an annual crop develops the disease, the plant debris be removed as thoroughly as possible. His 2- to 4-year figure between growing of the susceptible crop and planting of a susceptible tree species agrees with many recommendations on other crops for a rotation, while the suggestion that infected plant debris be removed seems particularly pertinent for trial when an orchard planting is contemplated following a susceptible crop and the grower cannot afford to wait several years. Zeller (142) found that two intervening crops (oats and vetch) between plantings of susceptible raspberry or potato gave satisfactory control but that a 4-year rotation was better. Wilhelm (129), however, studied this question by means of his "infection index" technique. He obtained a fairly high index in fields with up to 5 years intervening between the last tomato crop and the index test. With 8 years or more intervening the index was consistently low, with a correspondingly low strawberry plant loss.

Engelhard (41) provides a very thorough list of susceptible crop plants and weeds. Of the weeds listed the following may be named as frequently encountered in New York State orchards: Amaranthus spp., Chenopodium album L., and several species of Solanum.

With the tendency toward the use of some type of non-cultivation in orchards it seems reasonable that a grass or perhaps grass plus clover or alfalfa sod might be used after the trees are well established. During the first few years when the orchard is cultivated it should be kept clean of all weeds until mid-summer, when a non-susceptible cover crop may be planted.

Antibiosis in the Soil. Alfalfa has been found to be susceptible to Verticillium, but since practical experience with this crop in the rotation still seems to be favorable and reports from Russia indicate a clear antibiotic relation with alfalfa, this crop should be reexamined. Perhaps under many conditions the build-up of antagonistic microorganisms on its roots will prevent development of Verticillium spp. in spite of its susceptibility to the fungus.

A promising field for study is the encouragement of the development of antagonistic organisms in the soil. For example, Wilhelm (127) found that Verticillium failed to grow when introduced into natural field soil, grew vigorously in autoclaved soil, grew moderately well in soil treated with chloropicrin, and grew very poorly in soil treated with ethylene dibromide. This could all be explained by the presence of antagonistic fungi. The natural flora in the untreated soil would prevent all growth, the autoclaved soil would contain no other fungi, at least at first, and the soil treated with chloropicrin would have a reduced fungous population as contrasted with that treated with ethylene dibromide, a comparatively poor fungicide.

Soil Fumigation. Wilhelm (130) reported very good results with chloropicrin as a soil treatment for control of Verticillium wilt on strawberry. This material was first reported as effective by Godfrey (45). In an earlier report, Wilhelm and Ferguson (131) found chloropicrin somewhat more effective than chlorobromopropene, a material with which favorable results have been obtained (49, 73). McKeen and Bosher (84) obtained good results on strawberry with methyl bromide but poor control with ethylene dibromide. They state that lesion nematodes were present in the soil and, therefore, it cannot be certain whether ethylene dibromide failed because of lack of fungicidal action or because of poor nematocidal activity.

Any of these treatments should be tested in combination with various soil amendments to improve physical structure, antibiotic activity, and tree vigor. A chemical is needed that is more selective, one that will reduce infestation by Verticillium wilt fungi without destroying antagonists. For example, Nelson (91), working with mint, found that soil treatment with chloropicrin and other chemicals failed to control wilt, and in most cases actually increased it. He also found that more wilt occurred in steamed soil than in natural soil when both were artificially infested with Verticillium. He attributes this result to antagonists in the non-steamed

soil. It may well be that the chemical treatment reduced the population of antagonistic organisms more than that of the Verticillium.

Root Treatment. No reports of direct experimental work with trees have been encountered, but because of the strong probability that many infections occur through cuts made on the roots at planting it seems worth while to reexamine suggestions made in earlier literature that the roots should be treated by dipping in a disinfectant solution (109). This measure should be preceded by soil treatment with formaldehyde. Perhaps with newer materials such a procedure would be more effective.

Fertilization and pH. Apparently, proper fertilization might be expected to improve the chances of recovery of affected trees. Caroselli (21) cites work of others, and describes experiments of his own in which nitrogen fertilization appeared to reduce wilt development in maple. Work on other crops, already discussed, sometimes indicates a reduction of wilt with addition of potassium and with certain forms of nitrogen. Probably the balance of nutrients, as well as the form, is a factor here. Until more study is made on trees the only recourse is to maintain a good nutrient supply with the best balance known. Many affected trees probably will recover and make nearly normal growth under such conditions.

As already discussed, wilt is usually reported as less prevalent where the pH of the soil is lower, but there are certain conflicting reports. Furthermore, the change in pH required to achieve reduction in wilt is so great that pH adjustment does not seem feasible as a control measure.

Pruning and Wood Treatment. As noted earlier, there seems to be little danger of infection from inoculum carried on pruning tools. Much of the pruning is done when the temperature is too low for fungus growth, and the cuts are made smoothly which provides for rapid drying. Here again, in the absence of definite evidence, the practical operator cannot afford to spend a lot of time to prevent something that is unlikely to occur anyway.

Several authors suggest cutting out affected branches of trees. This seems to be usually a question of removing dead wood and branches weakened by the disease, but Gayford (43) suggests removing affected branches below the last sign of browning in the wood. He seems to imply that all of the infection may be removed in this manner. Wade (119) makes a similar suggestion, but states "... in many cases the disease enters through the roots, and the infection cannot be cut out." In this situation, probably more common, pruning accomplishes primarily the removal of weak branches that would be unlikely to recover.

#### Exclusion

This section refers primarily to planting only healthy trees in the orchard. Nursery trees should not be grown in fields where susceptible herbaceous crops have been grown. The possibility of the fungus being carried in the budwood should be examined, but until this is demonstrated to be a factor the practical grower cannot afford to take it into account. The propagator can avoid obviously affected trees in taking budwood, however.

#### Resistance

Resistance offers little help toward control of this disease on fruit trees. Most infections occur through the roots, and therefore the susceptibility of the rootstock largely determines severity of attack on the tree. As an extreme example, pear trees on quince rootstock may be killed, but it is doubtful that pear growing on a rootstock of a species of pear will be severely affected. The quince rootstock, however, is the only one available that is suitable for growing dwarf pear trees. For this reason it could not be given up as a rootstock for pear.

Plums growing on peach rootstock probably would be more severely affected than if they were on plum rootstock, but the peach is not a good rootstock for plum for other reasons also, and at least in the Northeast is not used extensively. On the other hand, peach on plum rootstock may be killed by *Verticillium* wilt, leaving the rootstock itself alive. Possibly, also, somewhat fewer infections of peach would occur on plum rootstock than on peach rootstock (30), but the peach is less expensive than plum rootstock to grow and generally provides a better root for the peach tree. Day (30) also reported *Verticillium* wilt as more severe on apricot on peach root than on Myrobalan. He reported it severe on apricot on apricot rootstock. He stated that apricot makes a better bud union on both peach and apricot rootstocks than on



Myrobalan. It seems, therefore, that the rootstock-scion combination is such a complex relationship that there is little chance to take advantage of resistance or tolerance to Verticillium in the selection of a rootstock. While control of this disease on stone fruits is far from satisfactory, measures such as sanitation, rotation, and cultural treatment seem to offer more immediate promise for study than does resistance.

On the other hand, in the case of avocado Zentmyer et al. (143) found the commonly used Mexican rootstock to be much less susceptible than the Guatemalan rootstock and suggested that the disease could become a serious problem on avocado if more use were made of the highly susceptible stocks. On a long term basis it might be worth while to examine the possibility of resistant rootstocks for the stone fruits.

## DISCUSSION

There is ample evidence that Verticillium spp. may cause serious disease on many species of Prunus, but there is a great need for tests by direct inoculations to determine relative susceptibility. The symptoms of hadromycosis, however, are sufficiently diagnostic that most reports of disease occurrence can be accepted without reservation, particularly if the pathogen is isolated.

Verticillium hadromycosis, therefore, appears to be a disease that is potentially very serious on most or all species of stone fruits grown for commercial fruit production. It is endemic in most or all parts of the world where stone fruits are an important commercial crop and reaches epiphytotic proportions in some orchards. With such wide differences in incidence on neighboring farms (88) careful study of natural occurrence should yield valuable information on conditions that favor the disease and furnish suggestions for trial of measures to prevent severe outbreaks. Such a study could take advantage of the wealth of information in regard to Verticillium hadromycosis on other crops.

Among the pome fruits, the evidence is strong that quince (Cydonia oblonga), Photinia villosa, and the two species of Raphiolepis named are susceptible to hadromycosis caused by species of Verticillium, although experimental proof appears to be lacking. In these cases, however, the symptoms, both morphologic and anatomic, seem much like those described for certain of the stone fruits for which experimental evidence is ample. The fungus isolated from affected xylem tissue of these four pome fruit species appears identical with that isolated from proved hosts, although in no case were inoculations made to the same or to other species.

For pear the evidence is less convincing except that budlings on quince rootstock, of course, fail to survive or at least do not make satisfactory growth when the rootstock is affected. The report by Montemartini (89) is strongly suggestive but should be checked by inoculation experiments. The symptoms described do not resemble so closely those on stone fruits attacked by this fungus as do the symptoms on quince. On apple, the evidence is still less convincing. There is only one report of the isolation of any form of Verticillium from discolored wood in Malus pumila and inoculations failed to cause wilt.

It would be wise for practical purposes to consider the common quince, Raphiolepis spp., and Photinia villosa as susceptible. The chances of apple and pear being susceptible to this disease hardly appear to warrant consideration by the practical grower unless additional evidence is obtained.

Verticillium wilt is a disease of stone fruits that does not receive the attention it deserves. It is less common, of course, than such diseases as leaf-spot, brown rot, and some of the virus diseases and is frequently lost sight of. Unfortunately, sometimes individual orchards suffer very severe losses, particularly when the trees follow crops of tomato. Scattered occurrences in situations other than those associated with susceptible herbaceous crops may not be noticed at all or are diagnosed incorrectly. Often a grower could avoid losses by comparatively simple precautions, and the chief reason he does not follow a better practice is that he is not aware of the problem.

## SUMMARY

All important commercial species of stone fruits are susceptible to Verticillium hadromycosis. No carefully controlled experiments have been made on differences in susceptibility but general experience gives us some rough comparisons. In the Northeast cherry and peach are damaged more than is plum. Elsewhere, almond and apricot also are highly susceptible. Among the pome fruits and related species, the common quince appears to be susceptible, as are two species of Raphiolepis and Photinia villosa. Possibly pear and apple are susceptible but only slightly so.

Apparently most severe outbreaks on stone fruits could be prevented if such trees were never planted following susceptible herbaceous crops, although there have been a few reports of severe incidence of the disease in the absence of such crops. Evidence indicates these outbreaks are most likely accounted for by susceptible weeds. A type of culture should be adopted that is capable of keeping such weeds under control because the fungus probably is carried into new fields in plant debris by winds and may build up there if susceptible herbaceous plants are present. Common weeds that have been named in this connection include Amaranthus spp., Chenopodium album, and Solanum spp.

If trees must be planted where susceptible crops have been grown in the immediate past presumably infection in the trees will be less if all possible plant debris is removed rather than plowed under.

Good cultural treatment should improve the ability of infected trees to recover. The possibility is discussed that antibiotic action in the soil as an aid in the reduction of amount of inoculum might be encouraged by growing suitable crops. Research is needed on this point.

Chemical fumigation of the soil has been disappointing and probably practical results depend as much on the influence of the fumigant on antagonistic fungi as on direct destruction of the wilt pathogen itself.

Resistance is not promising as a means of control of *Verticillium* wilt on fruit trees. Wide differences in susceptibility exist among species but closely related sorts do not appear to possess great differences. One species may be more severely affected when propagated on one rootstock than on another, but usually other considerations are sufficiently important that the grower could not afford to discontinue the use of the susceptible rootstock for this reason alone.

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# THE PLANT DISEASE REPORTER

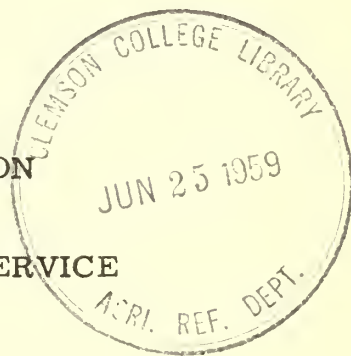
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CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

ROOTROT AND RELATED LITERATURE  
AN ANNOTATED BIBLIOGRAPHY, 1958



Supplement 256

June 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

ROOTROT AND RELATED LITERATURE  
AN ANNOTATED BIBLIOGRAPHY, 1958<sup>1</sup>

The Staff<sup>2</sup>

Plant Disease Reporter  
Supplement 256

June 15, 1959

INTRODUCTION

To facilitate rootrot research, to emphasize its importance as a distinct entity in plant pathology, and also to help to avoid unnecessary duplication of effort in searching the literature, the following annotated bibliography has been prepared from references appearing in periodicals published in 1958.

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<sup>1</sup>Contribution No. 2, from the Research Station, Research Branch, Canada Department of Agriculture, Harrow, Ontario.

<sup>2</sup>L. W. Koch, Director; A. A. Hildebrand, C. D. McKeen, Z. A. Patrick, R. N. Wensley and N. J. Whitney, Pathology Section; W. B. Mountain, R. M. Sayre, Nematology Section; and H. R. Boyce, Entomology Section.

## ACTINOMYCETES

See also 53, 68, 77, 99, 120, 121, 407, 679

1. EICHINGER, A. Kartoffelschorf und Oxalsäure. (Potato scab and oxalic acid.) Z. Acker-u. PflBau 105: 451-458. 1958. (Rev. Appl. Mycol. 37: 555. 1958.)  
This is a study of changes induced in the skin of potato tubers by deposits of Ca cations as related to infection by scab (Streptomyces scabies). A schedule of soil amendments is recommended, based on the hypothesis that the oxalic acid produced by the plant is the strongest inactivator of these ions. Synthetic fertilizers containing Mg and Na should be excluded, since their ions compete with those of Ca for oxalic acid. It is thought likely that resistance to scab is influenced by the capacity of different varieties for oxalic acid formation.
2. ELLETT, C. W. Bacteria parasitic on plants in Ohio. Ohio J. Sci. 58: 145-149. 1958. (Rev. Appl. Mycol. 37: 639. 1958.)  
Included in this list is Streptomyces scabies on beet, radish and potato.
3. GUNTZ, M., and M. COPPENET. Essais de traitements contre la gale commune de la pomme de terre. (Spray trials against common scab of potato.) Phytiatric-Phytopharm. 6: 187-195. 1957. (Rev. Appl. Mycol. 37: 555-556. 1958.)  
To control Streptomyces scabies on potato the soil was treated with a number of organic and inorganic compounds. The only treatments giving results that justified the expense involved were sulphur and PCNB.
4. MARTIN, W. J. Reaction of sweet potato varieties and seedlings to soil rot. Phytopathology 48: 445-448. 1958.  
Studies on varietal reaction to soil rot of sweet potato, incited by Streptomyces ipomoea (Person & W. J. Martin) Waks. & Henrici, have shown rather clear-cut differences among varieties, selections, and breeding lines, ranging from susceptibility (in Unit I Porto Rico, the principal variety planted in Louisiana) through some degree of tolerance (in the Heartgold and Acadian varieties) to considerable resistance (in certain other selections and breeding lines).
5. McKEE, R. K. Assessment of the resistance of potato varieties to common scab. Europ. Potato J. 1 (1): 65-80. 1958. (Rev. Appl. Mycol. 37: 505. 1958.)  
At the Nottingham University School of Agriculture a number of imported potato varieties resistant to common scab (Streptomyces scabies) were compared with a number of British ones. Techniques of soil inoculation and methods of rating scab are described. Results of greenhouse and field trials were closely parallel. The periderm test was used in most cases in the separation of resistant from susceptible varieties. A number of isolates of the pathogen were found to differ greatly in respect of virulence but there was no evidence of physiological specialization.
6. PHILLIPS, D. H. Report of the Mycological Department. Rep. States Jersey, 1956, 39-44. 1957. (Rev. Appl. Mycol. 37: 261. 1958.)  
This report notes that common scab (Actinomyces (Streptomyces) scabies) was unusually prevalent on potatoes.
7. PIERINGER, A. P. A greenhouse method for determining the disease reaction of potato seedlings to common scab caused by Streptomyces scabies (Thaxt.) Waks. & Henrici. Diss. Abstr. 17: 5. 1957. (Rev. Appl. Mycol. 37: 307. 1958.)  
Equal parts of vermiculite and normal potting soil infested by S. scabies was superior to infested normal soil as an infection medium in testing for resistance. There was a good distribution of the organism in the soil. Gives the effect of vermiculite, under wet and dry conditions, on the viability of S. scabies. Also, gives effect of long periods of high day-time greenhouse temperatures on viability. The type of tuber periderm was a measure of the resistance to the disease.

8. TURNER, P. B. The effect of calcium-potassium ratios on the incidence of potato scab. Diss. Abstr. 17: 1441-1442. 1957. (Rev. Appl. Mycol. 37: 417. 1958.)

This work was done to determine the effect on the incidence of potato scab of added increments of potassium and zinc. When, in 1951, the Ca-K ratio approached unity, Katahdin potatoes gave increased yields and were less affected by scab. The 1952 data, however, did not confirm this trend. 1953 results confirmed 1951 data. Zinc had no effect on scab or on yield. In the greenhouse, lime in bands at 9-inch depth did not reduce scab or increase yield of Chippewa potatoes at either of two pH levels, but tubers at pH 5.6 with 1000 lb. lime/acre mixed throughout the top 9 inches were the freest from scab and the largest harvested.

#### ANTIBIOTICS

See also 394, 624, 687

9. ABO-EL-DAHAB, M. K. Effects of certain antibiotics on representative phytopathogenic bacteria with special reference to *Pseudomonas solanacearum*. Diss. Abstr. 17: 2391-2392. 1957. (Rev. Appl. Mycol. 37: 520-521. 1958.)

The reactions of 34 species and strains of phytopathogenic bacteria to 10 antibiotics (names given) were investigated. Description is given of reactions of *Agrobacterium*, *Corynebacterium*, and *Pseudomonas* species. Detail is given of the reaction of *Pseudomonas solanacearum* strains and mutants to a number of the antibiotics. The nutritional characteristics of each strain are discussed in relation to the reaction of the strain to any particular antibiotic.

10. ARK, PETER A. and DAVID J. BINGHAM. Response of pear and cherry root stocks to streptomycin and tetracycline when applied to control crown gall. Plant Disease Repr. 42: 673-674. 1958.

Two antibiotics, streptomycin and tetracycline, which showed a high degree of activity against *Agrobacterium tumefaciens* in vitro, were tested under field conditions on French pear and Mazzard cherry seedling root-stock obtained from nurseries where the soil was known to be contaminated with crown gall bacteria. The roots and tops of the seedlings were pruned and dipped for 1 hour in the solutions. No perfect control was obtained. There was a very pronounced difference in the response of the different root-stocks to both streptomycin and tetracycline.

11. BONDE, REINER and BARBARA JOHNSON. Studies on the additive effect of streptomycin sulfate on different seed potato disinfectants for the control of bacterial ring spot. Plant Disease Repr. 42: 781-784. 1958.

Experiments were conducted to discover a seed potato disinfectant that will control the dissemination of ring rot (*Corynebacterium sepedonicum*) during the process of cutting seed potatoes. Seed pieces contaminated with the bacteria were treated with different disinfectants with and without streptomycin sulfate in the dipping solutions. Most of the disinfectants gave significantly better disease control when combined with streptomycin sulfate than they gave without this antibiotic. Streptomycin sulfate appeared to have an additive or synergistic effect when in combination with the disinfectants used for the control of the ring rot disease. Actidione was the only antibiotic used in these studies that materially injured the potato seed pieces and reduced germination when they were planted in the field.

12. DEEP, IRA W. Crown gall chemotherapy with Terramycin. Plant Disease Repr. 42: 1210-1213. 1958.

Incipient crown gall infections were eliminated from 1-year-old Mazzard cherry trees by a 400-ppm treatment with Terramycin for 50 minutes. An 800 ppm treatment with Terramycin for 15 minutes prevented infection by crown gall bacteria when the trees were planted in infested soil. Neither of these treatments was phytotoxic in the instances cited but they have been injurious in other trials.

13. DEEP, IRA W. Reduction in incidence of crown gall of Mazzard cherry following antibiotic treatments. *Plant Disease Repr.* 42: 476-478. 1958.  
Three antibiotic preparations, streptomycin sulfate, Agrimycin, and Terramycin, were tested for effectiveness in root treatments of Mazzard cherries to prevent crown gall caused by Agrobacterium tumefaciens (E. F. Sm. & Towns) Conn. All three preparations significantly reduced the incidence of infection, but Terramycin was by far the most effective. Chemotherapeutic activity was indicated. Best treatments from viewpoint of maximum effectiveness and minimum toxicity were Terramycin at 200 ppm for 1 hour and at 400 ppm for 15 minutes.
14. FINK, HENRY C. Streptomycin-fungicide mixtures as potato seed piece treatments. *Plant Disease Repr.* 42: 965-971. 1958.  
Seed-piece rot (Erwinia atroseptica) was controlled in the laboratory with streptomycin sulfate at 100 ppm. Mixtures of a number of fungicides and dieldrin with streptomycin did not have an adverse effect on control in the laboratory. There was no correlation between laboratory and field tests; no treatment investigated gave complete control of E. atroseptica in the field. Where fungicide-streptomycin mixtures were used, lower stands and yields were produced than where fungicides (except griseofulvin) alone were used, especially when streptomycin was added to glyodin, Fermate 10 lb., Fermate 5 lb., or Spergon 3 lb.; addition of dieldrin to the streptomycin-fungicide mixtures reversed this tendency, apparently by reducing the phytotoxicity of the mixtures.
15. MACLACHLAN, D. S. and M. D. SUTTON. The use of antibiotics in the control of potato ring rot. *Rep. Quebec Soc. Prot. Pl.*, 1956: 76-82. 1957. (Rev. Appl. Mycol. 37: 371. 1958.)  
In field trials on the use of several antibiotics in the control of the potato ring rot organism (Corynebacterium sepedonicum), the most promising was Terramycin which can be absorbed by actively growing potato plants through the roots and translocated to the growing point in 24 hours, the concentration there reaching a maximum within 48 hours. Other tests indicated that Terramycin moves down one branch and up to the tip of the adjoining branch. When, however, sap from the base of the stems was assayed Terramycin was not found.
16. PORTER, FRANK M. and CARROLL E. COX. Some effects of certain antibiotics and other organic chemicals on the growth of Sclerotium rolfsii in the laboratory. (Abstr.) *Phytopathology* 48: 463. 1958.
17. WINFREE, J. P., R. S. COX and D. S. HARRISON. Influence of bacterial soft rot, depth of water table, source of nitrogen and soil fumigation on production of lettuce in the Everglades. *Phytopathology* 48: 311-316. 1958.  
Soft rot of lettuce due to Erwinia sp. and possibly Pseudomonas sp. was studied at the Everglades Experimental Station, Florida, in 1955-1957. Streptomycin gave some control in the field but at effective strengths (100-200 ppm) tended to be phytotoxic. Tribasic Copper Sulfate plus Agrimycin-100 applied throughout the season reduced diseased heads from 96 percent (untreated) to 64 percent.

#### BACTERIA

See also 9, 10, 11, 12, 13, 14, 15, 61, 66, 94, 120, 134, 160, 199, 218, 253, 349

18. ARK, PETER A. and MILTON N. SCHROTH. Use of slices of carrot and other fleshy roots to detect crown gall bacteria in soil. *Plant Disease Repr.* 42: 1279-1281. 1958.  
The crown gall bacterium, Agrobacterium tumefaciens, forms good galls on slices of carrots, rutabagas, turnips, and table beets. Carrot root slices are found to be the best in detecting living organisms of crown gall in soil and galls can be seen on carrot slices after 5 or 7 days.



19. BELTRA, R. El agente etiologico de la tuberculosis del olivo en relacion con el suelo. (The etiological agent of olive tubercle in relation to soil factors. An. Edafol. y. Fisiol. Veg. 16: 557-577. 1957. (Biol. Abstr. D, 32: 2083. 1958.)

The relationship of various soil factors, including texture, structure, pH, and chemical composition, to the olive tubercle disease (Pseudomonas savastanoi) is discussed.

20. BUDDENHAGEN, I. W. and L. SEQUEIRA. Disinfectants and tool disinfection for prevention of spread of bacterial wilt of bananas. Plant Disease Repr. 42: 1399-1404. 1958.

A number of organic and inorganic chemicals were tested as possible materials for disinfection of pruning knives, which are responsible in many cases for the transmission from plant to plant of bacterial wilt of bananas caused by Pseudomonas solanacearum E. F. Smith. Due either to the instability of most of these chemicals in the presence of banana sap, or to their toxicity, only formaldehyde was considered satisfactory for field use.

21. DAVISON, ARLEN D. Plant diseases of economic crops occurring in Wyoming during 1958. Plant Disease Repr. 42: 1409-1410. 1958.

In the section on potato diseases it is reported that there occurred 1/10 of 1 percent ring rot, Corynebacterium sepedonicum (Spieck. & Kotth.) Skapt. & Burkh., infection in potato fields entered for certification. Fusarium solani (Mart.) Appel & Wr. f. phaseoli (Burkh.) Snyder & Hans. root rot was moderate to severe in bean fields throughout the State.

22. DOWSON, W. J. Plant diseases due to bacteria. Second edition. Pp. XV + 232 + 30 plates and 21 maps. (Cambridge: University Press, 1957.) Review in Nature 181: 1094-1095. 1958.

New British diseases dealt with include silvering of red beet (Corynebacterium betae Keyworth, Howell & Dowson) and slow wilt of carnation caused by a bacterium related to, if not identical with, Pectobacterium carotovorum f. sp. chrysanthemi Dowson.

23. FULKERSON, J. F. Differential response of alfalfa clones to variant forms of Corynebacterium insidiosum. (Abstr.) Phytopathology 48: 461. 1958.

This investigation determined the relative virulence of different isolates of the wilt organism, C. insidiosum. Root inoculation tests were used. Four alfalfa clones were inoculated, each having a known degree of susceptibility to the wild-type isolate. There was a difference between this isolate and another one as determined by differential host reaction, i. e., clone 83 was significantly more susceptible to the variant than to the wild-type isolate.

24. GARBER, E. D. Further data on the concentration of free histidine of turnip varieties and their response to inoculation with histidine-requiring mutants of Erwinia aroid-eae. Am. J. Botany 45: 523-525. 1958. (Chem. Abstr. 52: 18702d. 1958.)

The fleshy storage organs of three varieties of turnips, and three mutants of the organism, were used. Twelve plants of each variety showed these ranges in  $\mu\text{g}$  histidine/g fresh weight: 7-22, 5-44, 19-146. There was no relation between these contents and susceptibility to the mutants.

25. GRAHAM, C. D. Occurrence of soft rot bacteria in Scottish soils. Nature 181: 61. 1958. (Rev. Appl. Mycol. 37: 267. 1958.)

Seventeen widely different soil samples were examined for the presence of soft rot bacteria (Erwinia atroseptica), the cause of blackleg of potato. Most of the isolates that were capable of rotting potato tuber slices at 26° C were Pseudomonas spp. Suspensions of E. atroseptica were added to the various soils in jars. Some of these were buried to the neck in the field from November, while others were kept at room temperature. The only soft rot organisms that could be isolated in the following May were Pseudomonas spp.

26. GRANHALL, I. (Report of 10th Congress of the Scandinavian Agricultural Scientists' Society -- Stockholm 1956,) Nord. Jordbr. Forskn. 38 (1956): 137-531. 1957. (Rev. Appl. Mycol. 37: 571. 1958.)

This author contributed a general paper on "Ring rot (Corynebacterium sepedonicum) in potatoes" in Sweden and its control.

27. HUSAIN, AKHTAR and ARTHUR KELMAN. Relation of slime production to mechanism of wilting and pathogenicity of Pseudomonas solanacearum. Phytopathology 48: 155-165. 1958.

Culture filtrates of a highly pathogenic strain of Pseudomonas solanacearum caused wilting of tomato cuttings, whereas culture filtrates of weakly pathogenic and avirulent strains did not. A heat-stable, viscous substance capable of causing reversible wilting of tomato cuttings was obtained by alcoholic precipitation from the culture filtrate of the virulent strain. This substance was not present in the culture filtrates of the weakly pathogenic or avirulent strains. The substance appeared to be a complex polysaccharide of a high molecular weight, with glucose as a main component. The substance was present in a bacterial slime around cells of the pathogenic strain. It was shown experimentally that this extracellular polysaccharide or slime produced by the virulent strain is the primary wilting factor in tomato.

28. HUSAIN, AKHTAR and ARTHUR KELMAN. The role of pectic and cellulolytic enzymes in pathogenesis by Pseudomonas solanacearum. Phytopathology 48: 377-386. 1958.

Study was made of the production of pectic and cellulolytic enzymes of P. solanacearum and certain of their functions in the disease syndrome were determined. Liquid culture filtrates of three strains of P. solanacearum differing in pathogenicity contained pectinmethylesterase, polygalacturonase, and a cellulolytic enzyme. Two conclusions were arrived at relative to the mechanism involved in two major phases of pathogenesis: Induction of wilting and decomposition of tissues. The pectic enzymes were not involved in the wilting process. The possibility exists that the cellulolytic enzymes may play a subsidiary role in the wilting mechanism. Pectic and cellulosic constituents of the cell walls of tomato stems were decomposed by the enzyme systems of the pathogen. It was concluded that the main role of the enzymes of P. solanacearum in pathogenesis involves the breakdown of host tissue.

29. KIVILAAN, A. and R. P. SCHEFFER. Factors affecting development of bacterial stem rot of Pelargonium. Phytopathology 48: 185-191. 1958.

Although this is primarily a disease of the above-ground parts of the plant, it was demonstrated in this investigation that root invasion does occur. Twenty-five plants were inoculated by dipping the free roots in bacterial suspensions. Seventeen of these plants developed positive stem rot symptoms.

30. KLEIN, R. M. and J. L. KNAPP. Sterile induction of crown-gall tumors on carrot tissues in vitro. Proc. Nat. Acad. Sci. Wash. 43: 199-203. 1957. (Rev. Appl. Mycol. 37: 572. 1958.)

This paper describes refinements of techniques used for studying the synthesis and activity of the tumor-inducing principle, which appears to be a metabolic product of virulent crown-gall bacteria (Agrobacterium tumefaciens). The transformation of normal into tumor cells can occur only with the cooperation of a "heat labile" synthesis factor present in a number of plants, including beet, parsnip, and carrot roots, potato tubers, and unspecified herbaceous stems. Evidence suggests that the tumor-inducing principle is a deoxyribonucleic acid.

31. KLEMM, M., G. MASURAT and S. STEPHAN. Das Auftreten der wichtigsten Krankheiten und Schädlinge der Kulturpflanzen im Jahre 1953 im Bereich der Deutschen Demokratischen Republik. (The occurrence of the most important diseases and pests of cultivated plants in the year 1953 in the zone

of the German Democratic Republic.) NachrBl. dtsh. PflSchDienst, Berl., N. F., 11: 81-104. 1957. (Rev. Appl. Mycol. 37: 201. 1958.)

Root diseases of beet (Phoma betae, Pythium debaryanum, Aphanomyces laevis, etc.) were more frequent than in the previous year and severest in Mecklenburg and Saxony. Black leg (Erwinia spp.) of potatoes caused important losses in almost all regions, as also did virus diseases.

32. LUCAS, G. B. Tobacco diseases in Panama. Plant Disease Repr. 42: 1301. 1958.  
Granville wilt, caused by Pseudomonas solanacearum, is reported as one of the diseases.

33. MACLACHLAN, D. S. Machinery and warehouse disinfection in potato ring rot control. Potato Handb. 1958: 31-32. 1958. (Rev. Appl. Mycol. 37: 556. 1958.)

This note briefly describes disinfection measures against potato ring rot (Corynebacterium sepedonicum). Quaternary ammonium compounds have proved superior to other disinfectants for equipment. Semesan Bel (1 lb./10 gal.) and mercuric chloride (1:1,000 or 500) are recommended for disinfection of cutting knives.

34. MARCELLI, E. (Bacterial wilt (Pseudomonas solanacearum) of tobacco in Italy.) Ric. fitop. Campan. 13-14: 53-68. 1957. (Rev. Appl. Mycol. 37: 421. 1958.)

After reporting the occurrence of Pseudomonas solanacearum on tobacco in various parts of Italy, the author gives an account of the disease in semi-popular terms, based largely on the literature.

35. MEYER VON GREGORY, RUTH and HANS WARTENBERG. Untersuchungen über den Parasitismus von Erwinia phytophthora (Appel) Holland. (In German) Phytopath. Z. 32: 257-282. 1958.

36. MORGAN, O. D. Blackleg of tobacco in Maryland. Plant Disease Repr. 42: 318-319. 1958.

During the spring of 1957 blackleg of tobacco, caused by Bacillus aroideae Townsend (Erwinia aroideae (Townsend) Holland), occurred in many plant beds and in some fields where diseased seedlings were transplanted. The symptoms of the disease are described. It is mainly a leaf and stalk disease of seedlings, but some of the roots of the plants were infected also.

37. NELSON, K. S. Studies on the relationship of the mineral salts supplied to two varieties of Dianthus caryophyllus and the resistance of the plants to the bacterial wilt organisms (Pseudomonas caryophylli). Abst. Doctoral Diss. Ohio State Univ. 67: 489-492. 1950-1951. (1958) (Biol. Abstr. D, 32: page 3504. 1958.)

Notes were made on peptic materials from the roots and stems of two varieties of carnation grown in sand culture with varied amounts of P, K, Ca, and Na available. Commercial saponin and carnation extracts were tested on goldfish and on Pseudomonas caryophylli. Both of these killed the goldfish. Effects of Pseudomonas were complex, with stem and root extracts of both carnation varieties inhibiting its growth in vitro. It is suggested that saponin in the carnation is a factor in effecting resistance to bacterial wilt, and that resistance is also related to the mineral nutrition.

38. PEAKE, R. W., M. W. CORMACK and R. K. DOWNEY. Evaluation of alfalfa for resistance to bacterial wilt in field and greenhouse tests. Can. J. Plant Sci. 38: 405-414. 1958.

Describes the application of improved methods to large-scale field and greenhouse tests of alfalfa for resistance to bacterial wilt, Corynebacterium insidiosum (McCull.) Jensen. In the field tests rooted cuttings or seedlings were inoculated by the bare-root soak method when planted in the field in May and by hypodermic injection of each root in the fall. In the following spring or fall the plants were cut off below ground with a special blade, pulled and individually evaluated for wilt resistance. In the greenhouse the root-ball soak method of inoculation was used and readings of seedlings were made after 3 months. Greenhouse tests were as reliable as those obtained in the field,



and were particularly useful for rapid screening of large populations. Field tests proved desirable for simultaneous studies on wilt resistance, growth habit, winter hardiness, and other qualities, and for final evaluation of potential variety material.

39. REPORT OF COMMITTEE. How can we interpret the zero tolerance for bacterial ring rot in certified seed potatoes? *Am. Potato J.* 34: 142-148. 1957. (Abstr. *J. Sci. Food Agr.* 9: i-25. 1958.)

The difficulties involved in obtaining potato seed pieces free from ring rot are described. Precautions for keeping fields free from ring rot and a programme for seed growers are outlined.

40. RIBALDI, M. and A. PANELLA. On bacterial wilt of alfalfa (*Medicago sativa* L.) caused by *Corynebacterium insidiosum* (McCull.) Jensen, in Italy. *Euphytica* 7: 179-182. 1958. (Rev. *Appl. Mycol.* 37: 732. 1958.)

In 1957 the authors found bacterial wilt (*C. insidiosum*) affecting 2- to 3-year old stands of lucerne in Bologna, Italy. A breeding program has been started, using resistant American material, and methods are being developed for testing resistance under Italian conditions.

41. RIBALDI, MARIO. Ricerche sul diradamento dei medicali italiani. I. Su una caratteristica alterazione di natura batterica dell'apparato radicale dell'erba medica (*Medicago sativa* L.). *Phytopath. Z.* 31: 337-366. 1958.

After a bibliographical survey of the bacterial diseases of leguminous forage plants, the author describes typical changes caused by bacterial infection in the roots of alfalfa plants that were showing initial stages of wilting. He describes two isolates of wilt bacteria as new species; namely *Flavobacterium vasculorum* Rib. and *Aerobacter luteum* Rib. *Fusarium oxysporum* Schlecht. was usually isolated from affected tissues of severely injured plants.

42. RICHARDSON, L. T. and C. T. BUCKLAND. Eradication of ring rot bacteria from contaminated potato bags by moist heat treatment. *Plant Disease Repr.* 42: 241-245. 1958.

The effects of three different humidity levels in air at 70° C on the temperature and on the survival of the organism (*Corynebacterium sepedonicum* (Spieck. & Kott.) Skapt. & Burkh.) at various locations within a bale of jute bags were determined. The rate of heating of the jute and the mortality rate of the bacteria at each location was found to vary with the moisture content of the air. The mortality rate at each humidity level was highest at the center of the bale, decreased towards the surface and was lowest in the free space outside despite the reverse temperature gradient. This apparent anomaly is attributed to the original moisture content of the jute.

43. SEQUEIRA, LUIS. Bacterial wilt of bananas: Dissemination of the pathogen and control of the disease. *Phytopathology* 48: 64-69. 1958.

*Pseudomonas solanacearum* E. F. Sm. causes bacterial wilt of bananas, commonly known as Moko disease. Although infection can take place in the roots and spread from there into the foliage, this is not commonly the case. Most infections occur on the above-ground parts and dissemination occurs by pruning equipment and by infested soil lodging in wounds. The enforcement of a tool-disinfestation program gave almost complete control of the disease in experimental plots. Infested banana areas can be reclaimed successfully by a combination of disking five times during the dry season and fallowing for 9 months before replanting. The application of bactericidal chemicals was ineffective in eliminating the wilt organism from the soil.

44. SETH, J. and S. T. DEXTER. Root anatomy and growth habit of some alfalfa varieties in relation to wilt resistance and winter hardiness. *Agron. J.* 50: 141-144. 1958.

In these studies at Michigan State University the anatomy of five lucerne varieties resistant to wilt (*Corynebacterium insidiosum*) could in no way be differentiated from that of five susceptible ones.



45. SMITH, W. K. Chromatographic examination of the products of digestion of pectic materials by solution cultures of plant pathogenic and other bacteria. *J. Gen. Microbiol.* 18: 42-47. 1958.

Solutions containing pectic materials were digested by solutions from cultures of 25 bacteria and examined chromatographically for breakdown products. Galacturonic acid and oligouronides were found in the case of soft-rot Erwinia spp., Xanthomonas campestris, Pseudomonas marginalis, Bacillus polymyxa, and Klebsiella aerogenes (galacturonic acid only). Ability to produce enzymes capable of breaking down pectic substances to galacturonic acid and low oligouronides was found to be present in bacteria producing pectin methyl esterase.

46. SMITH, W. K. A survey of the production of pectic enzymes by plant pathogenic and other bacteria. *J. Gen. Microbiol.* 18: 33-41. 1958.

The soft-rot-causing species of Erwinia and two strains of Xanthomonas produced significant amounts of pectin methyl esterase, while 22 strains of pathogenic bacteria and 15 nonpathogens were found to produce  $\gamma$ -pectin glycosidase.

47. STARR, G. H. Potato ring rot information (as determined by a recent survey). *Am. Potato J.* 34: 264-268. 1957. (Rev. Appl. Mycol. 37: 307. 1958.)

This paper summarizes the results of a questionnaire on ring rot (Corynebacterium sepedonicum), addressed in July 1956 to workers in 17 potato-growing States of the U. S. A. and two Canadian Provinces.

48. STEINDL, D. R. L. "Bacterial mottle", a new disease of sugar cane in Queensland. *Cane Gr. quart. Bull.* 21: 6-8. 1957. (Rev. Appl. Mycol. 37: 182. 1958.)

This disease of sugar cane has been called "root disease", owing to the poor development of the rooting system. The symptoms are described. The causal organism has been shown to be a bacterium, not yet identified, but possessing many characteristics of Erwinia. It is probably carried by flood waters.

49. VEKEMANZ, J. (Control methods for the enemies of tobacco and potato.) *Bull. Inform. Inst. Etud. agron. Congo belge.* 7: 1-29. 1958. (Rev. Appl. Mycol. 37: 447. 1958.)

The potato diseases reported from certain parts of the Belgian Congo are caused by Alternaria solani and by Pseudomonas solanacearum.

50. VOLCANI, Z. Soft rot on Japanese radish caused by a strain of Erwinia carotovora. *Rec. agric. Res. Sta. Rehovot.* 7: 141-142. 1957. (Rev. Appl. Mycol. 37: 127. 1958.)

Soft rot of Japanese radish growing in Cabri, south Israel, was caused by a non-gas forming strain of E. carotovora.

51. ZACHOS, D. G. The brown rot of potatoes in Greece. *Ann. Inst. Phytopath. Benaki*, N. S. 1: 115-117. 1957. (Rev. Appl. Mycol. 37: 676. 1958.)

Symptoms of this disease, which caused considerable damage, were recorded from central Greece in 1951, Naxos Island in 1953, and southern Peloponnese and the neighbourhood of Athens in 1957, the causal organism being identified in the last two cases as Pseudomonas solanacearum.

52. ANNUAL REPORT, DEPARTMENT OF AGRICULTURE, KENYA, 1955, Vol. II, 237 pp. 1957. (Rev. Appl. Mycol. 37: 135-136. 1958.)

Bacterial wilt (Pseudomonas solanacearum) was reported on tomatoes. A soft rot of Zantedeschia rhizomes was caused by bacteria, probably Bacterium carotovorum (Erwinia carotovora). A root and stem rot of cassava is reported to be associated with Coprinus sp. In tea nurseries a root disease attributed to Ganoderma sp. was discovered, which destroyed the lateral root system.

53. (THE FEDERAL AGRICULTURAL EXPERIMENT STATIONS, LAUSANNE. REPORT OF WORK IN 1956.) Annu. agric. Suisse, (71, ed. fr. 58), N.S. 7: 606-844. 1957. (Rev. Appl. Mycol. 37: 261-262. 1958.)  
At Ependes one case of infection of potatoes by Erwinia atroseptica was noted. In an experiment with potato scab (Streptomyces scabies), PCNB at 90 kg/ha of active material, applied at a depth of 10 cm immediately before planting, markedly reduced infection in a plot in which beet had been grown previously, but was not effective where potatoes had been planted for 2 successive years. Tubers stored for 3 1/2 months after treatment at 60 or 90 kg/ha had an unpleasant odour and taste.
54. PLANT QUARANTINE ANNOUNCEMENTS. F. A. O. Plant Prot. Bull. 6: 27. 1957.  
Federal Republic of Germany: It is prohibited to import potatoes infected with Corynebacterium sepedonicum.
55. PLANT QUARANTINE ANNOUNCEMENTS. F. A. O. Plant Prot. Bull. 5: 194; 6: 27-29. 1957. (Rev. Appl. Mycol. 37: 263-264. 1958.)  
For the importation of potatoes into Norway an import license must first be obtained from the Ministry of Agriculture, and the consignment must be accompanied by a certificate from the Plant Protection Service of the country of origin that the potatoes are not infected by Corynebacterium sepedonicum and were grown in an area believed to be free from Synchytrium endobioticum.
56. PLANT QUARANTINE ANNOUNCEMENTS. F. A. O. Plant Prot. Bull. 6: 60. 1958.  
New Zealand: Included among imports prohibited are potatoes, from all areas, that are infected by Corynebacterium sepedonicum.
57. PLANT QUARANTINE ANNOUNCEMENTS. F. A. O. Plant Prot. Bull. 6: 93-95. 1958.  
Decree No. 263, published in La Gaceta, prohibits the importation into Nicaragua of cacao plants and parts from Panama, banana plants and parts from Honduras, where bacterial wilt (Pseudomonas solanacearum) has been found.
58. REPORT OF THE DEPARTMENT OF AGRICULTURE, N. S. W. FOR THE YEAR ENDED 30TH JUNE, 1956. 111 pp., 13 fig. 1957. (Rev. Appl. Mycol. 37: 133-134. 1958.)  
Bacterial wilt (Pseudomonas solanacearum) was severe in tobacco seedbeds at Bourne. In control studies, improved Ceresan and phenyl mercuric nitrate gave the best control of the gladiolus corm diseases, bacterial scab (Pseudomonas marginata), Sclerotinia gladioli, and Botrytis rot.

#### BIOLOGICAL CONTROL

59. CALDWELL, R. Fate of spores of Trichoderma viride Pers. ex Fr. introduced into soil. Nature 181: 1144-1145. 1958.  
In the course of an ecological study of Trichoderma viride Pers. ex Fr., observations have been made on the survival and germination of its conidia and chlamydospores in soil. The results show that in the soil types used, T. viride survives for considerable periods both as chlamydospores and conidia, and that there is a low rate of germination of these spores.
60. FEDORINCKIK, N. S. and L. K. VANDORFLAAS. (Effect of the antagonistic activity of the soil fungus Trichoderma lignorum Harz on increase in yields of agricultural crops.) Trud. vsesoyuz. Inst. Zashch. Rast., 5: 17-37. 1954. (Rev. Appl. Mycol. 37: 24. 1958.)  
In a series of pot and field experiments in the U. S. S. R. the introduction of T. lignorum into sterilized soil inhibited the growth of a number of fungus pathogens on several different hosts.
61. FEDOTOVA, T. I. (The influence of silicate bacteria on the susceptibility to diseases and yield of plants.) Plant Prot. Moscow, 1957, 3: 45-46. 1957. (Rev. Appl. Mycol. 37: 571-572. 1958.)

Introduction of silicate bacteria into the soil reduced rusts on wheat and barley, loose smut on maize, Ascochyta and a bacteriosis on peas, Fusarium (oxysporum) and a bacteriosis on lupin, and cucumber bacteriosis (Pseudomonas lacrymans), decreasing the diseases 2-3 times and increasing yields 20-30 percent. The same treatment against Fusarium (lini) on flax reduced infection to 7 percent and increased yield 16 percent.

62. FEDOTOVA, T. I. and E. F. KARASEVA. (The role of immune potatoes in soil disinfection from wart disease.) Plant Prot. Moscow, 1957 (5): 45-46. 1957. (Rev. Appl. Mycol. 37: 593. 1958.)

At the Litovskiy Experiment Station for Potato Diseases and Pests, trials showed that the varieties Fram, Puntukas, and Imandra resistant to Synchytrium endobioticum, were useful for freeing the soil from infection. After the crop 1 g of soil contained 4-18 zoosporangia compared with 453 in soil planted with the susceptible variety Valley.

63. GANDEL'MAN, T. C. (Agrotechnical measures against potato wart.) Potato, Moscow, 1958 (2): 44-46. 1958. (Rev. Appl. Mycol. 37: 593. 1958.)

In co-operative studies in U. S. S. R. on wart disease (Synchytrium endobioticum), it was found that infested soil was almost or completely cleared by planting rye, lupins, cabbage, maize, flax, or resistant potato varieties for at least 3 years; cabbage gave 100 percent control.

64. GARRETT, D. S. Inoculum potential as a factor limiting lethal action by Trichoderma viride Fr. on Armillaria mellea (Fr.) Qué. Trans. Brit. Mycol. Soc. 41: 157-164. 1958. (Rev. Appl. Mycol. 37: 649. 1958.)

Woody inocula of A. mellea were incubated for 23 days at 21°-24° C in autoclave-sterilized soil containing pure cultures of T. viride or Penicillium wortmannii, also dilutions of these with unsterilized soil to 1/4, and (with T. viride) to 1/8 strength. The inocula were then brushed clean and set in soil growth tubes, and the subsequent rhizomorph production by A. mellea over a period of 76 days was measured. The results indicated a significant correlation between the inoculum potential of T. viride and its lethal effect on A. mellea.

65. GRASSI, G. V. The biological control of Verticillium albo-atrum R. and B. by various antagonistic organisms. Diss. Abstr. 17: 1449. 1957.

At Purdue University it was observed that soil amendments stimulated the development of various saprophytes, which multiplied at the expense of pathogens, preventing their growth. The evidence showed that the incidence of wilt is related to the number of antagonistic organisms present in muck soil. These were isolated and, when introduced singly into soil inoculated with V. albo-atrum plus various amendments to stimulate the development of the antagonists, gave excellent control.

66. GRIFFITHS, E. and M. A. SIDDIQI. Microbial antagonism of Fusarium culmorum. Nature 182: 956. 1958.

In studies on the pathogenicity of Fusarium culmorum towards rye-grass a bacterium was found to be regularly present on the root surfaces, particularly of healthy roots. This bacterium was proven to be very antagonistic towards Fusarium culmorum, and to prevent pathogenic action of the Fusarium on roots protected by the bacterium. The bacterium possessed the typical morphology and flagellation of a Pseudomonas, and the biochemical reactions of Klebsiella aerogenes.

67. KUBLANOVSKAJA, G. M. and V. M. DŽALILOVA. Biological control of fusarium wilt on melons. Sad. i Ogorod, No. 2: 41-46. 1958. (Hort. Abstr. 28: 409. 1958.)

Two strains of actinomycetes (No. 935 and 1699) antagonistic to Fusarium oxysporum were used in pot experiments and small scale field trials. In the pot experiments germination of melon seed was stimulated by application, 10 days before sowing, of oil cake at 2 t. per ha or oil cake plus actinomycetes



at 3 t. per ha, the latter being considerably more effective. In the field trials the actinomycetes-oil cake fertilizer was used in split applications. The greatest reduction of infection was obtained from two applications, but the highest yield did not coincide with the lowest disease incidence, indicating that the actinomycetes possess not only antibiotic but also growth stimulating properties.

68. MIRZABEKYAN, R. O. and N. V. SINITSUINA. (Tests with actinomycetes against potato wart.) Plant Prot., Moscow, 1957 (5): 42-44. 1957. (Rev. Appl. Mycol. 37: 593. 1958.)

In investigations at the Academy of Sciences, Moscow, on actinomycete strains antagonistic to Synchytrium endobioticum, strain No. 167 and to a lesser extent 711 were the most active.

69. MOSKOVETS, S. N. (Cotton wilt and methods for its control in the Ukraine.) Trud. ukr. nauch.-issled Cotton Inst., Zashch. Rast., Kiev, 1956, pp. 46-55. 1956. (Rev. Appl. Mycol. 37: 537. 1958.)

In a comparative study in the Ukraine and Azerbaijan the incidence of Verticillium dahliae in cotton grown in a field previously planted with lucerne and certain cereals for at least 2 years was only 0.5-3.7 percent compared with 25-97.2 percent in fields previously bearing other crops. Applications of K increased resistance. A spacing of 70 x 10 cm per plant proved the best.

70. PARK, DAVID. Behaviour of soil fungi in the presence of bacterial antagonists. Trans. Brit. Mycol. Soc. 40: 283-291. 1957. (Biol. Abstr. 32: 2092. 1957.)

Selected native soil fungi and alien fungi were compared in their reactions to bacterial antagonism. In agar and liquid cultures there was no distinction between the two categories. In sand and soil cultures containing a mixed bacterial flora, differences in behavior were observed. In these artificial situations, the distinctions were not between alien fungi and fungi native to a particular soil, but between soil inhabitants generally, and fungi from other sources. The exochthonous fungi which remained viable in those cultures allowing of comparison did so solely by means of inhibited spores, whereas the soil inhabitants spread throughout the substratum as a mycelium, some cells of which persisted.

71. PARK, DAVID. Behaviour of soil fungi in the presence of fungal antagonists. Trans. Brit. Mycol. Soc. 40: 358-374. 1957. (Biol. Abstr. 32: 2092. 1958.)

Soil-inhabiting fungi were compared with exochthonous fungi in their reaction to fungal antagonism. In certain cultures containing fungi of both categories, the soil-inhabiting fungi became dominant, and subsequently demonstration of the presence of the exochthonous fungi became impracticable. Under conditions of antagonism that inhibited the growth of soil-inhabiting fungi, spores of exochthonous fungi remained demonstrable. The lack of success of exochthonous fungi under conditions permitting fungal growth is accounted for by the greater activity of the soil-inhabiting fungi. In a discussion of tolerance it is suggested that the effect of environment on survival of soil fungi is related to their tolerance for activity rather than to their total tolerance.

72. SERGEEV, L. A. (On a biological method for the control of Flax wilt.) Zashch. Rast., Kiev, 1956, pp. 56-62. 1956. (Rev. Appl. Mycol. 37: 355-356. 1958.)

In a study of the microflora of the rhizosphere of flax in southern Ukraine 25 strains of 9 species were isolated. Cultures on sterile oats were introduced into the soil in the field, together with flax seeds, to determine their antibiotic activity against Verticillium dahliae. Previously the soil had been inoculated with cultures of V. dahliae. The antibiotic fungi reduced infection from 44.4 to 32.2 percent. Some strains not only decreased the disease but increased yield.

73. SHOPINA, V. V. The role of the preceding crops with respect to the change of susceptibility of wheat to brown rust. Doklady vsesoyuz. Akad. Selskokhoz. Nauk im V. I. Lenina 22: 34-36. 1957. (Chem. Abstr. 52: 3927. 1958.)



The preceding crop was either cotton, sunflowers, or Indian corn. Wheat following corn will not be so heavily attacked by the rust. This may be explained by the amounts of P, K and N removed by the preceding crops from the soil or left there (analyses of plant parts are presented). Wheat following sunflowers contained more K in the leaves than any other wheat in these experiments.

74. TUPENEVICH, S. M. (Suppression of the parasitic activity of the fungus *Rhizoctonia solani* Kühn as the causal agent of black scurf of potato.) Trud. vsesoyuz. Inst. Zashch. Rast., 5: 5-16. 1954. (Rev. Appl. Mycol. 37: 54. 1958.)

In experiments in the U. S. S. R. black scurf of potatoes (*R. (Corticium) solani*) was successfully controlled by planting after winter wheat.

75. VAARTAJA, O. Effect of *Trichoderma* on tree seedlings and their pathogens. Bi-m. Progr. Rep. Div. For. Biol., Dep. Agric. Can., 13: 1. 1957.

*Trichoderma* strains isolated from tree seedlings were potentially pathogenic to seedlings of *Pinus* spp., *Betula* spp., and *Caragana arborescens*, especially in weak light, and they differed in pathogenicity. Each of 11 strains reduced the growth of *Rhizoctonia (Corticium) solani* at a distance of several cm; when the *Trichoderma* colonies met those of *C. solani*, they overgrew the latter. When seedlings of *Pinus banksiana* were grown in pots in different soils inoculated with two *Trichoderma* strains, the fungus appeared to increase the survival of the seedlings. It is suggested that the moderately phytotoxic and strongly antifungal antibiotics known to be produced by *Trichoderma* may accumulate only under certain conditions.

76. YIN, S. Y., et al. A further study on the biological control of *Verticillium* wilt of cotton. Acta phytopath. sinica, 3: 55-61. 1957. (Rev. Appl. Mycol. 37: 168. 1958.)

At the Liaoyang Cotton Experimental Station antagonistic actinomycetes cultured on cotton seed cake used as fertilizer stimulated the growth of cotton plants and decreased *Verticillium* wilt. Isolates G4 and 5406 gave best results; three applications of the fertilizer containing them resulted in a decrease of 31-50 percent in the disease and an increase of 14-40 percent in yield.

77. YIN, S. Y., et al. A preliminary study on the selection and culture of antagonists for some cotton disease organisms with reference to their field performance. Acta phytopath. sinica, 1: 101-114. 1955. (Rev. Appl. Mycol. 37: 43. 1958.)

Of 1205 actinomycetes isolated during 1950-54 in various parts of China, 42.7 percent were antagonistic to *Verticillium albo-atrum*, 35-45 percent to *Fusarium vasinfectum*, 25.2 percent to *Rhizoctonia solani*, and 33.2 percent to *Pythium* spp., all infecting cotton. The slowly sporulating isolates were generally the most active and those antagonistic to *C. solani* were usually highly antagonistic to the other fungi.

78. THIRTY-SEVENTH REPORT OF THE NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, CAMBRIDGE, 1956. -- 60 pp., 1957. (Rev. Appl. Mycol. 37: 2-3. 1958.)

In further studies on the interaction of *Rhizoctonia (Corticium solani)* and *Phytophthora infestans* on potato tubers, *C. solani* inoculated on tubers and on artificial media caused disorganization and the eventual disappearance of *P. infestans*. The addition of a liquid exudate from *C. solani* to a zoospore suspension of *P. infestans* caused cessation of movement and dissolution of the zoospore membrane in 30 minutes.

## CONTROL

Control -- Crop Manipulation

See also 124, 353

79. LOUW, H. A. The effect of various crop rotations on the incidence of take-all (*Ophiobolus graminis* Sacc.) in wheat. Sci. Bull. Dept. Agric. S. Afr. 379, 12 pp. 1957. (Rev. Appl. Mycol. 37: 714, 1958.)

The increased microbial activity in the soil, brought about by crop rotation (legumes-wheat), was found to aggravate rather than suppress the incidence of take-all, contrary to Garrett's findings, but although positively correlated with microbial activity, its incidence is also subject to other factors.

80. LOUW, H. A. Microbiological analysis of a Western Cape Province grain soil under various crop rotations. Sci. Bull. Dept. Agric. S. Afr. 378, 36 pp. 1957. (Rev. Appl. Mycol. 37: 714, 1958.)

A microbiological analysis carried out under four different crop rotation systems indicated that microbial activity was highest in legume-wheat plots, but so also was the incidence of take-all (*Ophiobolus graminis*).

Control -- Miscellaneous

81. ANTOINE, R. La production de boutures saines dans la lutte contre la maladie du rabougrissement des repousses de la Canne à sucre à l'île Maurice. (The production of healthy cuttings in the control of ratoon stunting disease of Sugar-cane in Mauritius.) Rev. agric. suc. Maurice (formerly Rev. agric. Maurice) 37: 8-13. 1958. (Rev. Appl. Mycol. 37: 677, 1958.)

The methods for control of this disease are presented in detail. There are three main features, production of resistant varieties, prophylactic treatment of implements, and hot water treatment of cuttings, the apparatus for carrying out the last on a large scale being described.

82. BAKSHI, B. K. Wilt disease of Shisham (*Dalbergia sissoo* Roxb.). IV. The effect of soil moisture on the growth and survival of *Fusarium solani* in the laboratory. Indian For. 83: 505-511. 1957. (Rev. Appl. Mycol. 37: 117, 1958.)

Studies suggest that *F. solani* on *Dalbergia sissoo* may be controlled by irrigation. The fungus grew and survived well in sterile loam soil with 20 percent moisture, but above this there was a sharp decline until contamination was eliminated with free water.

83. KON'KOVA, R. D. (Irrigation in the control of potato wilt.) Sborn. Trud. Yuzh. N. I. Inst. hydrotech. melior., 1956, 4: 247-252. 1956. (Abstr. from Referat. Zh. Biol., 1958, 2: 195. 1958.) (Rev. Appl. Mycol. 37: 504, 1958.)

In the Stavropol' region, U. S. S. R., the wilt of potatoes caused by *Fusarium oxysporum* and physiological disturbances was checked very successfully by maintaining the soil moisture at no less than 85 percent during flowering and 80 percent afterwards.

84. RUSSELL, R. C. and S. H. F. CHINN. The salt-water soak treatment for the control of loose smut of barley. Plant Disease Repr. 42: 618-621. 1958.

The soaking of barley seed in weak saline solutions was just as effective in controlling loose smut caused by *Ustilago nuda* (Jens.) Rostr. as the water soak treatment, and interfered much less with the germination of the seed.

85. STANKOVA-OPOCENSKA, E. (Aster wilt. I. A contribution to the biology of the causal organism of aster wilt (*Fusarium conglutinans* var. *callistephi*). II. A survey of the most suitable methods of control.) Sborn. cs. Akad. zemed. Ved, Rostl. Vyroba, 30: 727-740, 741-748. 1957. (Hort. Abstr. 28: 271. 1958.)

Soaking aster seeds for 30 minutes in a 0.1 percent solution of mercuric chloride controlled wilt but reduced germination. Steam sterilization of

the soil prevented infection for 3-4 weeks and stimulated growth. Carnations appeared to be an unsuitable preceding crop. Acti-dione reduced infection and stimulated germination.

86. TAMAQO, B. P. and F. T. ORILLO. Seed treatment of vegetables for control of damping-off. *Philippine Agriculturist* 40: 519-523. 1957. (Chem. Abstr. 52: 4090. 1958.)

At dosages of 0.5 percent by weight of Chinese cabbage seeds, Grano-san (I) and Semesan (II) dusts applied for damping-off control increased emergence of the seedlings, and Spergon increased the emergence of cabbage and eggplant seedlings. (I), (II), and Arasan SF-X injured lettuce seedlings. (I) and Crag 5400 were high in protective value especially on cucumber seedlings. The authors were unable to obtain satisfactory protection against post-emergence damping-off.

87. TARR, S. A. J. Control of seed-bed losses of groundnuts by seed treatment. *Ann. Appl. Biol.* 46: 178-185. 1958. (Rev. Appl. Mycol. 37: 695. 1958.)

Fungicidal treatment of groundnut seed was conducted under rainfall in the sandy soils of west-central Sudan and under irrigation in the alkaline clay soils of the Gezira. The benefits were greatest with slightly damaged seeds but also occurred even when selected, undamaged seed was sown by hand. Organisms involved included Aspergillus niger, A. flavus, and Rhizopus spp.

88. TYNER, L. E. The effect of water on the partial sterilization of barley seed by propylene oxide and by heat. *Phytopathology* 48: 177-178. 1958.

Three of the four genera of the fungi recorded on barley seed were eliminated satisfactorily by propylene oxide from either dry or moistened seed. Control of fungi was not effected by any heat treatment of the dry seed but the addition of moisture greatly facilitated their elimination. Rhizopus spp. were the most difficult to control but at 55° or 60° C they were fairly successfully eliminated from seed to which 20 or 30 percent water had been added.

#### FUNGI

See also 31, 52, 77, 381

89. ASHOUR, W. A. and M. M. EL-KADI. Damping-off disease of tomato seeds and its control. *Ann. agric. Sci., Cairo*, 1: 111-126. 1956. (Arabic summary.) *Rev. Appl. Mycol.* 37: 739-740. 1958.)

Fusarium semitectum, Rhizoctonia solani, and Alternaria tenuis were isolated from damped-off seedlings, F. semitectum mostly from unemerged and R. solani from diseased seedlings.

90. ASHOUR, W. A. Effect of watering treatment, seed treatment and date of sowing on emergence and damping-off of cotton seeds. Damping-off disease of cotton. 1 -- Studies of the causal organisms and their pathogenicity. *Ann. agric. Sci., Cairo*, 1: 161-176. 1956; 2: 81-94. 1957. (Rev. Appl. Mycol. 37: 721-722. 1958.)

Fusarium vasinfectum was isolated most frequently from damped-off cotton seeds, but Rhizoctonia (Corticium) solani, not present in winter, was most pathogenic; Mucor sp., Rhizopus nigricans, Pythium debaryanum, and Stemphylium sp. were also isolated. All were seed-borne. Emergence was better with all 6 present in the soil than with one alone. Of 7 fungicides tested in the first study and 9 in the second, 1 percent fernasan seed dressing was most effective in increasing the percentage of survival, but it had no effect on post-emergence damping-off. Different methods of irrigation had no effect.

91. ASTHANA, R. P. Incidence of wilt disease (on *Linum usitatissimum* in M. P.). *Nagpur agric. Coll. Mag.* 31 (1-4): 16-17. 1956-7. (Rev. Appl. Mycol. 37: 285. 1958.)

Wilted linseed plants contained either Fusarium sp. or Rhizoctonia sp. Seed-inoculation experiments over a period of 7 years showed that the Fusarium sp. alone caused 76.08 percent wilting, Rhizoctonia alone 10.4



percent, and a half-and-half mixture of both 50.83 percent. Treatment of seed with mercury compounds, particularly Ceresan, reduced wilting, which is most severe in a late crop.

92. BIANCHINI, C. L. Las llagas del café en Costa Rica. (The cankers of coffee in Costa Rica.) Bol. tech. Min. Agric. Industr. Costa Rica 21, 27 pp. 1958. (Rev. Appl. Mycol. 37: 660. 1958.)

For black canker Rosellinia ? bunodes was found to be responsible, but a Fusarium sp. was frequently associated with it. White root cankers yielded Trichoderma sp., Rosellinia sp., and an unidentified jade green fungus; the pathogenicity of all was confirmed. The disease is attributed to their combined action. The principal agent of ulcerated root canker was a Curvularia sp., though Fusarium oxysporum f. coffae was frequently isolated and its pathogenicity established. A reddish brown rot of the stem base of 1-2-year old plants was caused by Cylindrosporium sp., Fusarium oxysporum, and Tubercularia sp.

93. BÖNING, K. Starkes Auftreten von Schwärze an Getreide. (Extensive occurrence of blackening of cereals.) Pflanzenschutz 9: 115. 1957. (Rev. Appl. Mycol. 37: 29-30. 1958.)

An etiological connection between black mould (Cladosporium herbarum) and foot rot (Ophiobolus graminis) is postulated where they have occurred together on cereals in Germany.

94. BRIEN, R. M., et al. Diseases and pests of lettuce in New Zealand and their control. Inform. Ser. Dep. Sci. industr. Res. N. Z. 14, 38 pp. 1957. (Rev. Appl. Mycol. 37: 436. 1958.)

Damping-off, both pre- and post-emergence, due to Pythium spp. and Rhizoctonia (Corticium) solani, is reported. Among the bacterial diseases is included soft rot caused by Erwinia carotovora.

95. BUNKINA, I. A. Diseases of ginseng and their control. (Plant Prot., Moscow), 1957, 4: 39-40. 1957. (Rev. Appl. Mycol. 37: 498-499. 1958.)

Pathogens of ginseng in the Primorye, U. S. S. R., where the crop has recently been introduced, include Phytophthora cactorum, Colletotrichum panacicola, Alternaria panax, Fusarium spp., Rhizoctonia (Corticium) solani, and Ramularia spp., all of economic importance. Irrigation and choice of planting sites are poor and there are heavy losses in fields exposed to the sun. Against Fusarium spp. and C. panacicola seed treatment for 15 minutes in 0.25 percent calcium permanganate or 40 percent formalin (1:300) proved effective and did not reduce germination; the best results, however, were obtained with NIUIF-DRB and thiram on the seed, and soaking the roots of seedlings for 15 minutes in 1 percent Bordeaux or 0.25-0.3 percent calcium permanganate before transplanting gave very good control.

96. CHEVAUGEON, J. and A. RAVISÉ. Régime de l'eau et maladies parasitaires du riz en Afrique Occidentale. (Water regime and parasitic diseases of rice in West Africa.) Jour. Agric. Trop. et Bot. Appliquée 4: 143-151. 1957. (Biol. Abstr. 32: p. 2670. 1958.)

The most economical and rapid way of combating plant diseases is to change the environment harboring the pathogens. The paucity of water in the Senegal region and the excess of water in the Ivory Coast are both responsible for parasitic diseases of rice. In Senegal, Fusarium nivale was among the most important, including species of Rhizopus, Helminthosporium, Curvularia, and Phyllostica, among the 263 species of fungal organisms. The number of seedlings killed by pathogenic fungi is small. Even under the most favorable conditions less than 5 percent of plants are attacked. The major cause of seedling mortality was found to be anaerobiosis when seeds were planted in deep water.



97. CONNERS, I. L., R. A. SHOEMAKER, and D. W. CREELMAN. Thirty-sixth Annual Report of the Canadian Plant Disease Survey, 1956. --XXIX + 134 pp. 1957. (Rev. Appl. Mycol. 37: 205-206. 1958.)  
 Severe damage was caused to soybeans in southwestern Ontario by an undetermined sp. of Phytophthora, causing a root and stalk rot. Club root (Plasmodiophora brassicae) is spreading on Cruciferae in Canada. A canker of parsnips (Itersonilia perplexans) is reported for the first time from Canada in Pell County, Ontario. During the hot dry season of 1955 the pathogen isolated most frequently from white beans (Phaseolus vulgaris) affected by root rot in southwestern Ontario was Fusarium oxysporum, whereas in 1956, a cool wet season, F. solani f. phaseoli predominated.
  
98. CRAIG, J. and B. KOEHLER. Pyrenochaeta terrestris and Phaeocytoporella zeae on corn roots. Plant Disease Repr. 42: 622-623. 1958.  
 At Urbana, Illinois, eight species of fungi isolated from the roots of field corn with red root rot were tested for pathogenicity to dent corn seedlings in pots of infested soil in the greenhouse. Phaeocytoporella zeae and Pyrenochaeta terrestris were the only species causing extensive and consistent root rot, and P. terrestris was the only one that induced red discoloration.
  
99. DARPOUX, H., J. PONCHET and M. GUNTZ. Problèmes de pathologie végétale intéressant des régions à sol granitiques. (Interesting problems of plant pathology in areas with granitic soils.) Rev. Path. gén. 1957, pp. 843-853. 1957. (Rev. Appl. Mycol. 37: 455. 1958.)  
 The seriousness of club root (Plasmodiophora brassicae) of crucifers, potato scab (Streptomyces scabies), and take-all (Ophiobolus graminis) of Gramineae on certain granitic soils in Brittany is considered in relation to pH and to control methods.
  
100. DECKER, P. and S. A. OSTAZESKI. In Ann. Rept. of Agr. Experiment Stations, Florida, for year ending June 30, 1957. (Rev. Appl. Mycol. 37: 699-700. 1958.)  
 Root rots were important on yellow and blue lupins (Lupinus luteus and L. angustifolius); isolates from affected roots of both were Rhizoctonia and Fusarium spp., but in limited tests only Rhizoctonia spp. were pathogenic to blue lupin seedlings.
  
101. DRAKE, CHARLES R. Diseases of birdsfoot trefoil in six southeastern States in 1956 and 1957. Plant Disease Repr. 42: 145-146. 1958.  
 Root rots of birdsfoot trefoil caused by Fusarium spp. and Verticillium spp. attacked plants principally in spaced-plant nurseries.
  
102. EBBEN, MARION H. In Annual Report 1956, Glasshouse Crops Research Institute. 139 pp. 1958. (Rev. Appl. Mycol. 37: 633-634. 1958.)  
 Describing investigations into carnation wilt diseases (Verticillium cinerescens, Fusarium roseum, F. oxysporum f. dianthi, and Erwinia sp.) Marion H. Ebben states that F. roseum by itself frequently causes wilt. Acti-dione in agar completely inhibited the growth of V. cinerescens and greatly retarded that of F. roseum. Secondary infection of wilted plants commonly occurs, especially after cortical rotting by F. roseum. The slow development of wilt organisms within the plant handicaps prevention of the disease in carnations.
  
103. FEZER, K. D. A study of factors that influence survival of red clover, with special reference to root rots. Diss. Abstr. 17: 939. 1957. (Rev. Appl. Mycol. 37: 100. 1958.)  
 At Cornell University the fungi most frequently isolated from diseased roots of red clover were Fusarium solani, F. oxysporum, and Gliocladium sp., in that order. F. solani was pathogenic to seedlings and to both young and mature plants. It seems that all these fungi contribute to failure of red clover to survive more than 2 years in New York. In the greenhouse, treat-

ments which weakened the plants favored the development of tap root infection. Plants persisted longer in fields fumigated with methyl bromide.

104. FULTON, N. D. and K. BOLLENBACHER. Pathogenicity of fungi isolated from diseased cotton seedlings in Arkansas. (Abstr.) *Phytopathology* 48: 343. 1958.

Of 22 fungous isolates tested for pathogenicity on cotton seed and seedlings in the greenhouse and laboratory, Rhizoctonia solani and Pythium sp. caused the most pre-emergence killing. Most isolates were more pathogenic in tests held constantly at 21° C than at 27° C for 1 week and then changed to 16° C.

105. FULTON, ROBERT H. New or unusual small fruit diseases and disease-like occurrences in Michigan. *Plant Disease Reptr.* 42: 71-73. 1958.

Red stele of strawberry caused by Phytophthora fragariae was found for the first time in Michigan, in the variety Fairland which has previously been regarded as a red stele-resistant variety. Evidence was adduced that Armillaria mellea (Vahl) Quél. was responsible for a root rot of the highbush blueberry (Vaccinium australe). As blueberry is not indicated as a host of Armillaria, this is believed to be the first record for this fungus on this host.

106. GOMOLYAKO, M. I. (Fungi on the roots of spring wheat.) *J. Microbiol., Kiev*, 18 (3): 12-24. 1956. (Rev. Appl. Mycol. 37: 655. 1958.)

At the Microbiological Institute, Ukraine, 29 fungi were isolated in field and laboratory tests from the rhizospheres and roots of the spring wheat varieties Odessa 13, Melyanopus 69, and Narodna. Only Helminthosporium bondarzewi, Alternaria sp., H. sativum, and Pyrenochaeta sp. caused damage. Rhizoctonia solani did not penetrate the roots and is not considered dangerous. Further investigations may show that Cladosporium spp. are even beneficial.

107. GRANT, U. J. et al. (How to increase maize production in Colombia.) *Bol. Dep. Invest. agropec., Bogotá*, 1, 51 pp. 1957. (Rev. Appl. Mycol. 37: 279-280. 1958.)

Rots of the cob and roots of corn caused by species of Fusarium, Diplodia, Gibberella, and Pythium are responsible for considerable damage, though there are resistant varieties.

108. GROVES, A. B. Root diseases of deciduous fruit trees. *Bot. Rev.* 24: 25-42. 1958.

The article reviews work of the past decade in this field. It is a decennial supplement to Cooley, J. S. *Root Diseases of Deciduous Fruit Trees*. *Bot. Rev.* 12: 83-100. 1956. Fields of investigative efforts given a more extended treatment than offered earlier include replant problems, virus and nematode diseases, and non-parasitic disorders.

109. HAWN, E. J. Studies on crown bud rot of alfalfa in southern Alberta. *Diss. Abstr.* 17: 939-940. 1957. (Rev. Appl. Mycol. 37: 101. 1958.)

The main advance of the disease in each year occurs during the first month of active growth. Temperatures above 16° C arrest the development of the disease. The most pathogenic of isolates from crowns to crown buds were Rhizoctonia solani, Fusarium avenaceum, F. acuminatum, and Ascochyta imperfecta, in descending order. F. acuminatum was the predominant fungus until the third year, when its numbers were approximately equalled by C. solani. The later decline of C. solani coincided with a reduction in the rate of development of the disease. F. acuminatum appears to be equally active throughout the growing season, whereas C. solani generally appears most frequently in summer samples.

110. HAWN, E. J. Studies on the epidemiology of crown bud rot of alfalfa in southern Alberta. *Can. J. Botany* 36: 239-250. 1958.

Crown bud rot is widespread in irrigated alfalfa stands in southern Alberta. Rhizoctonia solani Kühn, Fusarium roseum Link sensu Snyder &

Hansen, and Ascochyta imperfecta Peck, acting alone or in combination produce brown to black lesions on the crown buds of plants in their second and subsequent years of growth. The host plant is most susceptible to the disease in early spring after winter dormancy.

111. HORTON-SMITH, C. (Edit.) Biological aspects of the transmission of disease. 179 pp., Edinburgh and London, Oliver and Boyd, 1957. (Rev. Appl. Mycol. 37: 10. 1958.)

In a symposium on biological aspects of the transmission of disease, organized in London by the Institute of Biology, papers of phytopathological interest included: a discussion of "The soil as a reservoir of pathogenic micro-organisms" and of root-infecting fungi in particular by S. D. Garrett.

112. IVANCHENKO, Y. N. (The causes of oak wilt in the Lipetsky garden in the Saval'sky Forest.) Trud. vsesoyuz. Inst. Zashch. Rast., 1957, 8: 221-225. 1957. (Rev. Appl. Mycol. 37: 742. 1958.)

Ophiostoma roboris, O. valachicum, O. kubanikum, and Fusarium sp. were isolated from wilted oak trees. Their pathogenicity was established by inoculation separately into healthy trees, each strain being recovered after 8 days from the superficial lesions formed. Typical wilt occurred only in trees inoculated with all four fungi. Scolytus intricatus appeared to be a carrier.

113. KENDRICK, J. B. Jr. and A. R. JACKSON. Factors influencing the isolation of certain soil-borne plant pathogens from soil. (Abstr.) Phytopathology 48: 394. 1958.

The presence of certain soil-borne plant pathogens is difficult to detect by soil-dilution techniques. Plating corn seed on water agar after incubation in soil has proved successful in trapping Pythium, Rhizoctonia, Fusarium, and Sclerotium spp. as well as certain other fungi. Soil moisture, temperature, and incubation period, however, influence the kinds and percentage recoveries of these fungi.

114. MACHACEK, J. E. Prevalence of Helminthosporium sativum, Fusarium culmorum and certain other fungi in experimental plants subjected to various cultural and manurial treatments. Can. J. Plant Sci. 37: 353-365. 1957. (Rev. Appl. Mycol. 37: 265. 1958.)

During 7 years of sampling 62 genera of microfungi were found in the soil of experimental plots. The five saprophytic species Aspergillus flavipes, Penicillium chrysogenum, P. intricatum, P. restrictum, and P. terrestre accounted for 52.7 percent of the colonies isolated. Fusarium culmorum and Helminthosporium sativum (Cochliobolus sativus) made up only 0.5 percent. Soil temperature and rainfall had no effect on the number of these and other fungus colonies, neither did crop rotation nor soil fertilization.

115. MESSIAEN, C. M. (Sugar content of maize stalks and parasitic lodging.) Rev. Path. veg. 36: 209-213. 1957. (Rev. Appl. Mycol. 37: 407. 1958.)

The author attempted to ascertain correlation between the lack of sugars in the roots of maturing maize plants and the susceptibility of roots and stalks to fungi causing lodging. Fungi used for inoculations were Colletotrichum graminicola, Gibberella zeae, and Phaeocytospora zeae. Results showed clearly that resistance to infection occurs when the sugar content is over 5 percent.

116. MORWOOD, R. B. Notes on plant diseases listed for Fiji. Agric. J. Fiji 27: 83-86, 1956. (Rev. Appl. Mycol. 37: 204. 1958.)

Phytophthora palmivora causes serious fruit and root rots of papaw. Panama disease (Fusarium oxysporum f. cubense) of banana, previously recorded in Fiji, has not been seen by the writer. Heavy losses of potato crops are caused by Fusarium wilt (F. oxysporum) and other diseases.

117. NELSON, PAUL E. Pathogenic soil fungi and diseases they cause. Florists' Exchange, 130 (2): 13, 48-49. 1958.



118. NOORDAM, D., D. P. TERMOHLEN and T. H. THUNG. Corky root symptoms of tomato caused by a sterile mycelium. Tijdschr. Plantenziekten 63: 145-152. 1957. (Biol. Abstr. 32: 875. 1958.)

A sterile fungus isolated from sieved and centrifuged corky root powder was mixed with silversand or sterilized soil. Tomatoes planted in pots filled with these mixtures showed symptoms of corky roots. From 39 out of 65 root pieces the same fungus was re-isolated.

119. PAPAÏOANNOU, A. J. Notes phytopathologiques. I. II. Ann. Inst. phytopath., Benaki, 8: 96-102. 1954; 10: 22-27. 1956. (Rev. Appl. Mycol. 37: 133. 1958.)

Diseases new to Greece included wilt of pistachio nut, believed to be caused by Fusarium sp. but also associated with Verticillium albo-atrum as a secondary invader.

120. PLANT PATHOLOGY DIVISION. Res. and exp. Rec. Minist. Agric. North Ireland 5 (1955): 129-151. 1957. (Rev. Appl. Mycol. 37: 3-4. 1958.)

Red core (Phytophthora fragariae) is now an acute problem in the strawberry-growing districts of County Armagh, where the problem will be to replace the susceptible variety Climax by another resistant to the disease. Over 20 cases of foot rot (Phytophthora cryptogea) of tomato were recorded, the earliest sample being encountered on April 20. Fusarium caeruleum and, to a lesser extent, Fusarium avenaceum were mainly responsible for dry rot of potato. F. culmorum and Cylindrocarpum radicola also cause the condition on occasion. Crown gall (Bacterium (Agrobacterium) tumefaciens) of garden beet was reported in County Londonderry. In mid-October, 1955, 20 percent of a recently lifted and severely scabbed (Actinomyces (Streptomyces) scabies) crop of Stormont Dawn potato in County Armagh exhibited a marked proliferation of the sprouts, with cauli-flower-like growths, simulating wart disease, at the rose end of the tuber. This was not necessarily due to the scab caused by S. scabies.

121. PLANT PATHOLOGY DIVISION. Res. and exp. Rec. Minist. Agric. North Ireland, 6 (1956): 158-181. 1957. (Rev. Appl. Mycol. 37: 324-326. 1958.)

Fusarium culmorum, F. sambucinum, and F. tricinctum are recorded as causing occasional rots of potato tubers. The greater prevalence of rots caused by F. caeruleum is thought to be related to its more frequent occurrence in the field and ability to infect tubers under conditions of low humidity. Five isolates of F. avenaceum from seed oats were pathogenic to potato tubers. In general, susceptibility to dry rot increases with age and is unaffected by slight variations in the storage temperature. Fusarium caeruleum on potatoes is easily spread by a cutting knife and may also enter the tuber through common scab (Streptomyces scabies) lesions. In experiments on the effect of nutrition in relation to club root (Plasmodiophora brassicae), the disease index fell as the dosage of ammonium sulphate plus superphosphate was increased. High levels of N and P were associated with the least severe attacks, K having the opposite effect.

122. PRASAD, N., I. M. PATEL and H. M. SHAH. "Chitri" disease of tobacco in Gujarat. I. Nature of disease. Proc. 1st Conf. Tob. Res. Wkrs., Bangalore: 72-74. 1957. (Coresta 1: 79. 1958.)

In the field the disease either attacks stray plants or forms round patches. Affected plants start wilting gradually and ultimately die; their vascular and parenchymatous tissues are affected. Nematodes and two fungi, Rhizoctonia and Fusarium, were found in the field. Twelve pathogenic strains of Fusarium were isolated from affected plants; nine of these were mostly in vascular tissues and three in the parenchyma. Isolates were divided into two species: F. oxysporum var. nicotianae and F. solani var. nicotianae. The authors conclude that the disease was not caused by nematodes or Rhizoctonia although the presence of nematodes increased the incidence of disease. The disease was attributed to a complex of Fusarium strains of two categories affecting the vascular and parenchymatous tissues

respectively.

123. RABINOVICH, Z. D. (Saprophytic and pathogenic fungal microflora of jute in the south-ern Ukraine.) *Mikrobiologiya* 25: 217-220. 1956. (Biol. Abstr. 32: 3224. 1958.)  
Rhizoctonia solani and Fusarium were found to cause a root rot of jute sprouts in the Odessa district of the South Ukraine Canal. Alternaria tenuis causes yellowing of the cotyledons and death of the sprouts. Trichothecium roseum decreases the germinating ability of the seeds, causing smothering and rotting of the sprouts.
  
124. RAGIMOV, U. A. (New diseases of cucurbits in the western districts of Azerbaijan SSR.) *Proc. Acad. Sci. Azerb. SSR*. 14: 65-70. 1958. (Rev. Appl. Mycol. 37: 623. 1958.)  
 During 1954-56 cucurbit diseases were studied in seven districts of Azerbaijan. Fusarium wilt was widespread on melons, cucumbers, and watermelons. Pythium aphanidermatum was recorded in cucumbers, melons, squash, and pumpkins. It was shown that cucurbits planted in fields previously sown with lucerne were attacked much less by Fusarium sp., to which all melons are susceptible.
  
125. SARMAH, K. C. Diseases in relation to environment. Two & a Bud (News Lett. Tocklai exp. Sta.) 4 (4): 14-16. 1957. (Rev. Appl. Mycol. 37: 677. 1958.)  
 Among tea diseases mentioned are the following: Violet root rot (Sphaerostilbe repens) is favoured by warm, wet conditions. Black root rot (Rosellinia arcuata) is found more often at high altitudes. Brown root rot (Fomes lamaoensis) occurs more usually in the plains, where its distribution differs somewhat from that of tarry root rot (Hypoxylon asarcodes).
  
126. SINGH, B. and R. S. SINGH. Temperature and moisture relations of the fungi causing seedling-rot, root-rot and wilt of Cyamopsis psoralioides DC. 1. Effect of temperature on growth of fungi in artificial media. 2. Effect of soil moisture on mortality under controlled conditions. *Agra Univ. J. Res. (Sci.)* 5: 135-141. 1956. (Rev. Appl. Mycol. 37: 103. 1958.)  
 Further studies at the Government Agricultural College, Kanpur, India, established that Rhizoctonia (Corticium) solani causing root rot, and Fusarium caeruleum wilt of Cyamopsis psoralioides grew best in artificial media at 28-30° and 26-28°C, respectively. Pre- and post-emergence losses due to Corticium solani occurred at 15-60 percent soil moisture. A combination of the two fungi was almost equally severe throughout the range of 15-60 percent. At 20 percent C. solani produced local necrosis of the hypocotyl and roots; at higher levels it caused rotting of the root or whole seedling.
  
127. STALDER, L. and F. SCHÜTZ. Untersuchungen über die kausalen Zusammenhänge des Erikawurzelsterbens. (Studies on the causal associations of root drying in Erica.) *Phytopath. Z.* 30: 117-148. 1957. (Rev. Appl. Mycol. 37: 239. 1958.)  
 The widespread and high mortality of Erica gracilis in Swiss nurseries is attributed in the first place to a disequilibrium in the root/shoot relation caused by N fertilizers, which at the same time inhibit the growth of beneficial mycorrhiza and promote that of Olpidium brassicae and an increasingly prevalent Rhizophidium sp. This is believed to be the first record of a Rhizophidium sp. as a parasite on plant roots.
  
128. TACONIS, P. J. (Diseases and pests of Christmas spruces.) *Ned. BosbTijdschr.* 29: 289-292. 1957. (Rev. Appl. Mycol. 37: 745. 1958.)  
 The pre-emergence phase of damping-off is associated in The Netherlands with infection by soil fungi, e.g. Corticium, Fusarium, Pythium and Coniothyrium spp., but the late stage of collapse, developing in September, has lately been shown to be due to nematodes.
  
129. TERMOHLEN, G. P. (Corky root of tomato caused by a sterile mycelium. II.) *Tijdschr. Plantenziekten* 63: 369-374. 1957. (Biol. Abstr. 32: 2083. 1958.)

Seventy percent of the isolates grown from diseased roots consisted of a sterile fungus. Inoculation experiments were successful in reproducing the disease only with sterile type fungi. Within the sterile group, about ten strains could be distinguished, differing in growth rate and color. The fungus is non-sporulating, dark-colored and slow growing. Microsclerotia were found in several cultures after 2-3 weeks.

130. TODOROVA, MME. V. (Foot and root rot of cereals.) Bull. Plant Prot., Sofia, 6: 15-28. 1957. (Rev. Appl. Mycol. 37: 527. 1958.)

Injuries resembling root rot caused by Ophiobolus graminis were observed. Gibellina cerealis was shown to cause foot rot; root rot of young plants was also attributed to Helminthosporium sativum, Rhizoctonia (Corticium) solani, Fusarium culmorum, F. nivale, and Pythium spp.

131. WAGNER, F. (Contribution to the lucerne wilt problem on the basis of a mycological study of the roots.) Pflanzenschutz 9: 109-110. 1957. (Rev. Appl. Mycol. 37: 101. 1958.)

Of 731 lucerne root fragments cultured on nutrient agar 6.95 percent yielded Verticillium albo-atrum, 3.69 percent Ascochyta imperfecta, 1.64 percent Cylindrocarpon spp., 27.31 percent Fusarium spp., 2.73 percent sterile or unidentified fungi, and 32.55 percent bacteria. Bacterial activity was great and suppressed the growth of fungi, especially V. albo-atrum and A. imperfecta, in the cultures and in some cases prevented the development of Fusarium spp., of which at least eight were probably partially responsible for the wilt. The composition of the fungal population did not remain constant during the investigation. The macroscopically visible discolorations of the vascular bundles and the cambium in wilted lucerne plants was not an infallible indication of the presence of a pathogen, while V. albo-atrum and A. imperfecta were frequently isolated from externally sound material.

132. WHITNEY, N. J. and C. G. MORTIMORE. Root and stalk rot of field corn in south-western Ontario. I. Sequence of infection and incidence of the disease in relation to maturation of inbred lines. Can. J. Plant Sci. 37: 342-346. 1957.

Investigation of root and stalk rot showed that the stalk rot phase of the disease occurred only after the root system was nearly totally diseased. It is indicated in a footnote that Fusarium spp. and one species of Pythium were isolated consistently from the rotted roots.

133. ANNUAL REPORT OF THE JUTE AGRICULTURAL RESEARCH INSTITUTE (1955-56). 144 pp. ? 1957. (Rev. Appl. Mycol. 37: 85-86. 1958.)

Fusarium solani was non-pathogenic when inoculated singly, but produced typical wilt symptoms when used together with Macrophomina phaseoli and Ozonium sp. Root rot of Hibiscus cannabinus was associated with Macrophomina phaseoli and F. oxysporum, alone or in combination, causing more damage together.

134. NEW VEGETABLE VARIETIES, LIST V. Proc. Amer. Soc. hort. Sci., 71: 591-600. 1958. (Rev. Appl. Mycol. 37: 746. 1958.)

Among vegetable varieties listed, with their resistance to various diseases (in parentheses), are (1) celery Slow Bolting Green No. 12 (yellows -- Fusarium apii); (2) peas Glacier, Surpass, Hardy, and others (Fusarium wilt -- F. oxysporum f. pisi), and Pacific Freezer (Fusarium root rot -- Fusarium spp.); (3) sweet potato Coppergold (stem rot -- F. bulbigenum var. batatis); (4) the tomatoes J. Moran, Grathens Globe (W. R.), and others (Fusarium wilt -- F. bulbigenum var. lycopersici), Grand Pak (resistant to Verticillium albo-atrum). The potato variety Merrimack is highly resistant to late blight (Phytophthora infestans) and ring rot Corynebacterium sepedonicum.

135. TWENTY-FIRST BIENNIAL REPORT, STATE PLANT BOARD OF FLORIDA, 1954-56. Rep. Fla. Pl. Bd. 2 (Bull. 11A). 1957.



The ornamental pathology section (pp. 78-89) of this report states that the most serious disease of pompon chrysanthemum is root rot and wilt, a complex of Pythium spp., Rhizoctonia (Corticium) solani, Fusarium oxysporum, and nematode damage.

#### Fungi -- Aphanomyces

136. SCHNEIDER, C. L. Further studies on the host range of Aphanomyces cochlioides. (Abstr.) Phytopathology 48: 463-464. 1958.

Seedlings of 94 plant species representing 31 families were exposed to zoospores of A. cochlioides in Petri dishes and in pots of soil. The species that became infected are named. In addition, the fungus was isolated from plants of each of these species grown in naturally infested field soil. A list of older plants as well as seedlings of common weeds and cultivated plants that were susceptible to infection is also given.

#### Fungi -- Armillaria

137. GIBSON, I. A. S. Armillaria root rot. Rep. For. Dep. Kenya, 1954-55, p. 20. 1957. (Rev. Appl. Mycol. 37: 190-191. 1958.)

In a survey for A. mellea in Kenya pine plantations Pinus canariensis was found to be the most susceptible and P. halepensis the least, with P. patula and P. radiata intermediate; plantations on grassland sites had little infection, while sites carrying bamboo, indigenous forest, or previous plantations were infested to a certain extent.

138. RAABE, R. D. Some previously unreported non-woody hosts of Armillaria mellea in California. Plant Disease Repr. 42: 1025. 1958.

The oak root fungus, Armillaria mellea, has been found on non-woody or herbaceous plants. These include Amaryllis vittata, Fuchsia hybrida, Impatiens oliverii, Pelargonium domesticum, and P. peltatum.

#### Fungi -- Botryodiplodia

See also 219

139. TWEEDY, B. and D. POWELL. Charcoal rot on strawberry in Illinois. Plant Disease Repr. 42: 107. 1958.

The charcoal rot organism, Botryodiplodia phaseoli (Maubl.) Thirumalachar, was isolated from vascular tissue of both roots and above-ground parts of strawberry. It has been established that the charcoal rot requires a high temperature along with a dry soil for best development.

#### Fungi -- Centrospora

140. SRIVASTAVA, S. N. S. Studies on Centrospora acerina (Hartig) Newhall, the cause of licorice rot of carrot. Trans. Brit. Mycol. Soc. 41: 223-226. 1958. (Rev. Appl. Mycol. 37: 692. 1958.)

Licorice rot of carrots was observed in Scotland in a field where they had been left overwinter. Only one of three varieties in the field was attacked. The fungus was shown to be pathogenic to celery.

#### Fungi -- Ceratocystis

141. BILBRUCK, JAMES DONALD. The oak wilt fungus, Ceratocystis fagacearum (Bretz) Hunt; Studies of the rate and extent of fungus penetration in oak roots and the nature of a toxic principle in oak heartwood which inhibits growth of the fungus. Diss. Abstr. 18: 372-373. 1958. (Biol. Abstr. 32: 3500. 1958.)

142. YOUNT, W. L. Results of root inoculations with the oak wilt fungus in Pennsylvania. Plant Disease Repr. 42: 548-551. 1958.

Red oak trees in four series 1954, 1955, 1956, and 1957, were inocu-

lated with Ceratocystis fagacearum in the roots at varying distances from the trunk. Trunk-inoculated trees served as check. Incubation periods for both trunk- and root-inoculated trees varied extensively from season to season. The length of time between inoculation and the first foliage symptoms was longer for the root-inoculated trees in every series. Possible reasons for this are discussed.

#### Fungi -- Clitocybe

143. DADANT, R. Le pourridié du caféier à Madagascar. (Root rot of coffee in Madagascar.) Café, Cacao, Thé, 1: 126-131. 1957. (Hort. Abstr. 28: 487. 1957.)

The parasitic fungus Clitocybe tabescens can survive for 6-7 years in dead coffee or other wood. Various hosts are listed, a very common one being Albizia lebbbeck, the principal coffee shade tree of Madagascar. No effective fungicidal treatment has yet been evolved. Spread of the disease has been successfully checked by ascertaining the exact extent of every affected section of the plantation and bark-ringing every diseased tree and every healthy coffee and shade tree in a belt surrounding the diseased patch. The exposed wood is treated with mineral oil to prevent bark renewal, and after exhaustion of root carbohydrate reserves and subsequent death these trees form a barrier against the fungus.

#### Fungi -- Colletotrichum

144. PULSIFER, H. G. Damping-off of cotton seedlings caused by Colletotrichum hibisci Poll. Iowa State Coll. Jour. Sci. 32: 57-61. 1957. (Biol. Abstr. 32: 875. 1958.)

Isolates of C. hibisci capable of causing tip blight and other symptoms in kenaf (Hibiscus cannabinus) were also capable of causing damping-off of cotton (Gossypium) seedlings, producing symptoms typical of damping-off due to C. gossypii.

#### Fungi -- Corynespora

145. BOOSALIS, M. G. and R. I. HAMILTON. Root and stem rot of soybean caused by Corynespora cassiicola (Berk. & Curt.) Wei. Plant Disease Repr. 41: 696-698. 1957.

Corynespora cassiicola was found to cause a previously undescribed root and stem disease of soybean. Soil temperatures above 19° to 21°C arrest the development of the disease before it can damage the host sufficiently to inhibit yield. The highest incidence of the disease was found in fields where soybeans had been planted for 2 successive years. The pathogen overwinters on infected root and stem tissues of soybeans and survives in infested, unsterilized soil for at least 2 years.

#### Fungi -- Dialonectria

146. ORIAN, G. Plant Pathology Division. Rep. Dep. Agric. Mauritius, 1955, pp. 90-93, 1957. (Rev. Appl. Mycol. 37: 205. 1958.)

Sphaerostilbe repens, as Dialonectria sp., was found associated with root disease in an experimental tea plot.

#### Fungi -- Fomes

147. JONES, T. W. and T. W. BRETZ. First report of tree mortality from Fomes annosus root rot in Missouri. Plant Disease Repr. 42: 988. 1958.

Fomes annosus, root rot, has been identified as the cause of extensive mortality in a plantation of shortleaf pine (Pinus echinata) in Missouri, where it was first observed in 1956. Additional killing of trees from the same cause continued during 1957.

148. MOLIN, MILS. A study of the infection biology of Fomes annosus. Medd. Skogsforskn.

Inst. Stockholm 47: 1-36. 1957. (English summary)

Root rot, Fomes annosus, in a young pine plantation was found to be spread by infection of roots in contact with infected old spruce stumps.

149. RIGGENBACH, A. Report of Plant Pathology Department. Rep. Rubb. Res. Inst. Ceylon, 1956, pp. 40-48. 1957. (Rev. Appl. Mycol. 37: 180. 1958.)

Root diseases (of rubber trees) especially white root (Fomes lignosus) are commonly present in replanted areas.

#### Fungi -- Fusarium

See also 21, 41, 61, 65, 66, 67, 82, 83, 85, 330, 333, 353, 378, 492, 525, 532, 617, 655, 657, 658, 698, 714, 715, 717, 723, 726, 728, 731, 732, 745, 746

150. ARMSTRONG, G. M. and J. K. ARMSTRONG. Effect of cutting roots on the incidence of Fusarium wilt of cotton, tomatoes, cowpeas and other plants. (Abstr.) Phytopathology 48: 341. 1958.

The percentage of plants showing external symptoms of wilt and the average number of days required for the first symptoms to develop were recorded. The procedure followed is outlined.

151. ARMSTRONG, G. M. and J. K. ARMSTRONG. The Fusarium wilt complex as related to the sweetpotato. Plant Disease Repr. 42: 1319-1329. 1958.

Ninety-two pathogenic isolates of wilt Fusaria from sweetpotato and 28 from flue-cured tobacco were tested on Porto Rico sweetpotato. Fifty-nine sweetpotato isolates were pathogenic on burley but only 23 were pathogenic on flue-cured tobacco. All tobacco isolates were pathogenic on flue-cured tobacco and sweetpotato; those tested on burley were also pathogenic on this host. The problem of reduction in pathogenicity of cultures is discussed. The host relationships of these races (1 and 2) and those from cotton, alfalfa, soybean, and cowpea are compared.

152. ARMSTRONG, J. K. and G. M. ARMSTRONG. A race of the cotton-wilt Fusarium causing wilt of Yelredo soybean and flue-cured tobacco. Plant Disease Repr. 42: 147-151. 1958.

Fusarium isolates were obtained from wilted soybeans in S. Carolina that wilted Yelredo soybean but not cowpea. They also caused wilt of cotton and of burley and flue-cured tobacco which are not the hosts for the two races (1, 2) of the cowpea-wilt Fusarium. Field observations (1938) indicated that the cotton-wilt Fusarium (F. vasinfectum or F. oxysporum f. vasinfectum Sny. & Hansen) was probably a cause of wilt of burley tobacco. This was verified by inoculation experiments. The host complex for the new race of cotton wilt Fusarium is the subject of this report.

153. BACHY, A. and C. FEHLING. (Vascular wilt of oil palm in the Ivory Coast.) J. Agric. trop. Bot. appl., 1957, 4: 228-240. 1957. (Hort. Abstr. 28: 303. 1958.)

The conditions favouring the occurrence of vascular wilt (Fusarium oxysporum f. elaeidis) in palms in the Ivory Coast were studied. Infection was found on both adult and replanted palms. Wilt spread was twice as fast on plots low in K as on plots with high K levels. It also occurred where Mn was deficient. Wilt infection seemed to be more frequent in low-lying areas.

154. CHATTERJEE, PARUL. The bean root rot complex in Idaho. Phytopathology 48: 197-200. 1958. (Biol. Abstr. 32: 2952. 1958.)

Evidence is presented to indicate that dry root rot of beans in Idaho is caused primarily by Fusarium solani f. phaseoli (Burkh.) Snyd. & Hans. There appeared to be three distinct physiologic and pathogenic strains of this species among the 224 isolates studied. Histological examination of infected plants revealed that F. solani f. phaseoli is capable of entering plants by direct penetration through stomata on the hypocotyl and through wounds. The mycelium of the most virulent isolates spread quickly through-



out the cortical tissue of the host plants but less virulent isolates appeared to be restricted in their development by the deposition of a brownish colored substance in the cortical cells adjacent to the points of entry.

155. CHATTOPADHYAY, S. B. and S. K. SEN GUPTA. Wilt of egg-plant (*Solanum melongena* L.). Indian J. mycol. Res. 2: 83-86. 1956. (Rev. Appl. Mycol. 37: 754. 1958.)

A wilt of eggplant in West Bengal was found to be caused by Fusarium solani. Pathogenicity was proved on Sutton's Long Purple.

156. COE, D. M. Some recent developments in diseases of ornamental plants in Florida. Proc. Fla. hort. Soc., 70 (1957): 390. 1958. (Rev. Appl. Mycol. 37: 664. 1958.)

Wilt (Fusarium oxysporum f. perniciosum) of Albizzia julibrissin is well established over a large area in northern Florida, where it is causing serious losses.

157. COLLINS, R. P. and R. P. SCHEFFER. Respiratory responses and systemic effects in *Fusarium*-infected tomato plants. Phytopathology 48: 349-355. 1958. (Chem. Abstr. 52: 21. 1958.)

Respiration in leaves of tomato plants was stimulated soon after infection with Fusarium oxysporum f. lycopersici and reached a peak 9-14 days after inoculation. Stems responded similarly. Evidence of systemic toxemia was found. Ethylene, fusarinic acid, and probably pectic enzymes were eliminated as respiratory stimulants. Ethylene hastened disease development when introduced in solution into inoculated susceptible cuttings and caused cuttings of similarly treated resistant plants to become diseased.

158. COULOMBE, L. J. (*Fusarium* wilt of broad beans.) Rep. Quebec Soc. Prot. Pl., 38 (1956): 26-33. 1957. (English summary) (Rev. Appl. Mycol. 37: 434. 1958.)

Wilt of broad beans caused by Fusarium oxysporum f. fabae appears to be becoming progressively more prevalent in Quebec. Isolates from affected plants were highly virulent when inoculated in sandy and compost soils.

159. DeVAY, J. E. et al. Corn diseases and their importance in Minnesota in 1956. Plant Disease Reprtr. 41: 505-507. 1957. (Biol. Abstr. 32: 2953. 1958.)

In Minnesota large amounts of fertilizers are used occasionally with no regard to the balance of available mineral elements in a particular soil. As a result of these practices, a marked increase in the damage caused by various diseases and pests of corn has been apparent. Gibberella spp. and Fusarium spp. are the most important causes of stalk rot in living plants in all stages of post-emergence in Minnesota.

160. DESROSIERS, R. and E. AMPUERO. Las enfermedades más importantes del campo que afectan al banano en el Ecuador. (The most important diseases affecting bananas in the field in Ecuador.) A.N.B.E. (Asoc. nac. Banan. Ecuador) 2 (1): 33-36. 1957. (Rev. Appl. Mycol. 37: 362. 1958.)

The symptoms and control of Panama disease (Fusarium oxysporum f. cubense) and bacterial wilt (Xanthomonas (Pseudomonas) solanacearum) in Ecuador are described.

161. ERWIN, DONALD C. *Fusarium lateritium* f. *ciceri*, incitant of *Fusarium* wilt of *Cicer arietinum*. Phytopathology 48: 498-501. 1958.

A new name, Fusarium lateritium Nees emend. Snyder & Hansen, f. ciceri (Padwick) n.f., is proposed for the incitant of *Fusarium* wilt of Cicer arietinum L. (garbanzo bean). Symptoms included a gray-green fading of leaves and a dark brown discoloration of the xylem tissues of the stems.

162. EVERETTE, G. A. Strains of *Fusaria* and their effect on tobacco varieties. Tobacco 146: 20-5. (Tobacco Sci. 2: 35-40) 1958. Tobacco Abstr. 2: 221. 1958.

A laboratory method of indexing varieties for resistance to *Fusarium*

wilt has not been refined to a point where it is reliable for individual plant selection. Classification of the isolates into groups was made by using cotton, sweetpotatoes, and flue-cured, dark-fired, one-sucker, and burley tobaccos. At least 17 strains of Fusarium, differing in pathogenicity, seem to be represented in the collection of isolates at the Kentucky Agricultural Experiment Station.

163. FORSBERG, JUNIUS L. Fusarium disease of gladiolus; its causal agent. Illinois Nat. Hist. Surv. Bull. 26: 447-503. 1955. (Biol. Abstr. 32: 262. 1958.)

After making a study of pathogenicity and physiology of 40 isolates of Fusarium from diseased corms, Forsberg proposed that all forms of the gladiolus Fusarium be included under the name F. oxysporum f. gladioli as causal agents of vascular, brown rot, and basal dry rot of gladiolus.

164. GERLACH, W., W. SAUTHOFF and H. PAG. Untersuchungen über die Fusarium-Welke an Aechmea fasciata (Lindl.) Bak. (Erreger: Fusarium bulbigenum Cke. et Mass. f. aechmeae Gerlach et Sauthoff n.f.). (Studies on the Fusarium wilt of A. fasciata (Lindl.) Bak. (Causal agent: F. bulbigenum Cke & Mass. f. aechmeae Gerlach & Sauthoff n.f.)) Phytopath. Z., 32: 416-432. 1958. (English summary) (Rev. Appl. Mycol. 38: 6-7. 1959.)

Tracheomycosis was associated with a wilt disease of Aechmea fasciata in Germany. The sole pathogen was a Fusarium of the section Elegans. The morphological characters are described. The name F. bulbigenum Cke. et Mass. f. aechmeae Gerlach et Sauthoff was proposed. The pathogenicity of this Fusarium was demonstrated.

165. GRAY, E. G. and I. A. NICHOLSON. Snow mould on upland pasture in North Scotland. Trans. & Proc. Bot. Soc. Edinburgh 32: 123-128. 1957. (Biol. Abstr. 22: 2082. 1958.)

Snow mould (Fusarium nivale) was prevalent in upland pasture in North Scotland in 1954-1956. Agrostis spp., A. canina, A. stolonifera, A. tenuis, Lolium perenne, Poa annua, and P. trivialis were most severely affected. Heavy autumn rainfall and prolonged snow cover in early spring apparently favored infection. In areas where grass had been killed out by snow mould, Aira praecox and certain mosses grew well and became dominant.

166. HAGEDORN, D. J. Some observations on diseases of Pisum sativum in several European countries in 1957. Tijdschr. PlZiekt. 64: 263-268. 1958. (Dutch summary.) (Rev. Appl. Mycol. 37: 748. 1958.)

In the Netherlands top yellows (pea leaf roll virus) was the most important disease and was often associated with foot or root rot (Fusarium spp.). Wilt (F. oxysporum f. pisi) was seen in two fields in England. In West Germany, where streak was the most important disease seen, Fusarium root rot (F. solani var. (f.) pisi) was also found, with other diseases.

167. HARRISON, D. J. A Fusarium rot of bulbous iris. Plant Pathology 7: 16-18. 1958.

Results indicate that a strain of Fusarium oxysporum causes a rot of bulbous iris. The fungus does not spread, at least to any extent, from diseased to healthy bulbs in the soil under greenhouse conditions. High temperatures appeared to favor incubation. It was observed that species of Penicillium frequently developed on the bulbs following a Fusarium rot. This often made it difficult to re-isolate Fusarium oxysporum following secondary invasion.

168. HENDRIX, FLOYD F. Jr., and L. W. NIELSEN. Invasion and infection of crops other than the forma susceptible by Fusarium oxysporum f. batatas and other formae. Phytopathology 48: 224-228. 1958. (Biol. Abstr. 32: 2953. 1958.)

In greenhouse and field experiments, the ability of various wilt-inciting Fusaria to invade and colonize roots of crops other than the formae susceptibles was studied, with emphasis on F. oxysporum f. batatas. F. oxysporum f.

batatas invaded and colonized the roots and stems of tomato, sweetpotato, cabbage, tobacco, soybean, snapbean, Irish potato, watermelon, cowpea, corn, and cotton when grown in sand culture. In other sand culture tests sweetpotato roots were invaded and colonized by F. oxysporum formae niveum, phaseoli, vasinfectum, lycopersici, conglutinans, and nicotianae. Only f. nicotianae caused external wilt symptoms in sweetpotato. Cultures of F. oxysporum f. lycopersici isolated from sweetpotato roots were less pathogenic to tomato than was the original culture. The several crops were planted in two fields naturally infested with F. oxysporum f. batatas. Two and 6 weeks after planting replicated samples of plants from each crop were collected for appraising their invasion by Fusaria. Fusaria were isolated from roots and stems of tomato, sweetpotato, cabbage, tobacco, soybean, snapbean, watermelon, cowpea, corn, and cotton. Wilt symptoms developed only in sweetpotato plants. Isolates from tobacco, soybean and corn were more pathogenic to sweetpotato than isolates from cowpea, snapbean, or tomato, but less pathogenic than isolates from sweetpotato plants. However, some isolates from tobacco, soybean and corn were as pathogenic as the isolates from sweetpotato. The ability of F. oxysporum f. batatas and other formae to invade and colonize the roots and stems of plants other than the formae susceptibles provides another means by which wilt Fusaria persist in soils in addition to their pathogenic and saprophytic habits.

169. HILDEBRAND, E. M. et al. Studies on sweet potato stem rot or wilt and its causal agent. Plant Disease Repr. 42: 112-121. 1958.

This investigation sheds light on the cultural identity and pathogenic behavior of the sweetpotato Fusarium (F. oxysporum Schlecht. f. batatatis (Wr.) Snyder & Hansen), the causal agent of stem rot or wilt disease.

170. HOUSTON, BYRON R., P. F. KNOWLES, and L. J. ASHWORTH. The determination of pathogenic races of Fusarium oxysporum f. lini. (Abstr.) Phytopathology 48: 394. 1958.

Sixty isolates of Fusarium oxysporum f. lini were tested to determine the variability of pathogenicity on six pure lines of flax derived from single plant selections of four varieties. Five distinct pathogenic races of the fungus were determined by differential pathogenicity on the six hosts.

171. HWANG, L., Y-S. CHEN and H-Y. HWANG. A preliminary study of sweet potato wilt and its control. Acta phytopath. sinica 2: 97-113. 1956. (Rev. Appl. Mycol. 37: 179-180. 1958.)

Sweetpotato wilt attacks the fibro-vascular bundles and infects cuttings and plant parts in close contact with the soil. The infected parts have a water-soaked appearance and later blacken and rot. Fusarium spp. were found associated with the disease. High humidity and high temperature are closely related to disease development.

172. JAMALAINEN, E. A. Overwintering of plants in Finland with respect to damage caused by low-temperature pathogens. Publ. Finnish State Agric. Res. Bd. 148: 5-30. 1956. (Biol. Abstr. 32: 1481. 1958.)

One of the most important reasons for poor overwintering is the presence of pathogenic fungi. In winter rye, winter wheat and other gramineous plants, damage is caused by Fusarium nivale and other fungi. Red clover was attacked by Fusarium in northern Finland.

173. KLING, E. G. (On the physiology of gladioli with yellows disease.) Bull. centr. bot. Gdn, Moscow, 1958, 30: 72-77. 1958. (Rev. Appl. Mycol. 37: 665. 1958.)

In several regions in the U.S.S.R. infection by Fusarium sp. and yellows has become very severe since 1954. Author recommends a 3- to 4-year interval before planting corms in fields that have had diseased plants, destruction of diseased plants early in the season, disinfection of the corms after harvesting and before planting, and the use of resistant



varieties only.

174. LAKSHMINARAYANAN, K. The physiology of host-parasite relationship in the *Fusarium* wilt of cotton. II. Pectin methyl esterase formation by *Fusarium vasinfectum* Atk. III. Distribution and derangement of free amino acids. *Proc. Indian Acad. Sci., Sect. B*, 47: 78-86, 115-123. 1958. (Rev. Appl. Mycol. 37: 479. 1958.)

The distribution of 23 amino acids in the roots, shoots, and leaves was examined chromatographically in 6- and 12-day-old susceptible and resistant varieties of cotton infected by *F. vasinfectum* and in healthy controls. In the control series cystine was consistently present in all organs of the resistant varieties but completely absent from susceptible variety K2, suggesting a relationship with the mechanism of wilt resistance. In the inoculated series cystine made its appearance in susceptible (K2) plants (roots and shoots only) at 6 days but was absent from these and from resistant varieties at 12 days. It is suggested that the appearance of cystine in K2 may represent a systemic immunological response.

175. MARLATT, ROBERT B. Onion *Fusarium* basal rot in Arizona. *Plant Disease Repr.* 42: 667-668. 1958.

A greenhouse experiment showed that onion bulbs were readily infected by the fungus, *F. oxysporum* f. *cepae*, when roots had been injured mechanically. Apparently healthy bulbs grown in inoculated soil could develop *Fusarium* basal rot when stored for 3 months at 75° F to 85° F.

176. MARTIN, J. P. and J. O. ERWIN. Changes in fungus populations of California orchard soils when cropped to orange seedlings in the greenhouse. *Soil Sci.* 86: 141-147. 1958.

It was found that the total numbers of fungi increased during cropping in the greenhouse while the kinds decreased. *Fusarium solani* persisted in similar numbers in the greenhouse and field soils.

177. NEELY, R. D. A study of *Fusarium* root rot and wilt of soybeans. *Diss. Abstr.* 17: 2132. 1957. (Rev. Appl. Mycol. 37: 568. 1958.)

In summer, 1953, a new disease of soybeans caused by *F. orthoceras* was reported from north-central Missouri on heavy river bottom soils. Symptoms were slight chlorosis, rapid wilting and subsequent drying of the leaves which remain attached to the stem, necrosis of lateral roots and discoloration of the vascular system of root and stem. Certain strains were tolerant or genetically resistant. The fungus tolerated a wide pH range (2-11) and temperatures of 10° to 40° C. A flooding inoculation technique was used. Variation in pathogenicity within *F. orthoceras* was noted. Wilt production is ascribed to a non-volatile substance, toxic to soybean plants, which is produced by the fungus on Richard's solution, later replaced by distilled water for 48 hours.

178. NISHIMURA, S. Observations on the fusaric acid production of the genus *Fusarium*. *Ann. phytopath. Soc. Japan*, 22: 274-275. 1957. (Japanese. Abs. from English summary.) (Rev. Appl. Mycol. 37: 763. 1958.)

It is reported that in a study of 25 strains of six species of *Fusarium* all strains belonging to *F. oxysporum* and *F. moniliforme* (*Gibberella fujikuroi*) produced fusaric acid in culture whereas those of other species (*F. solani*, *F. lateritium* (*G. lateritia*), *F. roseum*, and *F. nivale* (*Calonectria nivalis*)) did not.

179. NISHIMURA, S. Pathochemical studies on watermelon wilt. (Part 5.) On the metabolic products of *Fusarium oxysporum* f. *niveum* (E. F. Smith) Snyder et Hansen. *Ann. phytopath. Soc. Japan* 22: 215-219. 1957. (Japanese. Abs. from English summary.) (Rev. Appl. Mycol. 37: 753. 1958.)

These further studies on *Fusarium* (*bulbigenum* var.) *niveum* include a chromatographic method indicating the amount of fusaric acid present, one of the metabolic products of the pathogen responsible for the develop-

ment of the disease symptoms. It was detected in soils infested by the pathogen.

180. OSTAZESKI, S. A. The initial symptoms of red clover root rot; associated fungi, and the effect of inoculation methods on their pathogenicity. Diss. Abstr. 17: 2396-2397. 1957. (Rev. Appl. Mycol. 37: 547. 1958.)

In the early stages of red clover root rot greenhouse-grown plants were invaded by nematodes and a mycorrhizal fungus 10 days after planting. After 18 days lesions were found in the roots and after 45 days spots and killed rootlets were found. Most plants had no rootlets on the upper part of the taproot after 72 days. Fungi were associated with crown rots, outer phloem decay, in the cortex and epidermis of noncambial roots, but not with brown deposits in the xylem adjoining the remains of a dead or dying lateral root. The most frequent isolates included F. oxysporum and F. solani; other Fusarium spp. were among less frequently found fungi. When soil was inoculated with whole oats or maize-meal sand on which F. solani, F. oxysporum, or Gliocladium roseum had been cultured, all three were pathogenic. When mixed with soil as spore suspensions, blended tube cultures, or soil substrate inoculum, they were usually non-pathogenic. Other pathogenicity tests were conducted.

181. PARKINSON, D. and C. G. C. CHESTERS. Occurrence of Fusarium culmorum (W. G. Sm.) Sacc. in the rhizosphere of oats. Nature 181: 1746-1747. 1958. (Rev. Appl. Mycol. 37: 532-533. 1958.)

At the University of Nottingham studies on the fungal components of the rhizosphere microflora of oats revealed striking changes in the fungi present with increasing age of the roots and at different positions in the rhizosphere. F. culmorum and other Fusarium isolates (including F. avenaceum) increased in frequency with increasing age of the plants, most rapidly in the crown zone and least at the tip. Increase in the amount of F. culmorum present in root material was recently demonstrated to be associated with the degree of decomposition of the root. It would appear, therefore, that under an oat crop approaching senescence there develops in the soil a population of a potential pathogen which could have serious effects on a subsequent cereal crop.

182. PRENDERGAST, A. G. Observations on the epidemiology of vascular wilt disease of the oil palm (Elaeis guineensis, Jacq.). J. W. Afr. Inst. Oil Palm Res., 2: 148-175. 1957. (Rev. Appl. Mycol. 37: 52. 1958.)

Vascular wilt was significantly less in areas which had received adequate applications of K. New infections tended to be more frequent adjacent to existing ones, and severe wilt occurred in young palms replanted in old wilt sites.

183. PŘÍHODA, A. (Cactus rot.) Živa 4: 141-143. 1956. (Rev. Appl. Mycol. 37: 356. 1958.)

The symptoms and development of fungal disease of cacti caused by F. oxysporum, F. aqueductum var. dimerum, and other fungi are described.

184. PROTSENKO, E. P. (Premature yellowing of gladioli.) Bull. centr. bot. Gdn, Moscow, 1958, 30: 78-84. 1958. (Rev. Appl. Mycol. 37: 665. 1958.)

In many districts in the U.S.S.R. yellowing of gladioli caused by Fusarium spp. reaches 60 to 80 percent. The predominant species appear to be F. orthoceras var. gladioli causing withering, and F. oxysporum var. gladioli, rotting the corms. The pathogenicity of the two species was established by inoculation and dipping the roots in a spore suspension. Withering and yellowing is a specific tracheomycosis following the rotting of the rootlets by nonspecific Fusarium infection.

185. RAHEJA, P. C. and G. P. DAS. Development studies in crop plants II. -- Effect of cultural treatment on the incidence of gram wilt. Indian J. agric. Sci., 27: 237-

250. 1957. (Rev. Appl. Mycol. 37: 626-627. 1958.)

Work at New Delhi on the effect of spacing and date and depth of sowing on the occurrence of gram (Cicer arietinum) wilt (Fusarium orthoceras var. ciceri) showed the treatments to have no effect on early wilt which occurred 10-15 days after sowing. Incidence of late wilt decreased with delayed sowing, shallow seeding and wider spacing.

186. REID, JAMES. Studies on the Fusaria which cause wilt in melons. I. The occurrence and distribution of races of the muskmelon and watermelon Fusaria and a histological study of the colonization of muskmelon plants susceptible or resistant to Fusarium wilt. Can. J. Botany 36: 393-410. 1958.

It has been shown that more than one type of isolate of both the muskmelon Fusarium and the watermelon Fusarium occur naturally in infested soil. The isolates of both organisms could be divided into many cultural races, depending on the number of isolations made. Among these cultural races differences were demonstrated in their ability to establish successful host-parasite relationships with their respective host plants. The field reactions of various host varieties were shown to be a function of the races present in a soil at a given time. Fluctuations in the relative frequency of the race present in a field have been shown to occur, as well as changes in the races present. The effect of temperature on colonization appeared to be on the aggressiveness of the parasite rather than on the susceptibility of the host.

187. REID, JAMES. Studies on the Fusaria which cause wilt in melons. II. The effect of light, nutrition, and various chemicals on the sporulation of certain fusarial isolates, and preliminary investigations on the etiology of wilting of the muskmelon Fusarium. Can. J. Botany 36: 507-537. 1958.

Light was shown to affect the amount of microspore production in a number of Fusarium species. Macrospore production and the ratio of macrospores to microspores increased with increasing light intensity and vice versa. Only colony areas exposed to light during active growth produced macrospores on PDA or Czapek's agar. Both C- and N-sources were important in determining the kind and amount of sporulation in the species tested. Colony growth was appressed in light and pigmentation of the mycelium was produced in response to light. Various enzyme inhibitors induced different effects on growth and sporulation. Studies on the etiology of wilting indicated that the muskmelon Fusarium produces at least three chemical fractions which may contribute to wilting.

188. SAUTHOFF, W. and W. GERLACH. (On a hitherto unknown Fusarium wilt disease of Aechmea fasciata (Lindl.) Bak.). NachrBl. dtsh. PflSchDienst (Braunschweig), Stuttgart, 10, 1, 1-3. 1958. (Rev. Appl. Mycol. 37: 356. 1958.)

F. bulbigenum f. aechmeae f. nov. causes a wilt of Aechmea fasciata (ornamental) in Berlin. A wilt of the seedling leaves is followed by the appearance on the leaf base of a grey-green or brownish lesion, which under warm humid conditions rapidly spreads upwards over the leaf surface. The leaf collapses when the free part of the blade is reached and later rolls up and dries. This condition spreads from the outer to the inner leaves. Under cool dry conditions the original leaf base lesion does not spread upwards, but the fungus slowly penetrates the bases of the inner leaves. The internal symptoms are little affected by the environment. Brown discoloration of the vessels in the stem close behind the growing point is a reliable diagnostic feature. It is thought that Fusarium normally enters by the roots.

189. SCHNEIDER, R. (Studies on the variability and taxonomy of Fusarium avenaceum (Fr.) Sacc.). Phytopath. Z. 32: 95-126, 129-148. 1958. (Rev. Appl. Mycol. 37: 763. 1958.)

Sixty-eight single-spore isolates of F. avenaceum of different origin were examined in pure culture. The single-spore progeny of the initial cultures of all strains developed 70 to 100 percent variations. In paper No.



2 it is demonstrated that the morphological deviations of three variants from the original form of the fungus are linked with a loss of virulence and pathogenicity. They differed in pathogenicity not only from the original but also among themselves. In infection tests it was impossible to recreate the original virulence and pathogenicity by single or repeated passage through the host. The re-isolations were identical with the original inoculum. The forms from cereals, Lupinus spp., and carnation were not only pathogenic to their own hosts and to closely related species, and species of other genera in the same family, but also gave positive results in cross-infection tests. Thus, F. avenaceum is not host specific.

190. SEQUEIRA, L. et al. Role of root injury in Panama disease infections. *Nature* 182: 309-311. 1958. (Hort. Abstr. 28: 645. 1958.)

A heavy spore suspension of F. oxysporum f. cubense was applied to healthy main root surfaces both at the tip and in mature regions. No penetration was observed and the pathogen showed no evidence of ability to attack living cells of the main root. When the mature tissue of the main root was wounded deeply enough to expose the xylem, fungus penetration occurred rapidly. Wounding of immature tissue of the main root, however, did not result in fungus penetration. Some penetration of apparently intact lateral rootlets occurred, but injury was an important factor in rootlet invasion. There was a consistent stimulation of spore germination in the vicinity of a wounded root surface and an inhibition of spore germination by the intact root surfaces.

191. STOVER, R. H. and S. R. FREIBERG. Effect of carbon dioxide on multiplication of Fusarium in soil. *Nature* 181: 788-789. 1958.

F. oxysporum (lycopersici, nicotianae, cucumerinum) was stimulated by air enriched with 4 percent CO<sub>2</sub>; other Fusaria gave erratic results (including F. solani and F. roseum). It was then determined that F. oxysporum f. cubense was able to fix (radioactive) carbon (CO<sub>2</sub>) in its mycelium. This led the authors to suggest that stimulation of multiplication of the Fusarium species studied may be due to participation of CO<sub>2</sub> from the soil atmosphere in metabolic processes of the fungus.

192. STOVER, R. H. Studies of Fusarium wilt of bananas. II. Some factors influencing survival and saprophytic multiplication of F. oxysporum f. cubense in soil. *Can. J. Botany* 36: 311-324. 1958.

The effect of 1 percent glutamic acid, banana sap, water, and CO<sub>2</sub> on sporulation of F. oxysporum f. cubense in infested soil was studied under laboratory conditions. Increases in population were determined by microscopic examination and dilution plating on PDA containing rose bengal and streptomycin. The amount of multiplication (fungus) varied among different soils, samples from the same soil, and different experiments. This is attributed to unknown variables influencing multiplication and survival in soil microhabitats. The evidence obtained supports the thesis that F. oxysporum f. cubense can multiply saprophytically in soil.

193. TAMMEN, JAMES. Pathogenicity of Fusarium roseum to carnation and to wheat. *Phytopathology* 48: 423-426. 1958.

Sixty-two clones of Fusarium roseum were studied in a series of five cross-pathogenicity tests to determine whether the clones that incite a root, crown, and stem rot disease of the perpetual flowering carnation were pathogenically distinct from those of F. roseum f. cerealis which incites a seedling blight and root or foot rot of cereals. It is concluded that pathogenic clones of F. roseum, irrespective of the original host from which they were isolated, are not pathogenically specialized in respect to the tested host plants and that the carnation pathogen is F. roseum f. cerealis.

194. TEAKLE, D. S. Fusarium foot rot of cucurbits. *Queensland Agric. Jour.* 83: 253-255. 1957. (Biol. Abstr. 32: 1177. 1958.)

Foot rot in Queensland is caused by Fusarium solani f. cucurbitae which produces an orange colored rot on stems near the ground. Susceptibility of cucurbits ranges from high in pumpkins to low in cucumbers and rock melons. The disease becomes established in the soil and rotations of at least 3 years are necessary in infested areas. The fungus is also seed-borne, entering cucurbit fruit from the soil and penetrating the seed.

195. VAN ANDEL, O. M. Importance of amino-acids for the development of Fusarium oxysporum f. lupini Sn. et H. in xylem of lupins. Acta bot. neerl., 1956, 5: 280-286; Lab. Phytopath. Wageningen, 1956, Meded. 166. (J. Sci. Food Agr. 9: i-195. 1958.)

The growth of the fungus in a medium containing, as the sole source of C, one or more of the amino acids associated with the xylem-sap is studied. It is very unlikely that these amino acids act as sources of C for the invading fungus. No evidence is found of any inhibitory substance in the sap.

196. WEBER, G. F. Vascular wilt of mimosa in Florida. Plant Disease Reprtr. 41: 640-642. 1957. (Biol. Abstr. 32: 2955. 1958.)

The wilt disease of mimosa, due to Fusarium oxysporum f. perniciosum, has been spreading in Florida since 1952. Extensive bleeding on the trunk in the early stages of the disease was observed.

197. WOLF, F. T. Nutrition and metabolism of the tobacco wilt Fusarium. Torrey Bot. Club. B 82: 343-354. 1955. (Tobacco Abstr. 2: 397. 1958.)

The tobacco wilt fungus, F. oxysporum var. nicotianae, is able to utilize a wide variety of carbon sources. Only D-arabinose, lactose, and melibiose were poorly utilized of 16 substances tested. The fungus utilized nitrate, ammonium, or amino nitrogen. Growth on certain amino acids is far superior to that obtained on inorganic nitrogen sources. Nucleic acid derivatives were less effective than the best of the amino acids as sources of nitrogen. In shake culture the pathogen grows in a yeast-like fashion. In culture filtrates a red water-soluble pigment is produced which has the properties of an indicator. This pigment has been identified as rubrofusarin.

198. YAMAMOTO, W., N. OYASU and K. TAKIGAWA. Studies on the wilt disease of broad bean. I. Sci. Rep. Hyogo Univ. Agric. 2: 53-62. 1955. (Japanese. Abs. from English summary.) (Rev. Appl. Mycol. 37: 129. 1958.)

Broad bean wilt and root rot in Japan is associated with infection by Fusarium avenaceum (Fr.) Sacc. f. fabae (Yu) Yamamoto comb. nov., F. oxysporum f. fabae, F. solani f. fabae, and F. graminearum.

199. ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE, UGANDA, FOR THE YEAR ENDED 31ST DECEMBER, 1957. 1957. (Rev. Appl. Mycol. 37: 6. 1958.)

Panama disease of bananas (Fusarium oxysporum f. cubense) was found in a new locality. The disease was relatively static in endemic areas. The causal agent of a widespread and destructive damping-off disease of flue-cured tobacco in the Gulu area was identified as Pseudomonas solanacearum var. asiaticum.

#### Fungi -- Fusarium -- Resistance

200. BALLARD, J. C. and D. J. DeZEEUW. Spartan Rock -- a new Fusarium wilt resistant muskmelon. Quart. Bull. Mich. agric. Exp. Sta. 40: 822-824. 1948. (Rev. Appl. Mycol. 37: 625. 1958.)

Spartan Rock, resistant to Fusarium oxysporum f. melonis was selected from the F<sub>8</sub> generation from Minnesota 10-38 x Howell Honey Rock, after backcrossing F<sub>1</sub> & F<sub>2</sub> to Honey Rock.

201. CONROY, R. J. Fusarium wilt of rockmelon (Cucumis melo L.) in New South Wales. J. Aust. Inst. agric. Sci., 23: 152-154. 1957. (Rev. Appl. Mycol. 37: 64. 1958.)

The Delicious 51 rock melon is resistant to Fusarium oxysporum f. melonis under conditions inducing severe infection of susceptible varieties.

202. CULBERTSON, J. O. Registration of improved flax varieties VII. Agron. J. 49: 607-608. 1957. (Rev. Appl. Mycol. 37: 237-238. 1958.)

Raja was finally selected in 1952 as resistant to wilt (Fusarium lini).

203. NAIR, P. N. Effect of maleic hydrazide, thiourea, and 2,4-dinitrophenol on resistance to flax wilt. Phytopathology 48: 288-289. 1958. (Rev. Appl. Mycol. 37: 664. 1958.)

The above chemicals were added to a soil-vermiculite medium in which two varieties of flax resistant to wilt (F. oxysporum f. lini) were growing, some of which had been inoculated through the medium. The percentage wilt among treated inoculated plants was greater than among the untreated. In in vitro experiments all the chemicals stimulated growth of the pathogen, especially the higher concentrations of thiourea. There was no correlation between the effect of the chemical on growth in vitro and on the severity of wilt in the plant.

204. OCHSE, J. J. A new banana for Florida -- Musa paradisiaca L., variety Hadja. Proc. Fla. hort. Soc. 70 (1957): 340-341. 1958. (Rev. Appl. Mycol. 37: 669. 1958.)

The author recommends this plantain var., resistant to Panama disease (Fusarium oxysporum f. cubense) and sigatoka (Mycosphaerella musicola.)

205. PALMER, JOHN G. and R. L. PRYOR. Evaluation of 160 varieties of Gladiolus for resistance to Fusarium yellows, 1958. Plant Disease Repr. 42: 1405-1407. 1958.

The selection of resistant varieties was begun by inoculating gladiolus corms with a composite inoculum of six isolates of Fusarium oxysporum Schlecht. f. gladioli (Massey) Snyder & Hansen. Three groups of corms were prepared. Two of the groups were inoculated by rotating over a hardware-cloth grid in sand saturated with a spore and mycelial suspension composed of equal amounts of the Fusarium isolates. Water was used in place of inoculum on the third group. The numbers of germinated shoots and of shoots showing symptoms were recorded twice daily over a period of 14 weeks. Summaries of data indicate that immunity to yellows was not found but that variable degrees of resistance to isolates of the pathogen existed among the varieties of gladiolus.

206. PELLETIER, R. L. and J. SIMARD. (The effects of certain chemical products on the resistance of cabbage to yellows (Fusarium f. conglutinans) (Wr.) Snyder & Hansen.) Rep. Quebec Soc. Prot. Pl. 38 (1956): 40-44. 1957. (Rev. Appl. Mycol. 37: 385. 1958.)

When cabbage plants with type A resistance and others with type B resistance to F. oxysporum f. conglutinans were grown in vermiculite with Gallegly and Walker's nutritive solution with various chemicals, and subsequently inoculated with F. conglutinans by pouring a suspension over the roots, those with type A resistance given p-nitrophenol or 2,4-D had significantly lower disease indices than untreated plants. On the other hand the disease incidence of plants with type B resistance was significantly higher than untreated plants. This suggests that the physiology of plants with type A resistance differs from that of the others.

207. SHIMOMURA, T. et al. Resistance of lotus to the rhizome rot caused by Fusarium bulbigenum Wr. var. nelumbicolum N. et W. (In Japanese with English summary.) Ann. Phytopathol. Soc. Japan 20: 47-53. 1955. (Biol. Abstr. 32: 881. 1958.)

208. YEN, D. E. and I. A. M. CRUICKSHANK. Breeding of peas resistant to Fusarium wilt. N. Z. J. Sci. Tech. 38A: 702-705. 1957. (J. Sci. Food Agr. 9: i-71. 1958.)

Selection of wilt-resistant lines of three varieties of garden and two varieties of field peas is described.



Fungi -- Ganoderma

209. PIRONE, P. D. *Ganoderma lucidum*, a parasite of shade trees. Bull. Torrey bot. Club, 84: 424-428. 1957.

Sporophores of *G. lucidum* were present on the trunk bases or roots of nearly 20 percent of dead Norway maples and swamp maples in New York City and Atlantic Highlands, N. J. They were also found on living trees, with branches above the invaded area of trunk either dead or bearing undersized leaves. The pathogenicity of the fungus was indicated by soil inoculation experiments.

Fungi -- Helicobasidium

See also 633

210. SUZUKI, N. et al. Studies on the violet root rot of sweet potatoes caused by *Helicobasidium mompa* Tanaka. I. The disease invasion under field conditions. Bull. nat. Inst. agric. Sci. Tokyo 8, Ser. C: 1-28. 1957. (Rev. Appl. Mycol. 37: 557. 1958.)

The life history of *H. mompa* and the symptoms in sweetpotato are described. Infection originates chiefly from overwintering, soil-borne sclerotia. The earlier the planting, the heavier the infection. The pathogen grows on the outside of the sweetpotato from June until the end of Sept., when the hyphae from the infection cushion, formed by hyphal penetration into the middle lamellae of the outer cork layer, penetrate this layer and rot the inner starchy tissues. Resistant varieties either slough off the fungus at the point of infection by the formation of a fresh cork layer or during the period of rapid growth in July-Sept., inhibit further growth of the mycelium once the cork layer has been penetrated.

211. SUZUKI, N. Studies on the violet root rot of sweet potatoes caused by *Helicobasidium mompa* Tanaka. VI. Histochemical studies of the infected tissues. (1) Chemical changes as results of infection. Bull. nat. Inst. agric. Sci., Tokyo 8, Ser. C: 69-130. 1957. (Rev. Appl. Mycol. 37: 557. 1958.)

- SUZUKI, N. and S. TOYODA. VI. (2) Stimulated respiration and behaviour of phosphorus in infected tissues and their relation to defence reaction. Bull. nat. Inst. agric. Sci., Tokyo, 8, Ser. C: 131-173. 1957. (Japanese. English summary.) (Rev. Appl. Mycol. 37: 557. 1958.)

Histochemical studies showed that the resistance of the host is higher when young, decreases at maturity, and even more during storage. Infection causes a decrease of pH due to an accumulation of chlorogenic and caffeic acids, lignification of cell membranes, accumulation of polyphenols in the middle lamellae, formation of a secondary cork layer, and decomposition of cellulose. Other changes in infected cell constituents were noticed.

Fungi -- Helminthosporium

See also 367, 683, 702, 708

212. CLARK, R. V. The evaluation of variability in pathogenicity of *Helminthosporium sativum* and the relation of temperature to disease development of barley. Diss. Abstr. 17: 220-221. 1957. (Rev. Appl. Mycol. 37: 349. 1958.)

At the University of Wisconsin a comparison of the relative pathogenicity of 50 isolates of *H. sativum* (*Cochliobolus sativus*) on six barley varieties in the greenhouse showed differences in the development of seedling blight and root rot. In the course of field tests with five of these isolates, differences in pathogenicity were observed. Seedling blight and rot was severe from 8° to 28°C with a maximum rate of development at 20°C.

213. CLARK, R. V. and J. G. DICKSON. The influence of temperature on disease development in barley infected by *Helminthosporium sativum*. Phytopathology 48: 305-310. 1958.

In a study using six isolates of the fungus and six varieties of barley it was found that the spot blotch phase of the disease responded differently to

a temperature series than did the root rot and seedling blight phase.

214. DJIEMBAEV, J. T. (Diseases of hard wheat in North Kazakh S.S.R. and their control.) Trud. Resp. st. Zashch. rast. Kazakh. fil. VASKNIL 3: 171-191. 1956. (Abs. from Referat. Zh. Biol. 1957, 18: 182. 1957.) (Rev. Appl. Mycol. 37: 344-345. 1958.)

At the Shortandinskaya Exp. Sta., U.S.S.R., studies from 1949-51 on wheat diseases showed that root rot (Helminthosporium sativum) is especially prevalent in dry summers.

215. LANGE-DE LA CAMP, MARIA. Helminthosporium sativum in Mittel- und Norddeutschland. (Helminthosporium sativum in Central and North Germany.) Phytopath. Z. 32: 167-180. 1958. (Rev. Appl. Mycol. 37: 764-765. 1958.)

Tests at the Institut für Phytopathologie, Aschersleben, Germany, together with field observations, confirmed the occurrence of H. sativum on wheat, barley and rye in Central Germany and on the east edge of the Harz Mountains, and on barley in East Holstein. Physiologic races were detected.

#### Fungi -- Itersonilia

216. KEYWORTH, W. G. Plant Pathology Report. Rep. nat. Veg. Res. Sta., Warwick, 7 (1956): 60-64. 1957. (Rev. Appl. Mycol. 37: 1. 1958.)

A. G. Channon in further work on parsnip canker isolated Itersonilia sp. from infected roots from several localities. The fungus readily enters wounded or unwounded roots and the purplish-brown to black, often orange-flecked, lesions produced resemble many naturally occurring cankers.

217. KEYWORTH, W. G. Plant Pathology Report. Rep. nat. Veg. Res. Sta., Warwick, 8 (1957): 48-52. 1958. (Rev. Appl. Mycol. 37: 511. 1958.)

Itersonilia was isolated from over 60 percent of cankered parsnip roots sent in from 53 localities in England and Wales. From five of these localities roots were infected by a Phoma sp. which proved highly pathogenic to parsnips, producing a purplish black lesion closely resembling that of Itersonilia, though often slightly darker. Forms of Itersonilia isolated from diseased chrysanthemum and dahlia florets and other sources but differing from the parsnip isolates in some morphological characters were not pathogenic to parsnips.

218. WALKER, J. Diseases of parsnips. Agric. Gaz. N.S.W. 68: 404-406. 1957. (Rev. Appl. Mycol. 37: 197. 1958.)

Canker (Itersonilia sp.) causes losses of up to 70 percent in autumn-sown crops in the Sydney Metropolitan area. Soft rot (Erwinia carotovora) can be reduced by improved packing conditions.

#### Fungi -- Macrophomina

See also 139

219. VERNEAU, R. Nuove matrici dello Sclerotium bataticola (Macrophomina phaseolina). (New hosts of Sclerotium bataticola (Macrophomina phaseolina).) Ric. fitop. Campan., 13-14: 119-124. 1957. (Rev. Appl. Mycol. 37: 371. 1958.)

The isolation of M. phaseolina (M. phaseoli) from tomato plants near Naples and from potato stems, roots, stolons and tubers in 1957 constitutes new host records for Italy. Heavy losses were caused to the potatoes growing on a fine soil which had not been cultivated before.

#### Fungi -- Marasmius

220. VIÉGAS, A. P. Podridão das raízes do cafeeiro I, II. (Root rot of coffee. I, II.) Bol. Suptda Serv. Café, S. Paulo, 32, 368: 7-16; 369: 10-19. 1957. (Rev. Appl. Mycol. 57: 536. 1958.)

Description of the history, nature, terminology, etiology, external and internal symptoms, and other points of interest connected with a widespread die-back and root rot of coffee (Coffea arabica and its var.) in São Paulo, Brazil, caused by Marasmius viegasii Singer sp. nov., of which a description is given.

Fungi -- Monilochaetes

221. KANTZES, J. G. Nutrition, pathogenicity, and control of Monilochaetes infuscans Ell. and Halst. ex Harter, the incitant of scurf of sweet potatoes. Diss. Abstr. 17: 2394-2395. 1958.

Growth rates of isolates of the causal organism from different locations, on various substrates are recorded. The relative susceptibility of varieties and seedlings of the host was determined in the laboratory by an especially devised technique. A dip treatment prior to planting is essential for control. The best results were achieved with 2 lb./5 gal. thiram, ferbam, or captan, or 1-1000 Puratized Agricultural Spray.

Fungi -- Olpidiaster

222. WICKENS, G. M. Abyan root rot of cotton. Progr. Rep. Exp. Stas. Emp. Cott. Gr. Corp. (Aden), 1956-7, pp. 13-15. 1957. (Rev. Appl. Mycol. 37: 168. 1958.)

Cotton in the Aden Protectorate is affected by a wilt disease (Abyan root rot), the cause of which has not so far been definitely ascertained, but the condition of which is characteristically a root rot. The symptoms and general behaviour of affected plants agree closely with the description of the cotton disease attributed to Olpidiaster gossypii.

Fungi -- Olpidium

223. FRY, P. R. The relationship of Olpidium brassicae (Wor.) Dang. to the big-vein disease of lettuce. N. Z. J. Agric. Res. 1: 301-304. 1958.

Field observations and inoculation experiments suggest that O. brassicae is the cause of big-vein disease of lettuce. Soil treatment with captan, phygon, copper oxychloride, or thiram reduced incidence of the disease.

224. GROGAN, R. G. et al. The association of Olpidium with the big-vein disease of lettuce. Phytopathology 48: 292-297. 1958.

Examination of roots of typically diseased plants from several widely separated locales proved that all were consistently infected with O. brassicae (Wor.) Dang. Lettuce seedlings exposed to Olpidium-infected roots of lettuce or other hosts developed big-vein symptoms. When suspensions of Olpidium zoospores were filtered through filters capable of retaining the zoospores but able to pass a virus, the filtrates did not induce big-vein symptoms. These results indicate a causal relationship between Olpidium and the big-vein disease, which is not contradicted by any proof of virus etiology in the extensive literature on the disease.

Fungi -- Ophiobolus

See also 79, 80

225. GOTTLIEB, DAVID, et al. The resistance of various grasses to Ophiobolus graminis. Plant Disease Repr. 42: 26-29. 1958.

A number of important grasses grown in Chile were found susceptible to O. graminis in greenhouse studies. The species of Agropyron and Bromus were all very susceptible, whereas Agrostis and Arrhenatherum and Oryzopsis were resistant. In the genera Lolium and Hordeum, the resistance varied with the species.



Fungi -- Pellicularia  
see Fungi -- Rhizoctonia

Fungi -- Peronospora

226. RICH, SAUL. Field infection of radish roots with *Peronospora parasitica*. Plant Disease Reptr. 41: 1058-1059. 1957.

The losses in the second planting, with the beginning of cooler weather, were as high as 75 percent of the radishes harvested on some farms. The discolored areas remained firm, even after prolonged storage.

Fungi -- Phoma

227. KEMP, W. G. A new root rot of florists' chrysanthemums in Ontario. Can. J. Plant Sci. 38: 464-476. 1958.

An apparently undescribed root rot of *Chrysanthemum morifolium* is described. The disease is characterized by a severe root rot, general stunting, and foliar chlorosis and necrosis. A species of the form genus *Phoma* was found associated with the roots of the affected plants.

Fungi -- Phytophthora

See also 337, 373, 497, 656

228. ALANDIA, S. and F. H. BELL. Diseases of warm climate crops in Bolivia. F. A. O. Plant Prot. Bull. 5: 172-173. 1957. (Rev. Appl. Mycol. 37: 207-208. 1958.)

An avocado wilt was seen in various localities. *Phytophthora cinnamomi* has been isolated from the roots of dying trees and is presumed to be the cause of the disease.

229. BINGHAM, F. T., G. A. ZENTMYER, and J. P. MARTIN. Host nutrition in relation to *Phytophthora* root rot of avocado seedlings. Phytopathology 48: 144-148. 1958.

Avocado seedlings were grown in nutrient solution cultures into which *Phytophthora cinnamomi* was introduced. The root rot occurred in all treatments but the progress of infection was retarded where high concentrations of N or K had been used. Adaptation of the pathogen to the variations in the environmental conditions in the tests precludes host nutrition as a practical means of control of the disease.

230. BOYCE, A. M. Research and avocado root rot. Calif. Citrogr. 43: 3, 18, 20-21. 1957. (Rev. Appl. Mycol. 37: 295. 1958.)

*Phytophthora cinnamomi*, the agent of avocado root rot, is very probably not native to California. Well over 100 other hosts are known. The Duke avocado rootstock promises appreciable resistance and selections of this variety are being studied. Vapam is an effective soil eradicator for field use. Soil may also be treated by drying to a moisture content of below 1 percent. When soil is wet and well aerated zoospores are formed in abundance and the disease spreads rapidly. Varying the N, P and K levels has little effect on the fungus.

231. BYFORD, W. J. *Phytophthora verrucosa* on dahlia. Plant Path. 7: 38. 1958.

In a Border nursery in Scotland dahlia seedlings were affected by a general wilt. Oogonia and oospores of *P. verrucosa* were observed in the roots. This constitutes a new host record.

232. CALAVAN, E. C. Three major root rot diseases of citrus. Calif. Citrogr. 42: 431-432. 1957. (Rev. Appl. Mycol. 37: 235. 1958.)

*Phytophthora citrophthora* has been detected in all the important citrus areas in California, causing trunk gummosis, fruit rot, foot rot, root cankers, and destruction of feeder roots. *P. parasitica* thrives in warm conditions, causing destruction of feeder roots; root rot is especially severe in hot desert areas and in warm locations in intermediate valleys.

233. CHANT, S. R. A die-back of cacao seedlings in Nigeria caused by a species of *Phytophthora*. *Nature* 180: 1494-1495. 1957.

Since 1954 a *Phytophthora* sp., thought to be a form of *P. parasitica*, has caused considerable losses among cacao seedlings in Nigerian nurseries. About 95 percent control resulted from the application of a proprietary copper fungicide at 3- or 6-day intervals, but at intervals of 9 or 12 days only slight control was obtained.

234. CONVERSE, RICHARD H., et al. Two additional races of *Phytophthora fragariae* Hickman in Maryland. *Plant Disease Repr.* 42: 837-840. 1958.

Five physiological races of *Phytophthora fragariae* Hickman have been found in Maryland, two of them being previously undescribed.

235. FELIX, E. L. A *Phytophthora* blight and root rot of strawberry. *Plant Disease Repr.* 42: 818-819. 1958.

This *Phytophthora*, reported from Tennessee, differs in some respects from the red stele fungus, *P. fragariae*, and resembles the latter in others. Vascular discoloration, as in red stele, has not been observed to date in affected plants.

236. FREZZI, MARIANO. *Phytophthora cryptogea* causante de la muerte de *Populus simonii* en Mendoza, Argentina. (*P. cryptogea* as the cause of death of *Populus simonii* in Mendoza, Argentina.) *Rev. Argentina Agron.* 24: 136-143. 1957. (*Biol. Abstr.* 32: 3467. 1958.)

The fungus *P. cryptogea* is reported for the first time as a pathogen of the genus *Populus*. Its morphological, cultural, and biological characteristics are described and illustrated.

237. HERR, LEONARD JAY. Investigations of a *Phytophthora* root rot of soybeans. *Diss. Abstr.* 17: 957. 1957.

238. HICKMAN, C. J. *Phytophthora* -- plant destroyer. *Trans. Brit. Mycol. Soc.* 41: 1-13. 1958. (*Rev. Appl. Mycol.* 37: 519. 1958.)

This presidential address comprises a general consideration of the genus under the headings distribution and host range, survival, dispersal, and physiological specialization.

239. HILDEBRAND, A. A. A *Phytophthora* root and stalk rot of soybeans. (*Abstr.*) *Proc. Can. Phytopath. Soc.* 25: 14-15. 1957.

A serious root and stalk rot of soybeans in southwestern Ontario is caused by a fungus tentatively identified as *P. megasperma*. The first considerable outbreak, in 1954, coincided with the widespread planting of the highly susceptible Harosoy variety. Other varieties including Monroe, remained virtually unaffected. The disease is worst from May until mid-July, but can attack and kill plants throughout the growing season. In culture the causal organism grows at 7.5° to 32.5° C (opt. 25°).

240. HOPKINS, J. C. F. Plant diseases in British colonial dependencies. *F. A. O. Plant Prot. Bull.* 6: 9. 1957.

In Nigeria a serious wilt disease of seedling cacao is caused by *Phytophthora palmivora*. Effective control was achieved by 0.3 to 0.5 percent perenox sprays applied at 3-day intervals from germination until 6 weeks of age. In Sarawak a species of *Phytophthora*, not yet fully determined, has been isolated from root-rot of pepper (*Piper nigrum*).

241. JOHNSON, E. M. and R. A. CHAPMAN. Unusual occurrence of certain plant diseases in Kentucky in 1958. *Plant Disease Repr.* 42: 1411-1413. 1958.

Black shank, *Phytophthora parasitica* var. *nicotianae* developed as soon as 2 or 3 weeks after setting of tobacco in some fields. There have been some reports of black shank on farms where there has been no previous report of the disease. Red stele, *Phytophthora fragariae*, was present in strawberry fields throughout the State.

242. KAUFMANN, M. J. and J. W. GERDEMANN. Root and stem rot of soybean caused by *Phytophthora sojae* n. sp. *Phytopathology* 48: 201-208. 1958.

*Phytophthora sojae* n. sp. is the name proposed for the fungus found

associated with root and stem rot of soybeans in Illinois. A comparison of eight inoculation techniques revealed that two gave quick reliable results.

243. KLOTZ, L. J., T. A. DeWOLFE, and PO-PING WONG. Decay of fibrous roots of citrus. *Phytopathology* 48: 616-622. 1958.

The importance of Phytophthora citrophthora and P. parasitica as destroyers of fibrous feeder roots of citrus was demonstrated. Environmental factors favouring the parasitism are excess water and organic matter in the soil. Control measures are indicated.

244. KLOTZ, L. J., et al. Guard against introducing brown rot fungi. *Calif. Citrogr.* 42: 258. 1957. (Rev. Appl. Mycol. 37: 165. 1958.)

Brown rot fungi (Phytophthora spp.) present in the testas of seeds from infected citrus fruits infect nursery seedbeds, and hence, on transplanting, spread to nursery rows. Balled trees from such nurseries constitute an important source of infection on clean land. On the basis of trials in California with seed infected by P. citrophthora and P. parasitica, hot water treatment (4 min. at 120-125° F) is recommended for nursery seed.

245. KLOTZ, L. J., et al. Heat-treat citrus seed to kill Phytophthora brown rot fungi. *Citrus Leaves*, 37 (5): 14-15. 1957. (Biol. Abstr. 32: 269. 1958.)

Although Phytophthora spp. may be introduced into citrus groves in various ways, an important source is the soil and roots of balled trees. A large percentage of seeds extracted from "brown-rot" fruit carry Phytophthora in the seed coat. It is suggested that seeds be sterilized by 4 minutes immersion in well-agitated water held at 120° to 125° F.

246. KOVACHEVSKI, I. and A. BALEVSKI. (Plant protection in the People's Republic of China.) *Bul. Rast. Zash. Sofia*, 6: 3-29. 1957. (Tobacco Abstr. 2: 503. 1958.)

A part of this report records the main plant diseases and pests in China and measures for their control. Important diseases noted included Phytophthora parasitica var. nicotianae.

247. MARCELLI, E. Un marciume del piede del tabacco in semenzaio e in campo causato da Phytophthora sp. (A foot rot of tobacco in seedbed and field caused by Phytophthora sp.) *Ric. fitop. Campan.* 13-14, pp. 125-159. 1957. (Rev. Appl. Mycol. 37: 376. 1958.)

This is an account of a study of a foot rot of tobacco in Italy caused by a fungus which differed from P. parasitica var. nicotianae in its lesser pathogenicity; it is identified provisionally as P. palmivora, not previously recorded on tobacco in Italy.

248. McKEEN, W. E. Red stele root disease of the loganberry and strawberry caused by Phytophthora fragariae. *Phytopathology* 48: 129-132. 1958.

On Vancouver Island a root decay of loganberry and strawberry is incited by a strain of Phytophthora fragariae, that invariably is closely followed by Pythium spp.

249. MUNGOMERY, R. W. Division of Entomology and Pathology. Rep. Bur. Sug. Exp. Stas. Qd. 57: 66-68. 1957. (Rev. Appl. Mycol. 37: 308. 1958.)

Phytophthora drechsleri caused a wilt of velvet bean (Mucuna deeringiana) in the Mulgrave area of Queensland. The disease had not been encountered previously.

250. NEWHOOK, F. J. Mortality of Pinus radiata in New Zealand. Abs. in Proc. Can. Phytopath. Soc. 25: 16. 1957.

In the serious wilt disease caused by Phytophthora cinnamomi, which is responsible for heavy losses in P. radiata shelter belts in many parts of New Zealand, groups of mature trees die rapidly in spring and early summer after abnormally wet winters following destruction of the absorbing rootlets. Grid sampling showed that the fungus is highly concentrated in the fibrous root zones of the trees.



251. PURSS, G. S. Stem rot: a disease of cowpeas caused by an undescribed species of *Phytophthora*. Qd. J. Agric. Sci. 14: 125-154. 1957.

The causal organism is a new species, *P. vignae* Purss, of which a description is given. Excess of water increases disease incidence on lightly infested soil, but is immaterial when soil is heavily contaminated. Seed-borne infection could not be shown.

252. SAREJANNI, J. A. and N. STAMATINI. (*Phytophthora* of tobacco in Greece.) Benaki Inst. Phytopath. Ann. 1: 51-56. 1935. (Tobacco Abstr. 2: 14-15. 1958.)

This summary points out that the *Phytophthora* disease of tobacco was first identified in Greece in 1930, but according to growers was probably present much earlier. The fungus corresponds in morphology to the old species, *P. nicotianae* Breda de Haan. It causes a damping-off of seedlings, a wilting and yellowing of plants in the field, and a leaf spot of full-grown plants.

253. SHOEMAKER, R. A. and D. W. CREELMAN. Thirty-seventh Annual Report of the Canadian Plant Disease Survey, 1957. 132 pp. 1958. (Rev. Appl. Mycol. 37: 515-516. 1958.)

*Phytophthora* root and stalk rot of soybean in southwestern Ontario (*P. ? megasperma*) was the most severe for 3 years owing to heavy rainfall and the widespread use of the susceptible Harosoy. The new variety Chip-pewa was susceptible but Harman was tolerant. Yield reductions in badly affected fields were 18-25 percent. *Corynebacterium sepedonicum* on potato increased in prevalence in parts of Quebec and Ontario.

254. TEAKLE, D. S. Avocado root rot. Qd. Agric. J. 83: 701-704. 1957.

Avocado trees may be killed by *Phytophthora cinnamomi* attacking the roots, especially after long periods of wet weather. Because most of the feeder roots are already rotted when decline first shows, it may be difficult to find any containing the fungus.

255. TEAKLE, D. S. Papaw root rot caused by *Phytophthora palmivora* Butl. Qd. J. Agric. Sci. 14: 81-91. 1957.

The relative pathogenicity of *Phytophthora palmivora* and *Pythium vexans* was investigated. The former causes a severe root rot, predisposing factors being waterlogging, high soil temperatures and root damage. Crop rotation and drainage are likely to afford some control.

256. TSAO, PETER H. Serial dilution method for estimating disease potentials of citrus *Phytophthoras* in the soil. (Abstr.) Phytopathology 48: 398-399. 1958.

A serial dilution method, using lemon fruit as host, was developed that provided means for studying distribution and factors influencing the disease potential of *P. citrophthora* or *P. parasitica* in the soil. The disease potential index of a given soil was defined as the reciprocal of the highest of the dilutions that yielded brown rot lesions on the test fruits.

257. WATERHOUSE, GRACE M. *Phytophthora citricola* Sawada (Syn. *P. cactorum* var. *applanata*). Trans. Brit. Mycol. Soc. 40: 349-357. 1957.

Evidence is presented that *Phytophthora cactorum* var. *applanata* Chester is synonymous with *P. citricola* Sawada, which has priority. Also, the latter is sufficiently distinct from *P. cactorum* to be retained as a separate species.

258. ZENTMYER, G. A. and A. O. PAULUS. *Phytophthora* avocado root rot. Circ. Calif. Agric. Exp. Sta. 465: 1-15. 1957.

The symptoms are described. Infection may be introduced by the movement of the infected soil or water, the use of infected avocado seeds in nursery stock, or by numerous alternate host plants, which are listed. Measures which help to prevent the spread of the disease or to mitigate its effects are outlined.

259. ZENTMYER, G. A. Prevention of *Phytophthora* root rot development in new plantings, and other phases of root rot research. Yearb. Calif. Avoc. Soc. for 1957, pp. 55-57.
260. ZENTMYER, G. A. Report on avocado diseases, culture and seed collections in Chile -- June 1956. Agricultura t c., Santiago, 16: 43-46. 1956. (Rev. Appl. Mycol. 37: 295. 1958.)  
 Root rot of avocado (*Phytophthora cinnamomi*) was found in the La Cruz and San Vicente areas.
261. ANNUAL REPORT ON THE DEPARTMENT OF AGRICULTURAL RESEARCH, FEDERATION OF NIGERIA, FOR THE YEAR 1956-57, 48 pp. 1958. (Rev. Appl. Mycol. 37: 635. 1958.)  
 A *Phytophthora*, which from peculiarities in the structure of the sporangial wall must be regarded either as a new species or as a new variety of *P. parasitica*, was consistently isolated from Sierra Leone rough lemon stocks and later from Rangpur lime and sweet orange with gummosis disease.
262. JAARVERSLAG 1956 PROEFSTATION VOOR DE FRUITTEELT IN DE VOLLE GROND. (Report for 1956 of the Expt. Sta. for Outdoor Fruit Culture) -- 87 pp., 1957. (Rev. Appl. Mycol. 37: 239-240. 1958.)  
 Both *Phytophthora cactorum* and *P. syringae* could be isolated from the soil of an orchard with collar rot.
263. REPORT OF THE DEPARTMENT OF AGRICULTURE, N. S. W., FOR THE YEAR ENDED 30th JUNE, 1956. 111 pp., 1957. (Rev. Appl. Mycol. 37: 133-134. 1958.)  
 The host range of *Phytophthora cinnamomi* was extended by 17 new records, mostly on native and ornamental plants, and a number of other records of root and crown rots caused by *Phytophthora* spp.
264. REPORT ON PHYTOPHTHORA DISEASE. Soybean Digest, 18: 11. 1958.  
 A warning that *Phytophthora* may this year cause more than the 1957 loss of 1 1/2 million dollars to Ohio soybeans has been issued by one of the farm papers. The variety Harosoy is particularly susceptible and the disease was found in two out of every three Harosoy fields checked by pathologists of the Ohio Agricultural Experiment Station.

Fungi -- Phytophthora -- Resistance  
 See also 616

265. BARRIE, A. G. Cowpeas resistant to wilt. Cane Growers' Quart. Bull. 21: 39-41. 1957.  
 The utility of cowpeas as a green manure crop has been greatly reduced by their susceptibility to wilt caused by *Phytophthora* sp. A test involving planting dates and varieties showed differences in wilt resistance, and that early planting reduces mortality caused by wilt. Three varieties were found fully wilt-resistant.
266. FLETCHER, W. A. Citrus varieties and rootstocks for New Zealand. Orchard N. Z., 30(11): 9. 1957. (Rev. Appl. Mycol. 37: 353. 1958.)  
 An additional rootstock known as yuzu (a hybrid of Mandarin and *Citrus ichangensis*), though somewhat susceptible to *Phytophthora* root and collar rot, appears to be more drought resistant than sweet orange, which is the least tolerant of drought but seems to be tolerant of or resistant to all the main viruses causing decline.
267. HARRIS, R. V. Plant Pathology. Rep. E. Malling Res. Sta., 1956, pp. 25-30. 1957. (Rev. Appl. Mycol. 37: 131-132. 1958.)  
 A test of resistance of 29 apple rootstock clones to five isolates of *Phytophthora cactorum* revealed variation in pathogenicity of the fungus and in rootstock resistance. The pathogen is widely distributed in the soils of

orchards affected by collar rot and is not more highly concentrated round infected trees, but no evidence of mycelial growth in soil was obtained.

268. KLOTZ, L. J. and T. A. DeWOLFE. Possible solution for a basic disease problem. Calif. Citrogr. 43: 80, 85. 1958.

All the rootstocks so far found to be resistant to tristeza (virus) are susceptible to brown rot gummosis (*Phytophthora* spp.) with the exception of some trifoliate selections. Among these trifoliate selections are two which have recently also been found to show resistance to fibrous root rot caused by the same gummosis fungi followed by secondary organisms. The importance of this finding lies in the fact that all other rootstocks tested, including the sour orange, are susceptible to this form of attack, which is probably responsible for much of the deterioration apparent in many old Californian orchards. The use of trifoliate stock, however, necessitates using exocortis-free budwood, and at present supplies of both stocks and budwood are inadequate. In cases where it is necessary to plant tristeza-resistant, but gummosis-susceptible, stocks on old citrus land, it is important to ensure that both plants and soil are free from gummosis organisms. For soil treatment the best compounds found so far are vapam and mylone, but because of their cost it is suggested that only the tree sites should be treated in a circle 8 feet in diameter. The trees can be planted 1 month after treatment.

269. KLOTZ, L. J. Protecting young trees against brown rot gummosis. Calif. Citrogr., 42: 42. 1956. (Rev. Appl. Mycol. 37: 165. 1958.)

Regarding practical control measures against brown rot gummosis of citrus (*Phytophthora* spp.) the danger is stressed of the increasing use of susceptible rootstocks to replace sour orange, on account of tristeza virus. Prophylactic measures against the introduction of infection are outlined.

270. McKEEN, W. E. Races of and resistance to *Phytophthora fragariae*. Plant Disease Repr. 42: 768-771. 1958.

A report of results of tests for resistance of some common strawberry varieties to 11 different isolates of *Phytophthora fragariae*.

271. MORTON, GEORGE. Soybean research at Purdue. Soybean Digest 19: 16-18. 1958.

All varieties and strains of soybeans are evaluated for the reaction to *Phytophthora* root rot and other diseases. Resistance to *Phytophthora* root rot is being bred into resistant varieties.

272. SIMMONDS, J. H. Science Branch, Plant Pathology Section. Rep. Dept. Agric. Qd., 1956-57, pp. 63-64, 1957. (Rev. Appl. Mycol. 37: 205. 1958.)

The cowpeas C. P. I. 12153, Blackeye 5, Malabar, and C. P. I. 12148 again proved resistant to *Phytophthora* sp.

273. WOLF, F. A. Notes on tobacco diseases and disorders in Venezuela. Tobacco, N. Y., 145, (2), pp. 20-21, 1957. (Rev. Appl. Mycol. 37: 246. 1958.)

Flue-cured varieties developed in Virginia or North and South Carolina for resistance to *Phytophthora parasitica* var. *nicotianae* are found to exhibit almost perfect resistance to or tolerance of the fungus in Venezuela.

274. WOODHEAD, C. E. Collar rot and root rot of Cox's Orange Pippin and other apple varieties. Orchard N. Z., 30: (6): 16-17, 19, 21; (7): 2, 5, 7, 9. 1957.

A survey showed that collar rot (*Phytophthora cactorum*) is a serious disease of single-worked Cox's Orange Pippin trees in certain orchards. By topworking Cox on other varieties the risk of infection was reduced by at least 75 percent. Defective drainage was dominant in increasing disease incidence.

275. ZENTMEYER, GEORGE A. Resistance to *Phytophthora cinnamomi* in the genus *Persea*. (Abstr.) Phytopathology 48: 399. 1958.

In the search for a resistant rootstock, seeds of varieties of avocado



(Persea americana) and of other native species of Persea were collected in Mexico, Central America, Colombia, Ecuador, Peru, Chile, Argentina, Brazil, Venezuela, Trinidad, Puerto Rico, and Cuba. High resistance to P. cinnamomi was found in five small-fruit species of Persea, and moderate resistance was found in two P. americana types. Collections were tested by a rapid, severe method using aerated nutrient solutions; and by the less severe method of planting seedlings in infested soil in greenhouse or lathhouse.

276. ZENTMEYER, G. A. The search for resistant rootstocks in Latin America. Yearbk. Calif. Avoc. Soc. for 1957, pp. 101-106.

Persea spp. were collected in 1956, with particular reference to resistance to Phytophthora cinnamomi.

277. FIFTH ANNUAL REPORT, 1957-8, SCOTTISH HORTICULTURAL RESEARCH INSTITUTE, 51 pp., 1958. (Rev. Appl. Mycol. 37: 697-699. 1958.)

At Auchincruive, each of 36 isolates of Phytophthora fragariae, the cause of red stele of strawberry, fell into 1 of 4 groups as determined by its ability to infect the indicator varieties used. Altogether, 573 plants (strawberry and Fragaria spp.) immune from attack by the Huxley race of P. fragariae were found; many of these appear to be immune also from a second race, but all are susceptible to a third, which infects Climax.

278. FORTY-SEVENTH AND FORTY-EIGHTH ANNUAL REPORTS, 1956, 1957, JOHN INNES HORTICULTURAL INSTITUTION, 47 pp., 1956; 47 pp., 1957. (Rev. Appl. Mycol. 37: 696-697. 1958.)

Survey of parental breeding material of strawberries in 1956 yielded 15 unrelated clones resistant to the common strain of Phytophthora fragariae.

#### Fungi -- Plasmodiophora

See also 374, 713

279. COLHOUN, J. Club root disease of crucifers caused by Plasmodiophora brassicae Woron. Phytopath. Pap. Commonw. Mycol. Inst. 3, 108 pp. 1958. (Rev. Appl. Mycol. 37: 746. 1958.)

A valuable and comprehensive monograph of the disease.

280. GORLENKO, M. F. (Ed.) (The immunity of plants from diseases and pests.) 212 pp., Agricultural Literature, Moscow, 1956. (Rev. Appl. Mycol. 37: 331-333. 1958.)

Cabbage varieties susceptible to club root (Plasmodiophora brassicae) develop normally and resist the disease when root-grafted with a resistant variety; the contrary is observed with the most resistant variety, Yazik Zwornika, when grafted with a susceptible variety.

281. MAKLAKOVA, G. F. Conditions of club root infection. Doklady vsesojuz. Akad. sel'sk. Nauk., 23: 31-36. 1958. (Hort. Abstr. 28: 407. 1958.)

Observations have shown that club root (Plasmodiophora brassicae) attacks both seedlings and older cabbage plants and is affected by environment. For control the following preventive measures are recommended: (1) planting on well drained or elevated land. (2) Planting in groups on the square for good weed control and root aeration. (3) Raising seedlings in frames in peat with AMB or in nutrient blocks which do not contain soil. (4) Inspection of the root system of seed plants before replanting.

282. PLANT DISEASE SURVEY FOR THE TWELVE MONTHS ENDING 30th JUNE 1957.

Twenty-seventh Annual Report N. S. W. Dept. Agr. Biological Branch, Division of Science Services, 32 pp. 1957. (Rev. Appl. Mycol. 37: 326-327. 1958.)

Club root (Plasmodiophora brassicae) continues to be severe in crucifers.

283. PLANTESYGDOMME I DANMARK 1955. Årsoversigt samlet ved Statens plantepatologiske Forsøg, Lyngby. (Plant diseases in Denmark 1955. Annual report com-

piled by the State Phytopathological Experiment Station, Lyngby.) Tidsskr. Planteavl, 61: 561-619. 1957. (Rev. Appl. Mycol. 37: 441-442. 1958.)

Club root of cabbage (Plasmodiophora brassicae) was more troublesome and widely distributed than for many years, causing heavy damage in dry field areas.

284. REPORT OF THE ROTHAMSTED EXPERIMENTAL STATION FOR 1957, 316 pp. 1958. (Rev. Appl. Mycol. 37: 630-633. 1958.)

Tests showed that almost all plants of the long radish variety Woods Frame developed symptoms when inoculated with Plasmodiophora brassicae, whereas the Red Forcing turnip radish was highly resistant.

285. THIRTY-SEVENTH ANNUAL REPORT, DEPT. OF AGRIC., CALIFORNIA, FOR THE PERIOD ENDING 31 DECEMBER, 1956. Bureau of Plant Pathology and Plant Quarantine. Bull. Dep. Agric. Calif. 46: 165-182; 183-190. 1957. (Rev. Appl. Mycol. 37: 206-207. 1958.)

Club root of broccoli (Plasmodiophora brassicae) was found in Humboldt County, this being its first occurrence in the State outside the San Francisco Bay region.

Fungi -- Pyrenochaeta  
See also 643.

286. MARLATT, ROBERT B. and R. T. MCKITTRICK. Pink-root resistant onions for Arizona. Plant Disease Reptr. 42: 1310-1311. 1958.

Pink root, caused by Pyrenochaeta terrestris (Hansen) Gorenz, J. C. Walker & Larson, was found to be causing losses in scattered plantings through Arizona's Salt River Valley in 1953. Differences in varietal reaction were reported.

Fungi -- Pythium  
See also 248

287. FREZZI, M. J. Especies de Pythium fitopatogenas identificadas en la Republica Argentina. (Phytopathogenic species of Pythium identified in the Argentine Republic.) Rev. Invest Agríc., B. Aires 10: 113-241. 1956. (Rev. Appl. Mycol. 37: 337-338. 1958.)

Descriptions are given of 17 species isolated from 140 host species in Argentina, with a key to their identification. P. debaryanum and P. ultimum followed by P. irregulare are the most widespread and the most commonly isolated from a large number of hosts. P. debaryanum was demonstrated by inoculation to cause a virulent potato tuber rot. P. dissotocum was associated with damping-off of white mulberry in a nursery.

P. aphanidermatum caused pea root rot, killing about 40 percent of the plants at the Estación Experimental de Manfredi. It was associated with necrotic stem lesions and rotting of the entire root system of mature Cereus aethiops in a hothouse at the station. It was present with Phytophthora parasitica in necrotic strawberry roots, and was highly virulent to seedlings of Ceratonia siliqua.

Pythium torulosum was isolated only from diseased Piptadenia rigida. P. intermedium caused damping-off of Piptadenia rigida, chilli pepper, tomato, white mulberry. P. graminicola was isolated from dead and chlorotic arrowroot plants. P. periplocum was isolated in conjunction with P. irregulare from date palms with root rot. P. catenulatum was associated with damping-off of tomato, eggplant, red pepper (Capsicum annum) and Cyamopsis tetragonoloba. P. debaryanum was isolated from groundnut husks and kernels, from root-rots of Arachis pusilla and Cicer arietinum, and from damped-off white mulberry.

Damped-off tomato and red clover and 18-month-old Cupressus horizontalis plants with all their roots rotted yielded Pythium polymorphon. P. rostratum was also present in damped-off tomato and white clover and

was associated with P. irregulare in damping-off of Pinus halepensis. P. ultimum, isolated from 82 hosts, especially seedlings, caused the death of mature hemp and coffee by killing all the roots. P. vexans was isolated from severe root-rot of Begonia rex.

P. irregulare caused root necrosis of various barley varieties. Another strain of the fungus was pathogenic to oats and wheat, destroying entire root systems of 25-day-old plants following inoculation. P. irregulare was responsible also for the damping-off of tobacco and Pinus pinea, root rot and wilt of globe artichoke, root rot of mature kidney beans and salsify, and root rot of mature pea plants.

P. mastophorum was isolated from severely damped-off parsley and cabbage; P. oligandrum from necrotic roots in various safflower lines, from severe root rot of mature plants of Antirrhinum majus, from Phaseolus acutifolium var. latifolius with root rot and stem necrosis, and from pea plants and 1-2-year-old apple trees with dead roots. P. spinosum caused damping-off of Gypsophila sp. and eggplant.

288. HALPIN, J. E. and E. W. HANSON. Effect of age of seedlings of alfalfa, red clover, Ladino white clover, and sweetclover on susceptibility to Pythium. *Phytopathology* 48: 481-485. 1958.

Seedlings of alfalfa, sweetclover, red clover and Ladino white clover were susceptible to five species of Pythium in sand culture in a greenhouse at 20-23° C, when inoculated at the time of seeding, but were immune when inoculated 3 or more days after seeding. P. debaryanum, P. ultimum and P. irregulare were the most pathogenic; P. splendens was intermediate; P. paroecandrum was least pathogenic.

289. HAMPTON, R. O. Host specialization in Pythium graminicolum and pathogenicity of P. graminicolum to four host species in soil amended with nitrogen and phosphorus. (Abstr.) *Iowa State Coll. J. Sci.* 32: 184-185. 1957. (*Rev. Appl. Mycol.* 37: 527. 1958.)

Six isolates of Pythium graminicolum isolated from the roots of maize, Setaria, wheat, barley and rye were grown in continuously cropped and rotation-cropped soils. After the eighth generation the fungus was reisolated and examined for host specialization. The virulence of variety isolates was not significantly influenced by the level of resistance of the crop varieties to which they were exposed. P. graminicolum was not present in the roots of maize plants under 14 or over 132 days old.

290. HAWKER, LILIAN E. et al. Studies on vesicular-arbuscular endophytes. I. A strain of Pythium ultimum Trow in roots of Allium ursinum L. and other plants. *Trans. Brit. Mycol. Soc.* 40: 375-390. 1957. (*Biol. Abstr.* 32: 2090. 1958.)

A phycomycetous endophyte, forming typical vesicular-arbuscular mycorrhizas with the roots of Allium ursinum and of some other plants, is described. Pythium ultimum was almost invariably obtained by a section-embedding technique. Inoculation with isolates of Pythium ultimum, under certain conditions, led to typical hyphae and vesicles within the root and, in older seedlings, to the formation of characteristic arbuscules.

291. KENDRICK, J. B. et al. Cantaloupe crown blight study. *Calif. Agric.* 11 (5): 5-6. 1957.

This publication deals with the geographical distribution of a disease generally associated with decayed roots. Leaves shrivel and die on runners. The trouble occurs where there is winter planting. (See Abstr. No. 300.)

292. LINDBERG, G. D. A serious disease of Melilotus indica associated with soils infected with Pythium. (Abstr.) *Phytopathology* 48: 395. 1958.

Yields of Melilotus indica, grown as a green manure crop with sugar-cane, have been reduced several hundred percent in soils highly infested with Pythium. Two phases of disease were readily apparent: 1) poor stands caused by damping-off with Pythium ultimum, 2) severe stunting, yellowing and premature loss of leaves in affected plants surviving the seedling stage.



293. SCHNEXNAYDER, C. A. and E. V. ABBOTT. Study during 1956 of the effects of stunting disease on yields of cane and sugar in Louisiana. Sugar Bull. N. Orleans 35: 334-339. 1957. (Rev. Appl. Mycol. 37: 56. 1958.)  
The fact that seed piece decay caused plant cane stand failure of Louisiana Purple despite treatment demonstrates the continuing importance of seed piece diseases, e.g. red rot (Glomerella tucumanensis) and root rot (Pythium spp.), and the possibility that ratoon stunting favours the development of these pathogens by delaying germination of the seed cutting and the establishment of independent new plants requires further investigation.
294. SHARAN, N. Damping-off of Gul Mohur (Delonix regia Raf.) in India. Plant Disease Repr. 42: 1408. 1958.  
A severe damping-off disease of seedlings of Gul Mohur (royal poinciana) was observed during July 1955 at the Botanical garden at Kanpur. Pythium sp. was isolated and inoculations with this fungus demonstrated its pathogenicity. The causal organism was identified as P. debaryanum.
295. SRINIVASAN, K. V. Current Sci. 25: 299-300. 1956. (Biol. Abstr. 32: 875. 1958.)  
Pythium catenulatum Mathews causing sugarcane seedling root rot.
296. TAKAHASHI, M. and S. ITOI. Studies on the mechanism of resistance in the damping-off of cucurbit seedlings. 3. The changes in oxidase activity, polyphenols and ascorbic acid in the seedling tissues of pumpkin inoculated with Pythium ultimum. Bull. Univ. Osaka Pref. Ser. B. 6: 123-125. 1956. (Hort. Abstr. 28: 69. 1958.)  
It was found that the activity of oxidase and peroxidase was greater and that polyphenols accumulated more in the affected parts of inoculated seedlings than in healthy tissue. Two days after inoculation the diseased seedlings contained more ascorbic acid and oxidized ascorbic acid than the controls.
297. TEAKLE, D. S. A lucerne root rot caused by Pythium myriotylum. Qd. J. Agric. Sci. 13: 241-243. (Rev. Appl. Mycol. 37: 244. 1958.)  
In S. E. Queensland P. myriotylum was found associated with a root rot of lucerne seedlings which resulted in a general unthriftiness of the plants, chlorosis, and progressive defoliation. The fungus proved strongly pathogenic to lucerne seedlings in laboratory inoculation tests, but field attack appeared to be related to the nutrient status of the soil.
298. THOMPSON, H. S. Pythium rot of Saintpaulia. Can. J. Botany 36: 843-863. 1958.  
Pythium ultimum readily infected leaf cuttings, rooted cuttings, and the petioles and leaves of plants when these were in contact with moist infested soil. The disease developed over a broad range of moistures and temperatures.
299. VAN DER ZWET, T. The effect of flooding on Pythium root rot in non-sterile soil. (Abstr.) Phytopathology 48: 345-346. 1958.  
Severe root rot of sugarcane and maize has been artificially induced by Pythium arrhenomanes only in sterilized soil. Severe root rot was obtained in soil flooded for 72 hours, and flooding 2 days after planting maize seedlings resulted in more infection than flooding before or at planting, or more than 2 days afterwards. Maize planted in flooded soil 2 days after infestation showed 38.5 percent root infection compared with 2.5 percent in the non-flooded control.
300. WEDDING, R. T. et al. Crown blight of cantaloupe. Calif. Agric. 11 (6): 5-7. 1957.  
Paper describes a series of studies of the possible causes of the disease, a number of which indicated the inadequacy of the root system. In experiments with both soil temperature and soil moisture as variables, there was a highly significant correlation between crown blight rating and the number of dead roots. Artificial inoculation with several fungi (Fusarium, Pythium, Rhizoctonia, and Sclerotium) associated with cantaloupe roots did

not increase the incidence or severity of the disease. (See Abstr. No. 291.)

Fungi -- Rhizoctonia

See also 74, 627, 650, 717, 719

301. BŁASZCZAK, W. (Studies on rhizoctoniosis of potatoes. I. Studies on rhizoctoniosis of potatoes with special consideration of its control. II. Comparative studies of 25 strains of *R. solani* Kühn collected in Poland.) *Prace Kom. Nauk. roln. leśn. Poznań* 4 (4): 1-78, 79-114. 1958. (Rev. Appl. Mycol. 37: 676. 1958.)  
 The first part describes treatment of tubers with 0.1 percent  $\text{HgCl}_2$ . Autumn treatment was more effective than spring treatment. The 25 isolates of *R. (Corticium) solani* from potato tubers described in part II showed a wide variance in pathogenicity and distinct morphological and cultural differences.
302. FLENTJE, N. T. and H. K. SAKSENA. Studies on *Pellicularia filamentosa* (Pat.) Rogers. II. Occurrence and distribution of pathogenic strains. *Trans. Brit. Mycol. Soc.* 40: 95-108. 1957. (Biol. Abstr. 32: 2082. 1958.)  
 The pathogenicity to five host families of 68 isolates of *P. filamentosa* and 12 of *P. praticola* was examined. Strains specialized to particular crops frequently occurred.
303. FLENTJE, N. T. Studies on *Pellicularia filamentosa* (Pat.) Rogers. III. Host penetration and resistance, and strain specialization. *Trans. Brit. Mycol. Soc.* 40: 322-336. 1957. (Biol. Abstr. 32: 2088. 1958.)  
 The methods of infection of several hosts by a root-attacking strain and a number of stem-attacking strains of *P. filamentosa* were studied with particular attention to formation of appressoria and penetration hyphae.
304. GREEN, V. E. Observations on fungus diseases of rice in Florida 1951-1957. *Plant Disease Repr.* 42: 624-628. 1958.  
 In the Everglades area *Rhizoctonia oryzae* caused only slight damage. One outbreak of seedling blight (*Corticium rolfsii*) which killed 10 percent of the plants was arrested by early irrigation.
305. KULMATYCKA, I., P. LESZEZENKO, and K. MALEC. Rhizoctonia disease of potatoes. *Acta Agrobot.* 3: 27-43. 1955. (Biol. Abstr. 32: 1181. 1958.)  
 A description of the results of studies on the common potato disease caused by *Rhizoctonia solani* is preceded by a review of the earlier literature.
306. KURATA, H. and J. NISHIMURA. Studies on the control of *Corticium* foot-rot of wheat plants. I. Soil conditions and disease incidence. *Ann. Phytopath. Soc. Japan* 22: 97-102. 1957. (English summary) (Rev. Appl. Mycol. 37: 470. 1958.)  
 The effects of soil types, manures, and fertilizers on the development of foot rot (*Corticium gramineum*) were studied. Results showed that least injury occurred to wheat grown in sandy soil to which organic manure, fertilizers, and lime were added. The severity of the disease generally increased with the number of fungi in the soil, while decreasing with an increase of bacteria.
307. LEACH, C. M. and MERLE PIERPOINT. *Rhizoctonia solani* may be transmitted with seed of *Agrostis tenuis*. *Plant Disease Repr.* 42: 240. 1958.  
*Rhizoctonia solani*, which causes a rapid damping-off of Oregon-grown bentgrass seedlings (*Agrostis tenuis*), was found to be seed-transmitted.
308. RICH, SAUL. Rhizoctonia root rot on stored horseradishes in Connecticut. *Plant Disease Repr.* 42: 554. 1958.  
 Locally grown horseradish roots developed a firm, fibrous, odourless rot in storage. The rotted tissue was abundantly invaded with the mycelium of *R. solani*.

309. TEN BOER, H. Het Rhizoctonia problem in Groningen. (The Rhizoctonia problem in Groningen.) Landbouwwoorlichting 15:70-74. 1958. (Rev. Appl. Mycol. 37: 505, 1958.)

The results of further efforts to solve the problem of infection by Rhizoctonia (Corticium) solani on potatoes in N. Groningen, Netherlands again demonstrated the paramount value of clean "seed".

310. VAN EMDEN, J. H. Waarnemingen betreffende het parasitisme van Pellicularia filamentosa (Pat.) Rogers (= Rhizoctonia solani Kühn) ten opzichte van de aardappel-plant. (Observations on the parasitism of Pellicularia filamentosa (Pat.) Rogers (= Rhizoctonia solani Kühn) on the potato plant.) Tijdschr. PlZiekt. 64: 276-281. 1958. (English summary.) (Rev. Appl. Mycol. 37: 736, 1958.)

In field studies at the Instituut voor Plantenziektenkundig Onderzoek, Wageningen, R. (Corticium) solani was often found on symptom-free potato plants; lesions, where present, were restricted to the stems and stolons. The roots of plants growing in vitro in Knop agar inoculated with the fungus were immune from attack until the death of the stems. Temperature and light under which the plants were being grown affected disease incidence.

311. WEBER, GEORGE F. and L. ABREGO. Damping-off and thread blights of coffee in El Salvador. Plant Disease Reptr. 42: 1378-1381. 1958.

New disease manifestations on coffee seedlings in seed beds, caused by Rhizoctonia solani, are described and illustrated. Damping-off of coffee seedlings by Corticium rolfsii is reported for the first time. Silky thread blight of coffee caused by Rhizoctonia ramicola is reported and illustrated, and cultural characteristics of Corticium koleroga are compared with each of the above.

#### Fungi -- Rosellinia

312. ABE, T. and M. KONO. Studies on the white root rot of tea bush IV. On the toxicities of cultural filtrate of the fungus. Sci. Rep. Fac. Agric. Saikyo Univ. 8: 74-80. 1956. (Rev. Appl. Mycol. 37: 182, 1958.)

In further cultural studies on Rosellinia (necatrix), isolate R1, no direct correlation was found between mycelial weight and toxicity of culture filtrates from different media, nor between osmotic pressure and toxicity.

313. BONILLA, E. La "llaga negra" del cafeto y su combate. (Black root rot of coffee and its control.) Rev. cafet. Colomb. 14 (134): 35-38. 1958. (Hort. Abstr. 28: 487. 1958.)

Coffee trees affected by the root fungus Rosellinia bunodes were cured by exposing and treating the root collar with 5 gal. per tree of a 1.5 percent suspension of Terraclor.

314. RODRÍGUEZ, RICARDO A. "Torbo", a tropical disease of potatoes. Plant Disease Reptr. 42: 972-980. 1958.

"Torbo", a serious disease of potatoes in Costa Rica, in addition to attacking the tubers, may cause stem canker and root rot with resultant wilting of young plants. The two stages of the disease, which are described as white and black, are caused by a fungus which probably belongs to the genus Rosellinia, and which seems to consist of more than one strain. Terraclor and Vapam were effective as drenches during dry-season conditions, in two applications at a 3-week interval with 250 kilograms and 100 litres per hectare, respectively.

#### Fungi -- Sclerotinia

315. PARTYKA, R. E. and W. F. MAI. Nematocides in relation to sclerotial germination in Sclerotinia sclerotiorum. Phytopathology 48: 519-520. 1958.

The nematocide, D-D mixture, increased the incidence of drop of lettuce



caused by Sclerotinia sclerotiorum. The data presented indicates that D-D stimulates stipe formation of sclerotia in treated soil.

Fungi -- Sclerotium

See also 16

316. DUBEY, H. D. Relation of soil texture and occurrence of root rot disease (Sclerotium rolfsii Sacc.) of peanut. Plant Disease Repr. 42: 1376-1377. 1958.

The root rot disease of peanut caused by Sclerotium rolfsii was much more prevalent in two fields than in other affected fields. These fields were high in sand and low in clay as compared to the heavier textured soils where the disease incidence was low.

Fungi -- Spongospora

See also 665, 666

317. TOMLINSON, J. A. Crook rot of watercress. III. The causal organism Spongospora subterranea (Wallr.) Lagerh. f. sp. nasturtii f. sp. nov. Trans. Brit. Mycol. Soc. (In press).

Fungi -- Stemphylium

318. MUKULA, J. On the decay of stored carrots in Finland. Acta agric. scand., Suppl. 2, 132 pp. 1957. (Rev. Appl. Mycol. 37: 196-197. 1958.)

Contamination of stored carrots by Stemphylium-Fusarium was found to be soil-borne, increasing as the result of successive carrot cultivation in the same field.

Fungi -- Synchytrium

See also 62, 63, 68

319. BOJNANSKY, V. Das Auftreten und Verschwinden des von Schilberszky beschriebenen Kartoffelkrebses, (Synchytrium endobioticum (Schilb.) Perc.) in der Slowakei. (The occurrence and disappearance of potato wart disease in Slovakia.) NachrBl. dtsh. PflSch-Dienst, Berl., N. F. 11: 109-114. 1957. (Rev. Appl. Mycol. 37: 304. 1958.)

Historical data on this disease in Slovakia indicates that it first occurred at Hornany (then in Hungary, now in Czechoslovakia) in 1888, though it was not reported by Schilbersky until 1896. Its subsequent disappearance would appear to have coincided with a dry period from 1890-99. The next reported occurrence was at Kysuce in 1939.

320. FEDOTOVA, T. I., E. F. KARESEVA, and M. I. RAKOVICH. (The difference in the activities of the causal organism of potato wart disease.) (Rep. Lenin. Acad. agric. Sci.), 22: 31-33. 1957. (Rev. Appl. Mycol. 37: 246. 1958.)

At the State Scientific Research Institute for Plant Protection in U. S. S. R. observations have established the existence of 47 potato varieties resistant to wart disease (Synchytrium endobioticum). The greater virulence of isolates from some districts indicates the existence of a new strain of the fungus.

321. GEDZ, S. M. (The importance of vegetative hybridization for increasing immunity of potatoes to wart disease Synchytrium endobioticum (Schilb.) Perc.). (Rep. Lenin. Acad. agric. Sci.) 22: 28-30. 1957. (Rev. Appl. Mycol. 37: 245-246. 1958.)

In field and laboratory trials at the University of Chernovitz, U. S. S. R., potato varieties resistant to wart disease were grafted to susceptible varieties using eyes, roots, and shoots. If the grafting material was treated for 5-6 days with 0.0005 percent heteroauxin solution in cotton wool the results were very satisfactory. The first, second, and third generations of some combinations proved completely resistant.

322. GEDZ, S. M. (On the nature of the immunity of potatoes from wart disease and some

methods for increasing it.) (Agrobiology), 1958: 108-117. 1958. (Rev. Appl. Mycol. 37: 502. 1958.)

In experiments in the Ukraine, with the susceptible potato varieties Ella and Alma growing in soil infested with Synchytrium endobioticum, the spring crop was practically free from infection whereas the autumn one was very severely attacked. On grafting susceptible to resistant varieties, 41 percent of the new combinations were found to be highly resistant; Ella, Epron, and Seyanets 106, each on Ubel, and Seyanets 20 and 24 on Majestic gave good results.

323. MOORE, W. C. The breakdown of immunity from potato wart disease. Outlook on Agric. 1: 240-243. 1957. (Rev. Appl. Mycol. 37: 554. 1958.)

After a brief introduction dealing with the control of the spread of Synchytrium endobioticum by means of import restrictions, the author discusses the occurrence of new physiologic races of the fungus in various geographic locations.

324. MORGAN, G. C., and E. H. PETERS. The potato wart disease problems in Newfoundland. Rep. Quebec Soc. Prot. Pl., 1956, pp. 62-68. 1957. (Rev. Appl. Mycol. 37: 369. 1958.)

In this semi-popular review of potato wart disease (Synchytrium endobioticum), it is stated that sufficient land free from wart is available in the west of Newfoundland for the production of approved seed.

325. MYGIND, H. Kartoffelbrok. En samlet oversigt. (Potato wart. A collective survey.) 58 pp., Statens Plantetelsyn, Copenhagen, 1957. (Rev. Appl. Mycol. 37: 734. 1958.)

This is a useful manual which comprises sections on the symptomatology, etiology, and biology of Synchytrium endobioticum; information on varietal reactions, and on physiological races; the various modes of infection and control.

326. ULLRICH, J. Die physiologische Spezialisierung von Synchytrium endobioticum (Schilb.) Perc. in der Bundesrepublik. (The physiologic specialization of Synchytrium endobioticum (Schilb.) Perc. in the Federal Republic.) Phytopath. Z., 31: 273-278. 1958. (Rev. Appl. Mycol. 37: 502. 1958.)

Five varieties and two strains of potatoes were used as differential varieties at the Institut für physiologische Botanik, Brunswick, for the identification of five biotypes of S. endobioticum found in Germany.

- (327. No abstract for this number.)

#### Fungi -- Verticillium

See also 65, 69, 72, 76, 662, 695, 710, 724

328. BATES, G. R. Botany and Plant Pathology. Rep. Minist. Agric. Rhod., Nyasaland. 1955-6, pp. 79-86. 1956. (Rev. Appl. Mycol. 37: 134-135. 1958.)

Verticillium dahliae was responsible for wilt of tomatoes under glass and was associated with wilt symptoms in eggplant and okra.

329. BURTON, C. L. and D. J. DeZEEUW. Studies on transmission of Verticillium wilt of eggplant in Michigan. Plant Disease Repr., 42: 427-436. 1958.

Laboratory results indicate that seed transmission of Verticillium wilt of eggplant is unlikely to occur in practice.

330. BUXTON, E. W. Problems of plant wilt diseases. Agric. Rev. 3 (7): 28-35. 1957. (Rev. Appl. Mycol. 37: 450. 1958.)

A survey presents up-to-date information under the headings of Verticillium wilt, Fusarium wilt, wilt problems in Britain, research problems, and control methods.

331. DAVIES, R. R. and I. ISAAC. Dissemination of Verticillium albo-atrum through the atmosphere. Nature 181: 649. 1958. (Rev. Appl. Mycol. 37: 497. 1958.)

Following the trapping of colonies of V. albo-atrum on agar plates in a lucerne stand and the isolation of this fungus from house dust in Edinburgh and from the atmosphere in a garden in London, an investigation was initiated to determine the number of V. albo-atrum spores in the air within and above lucerne crops at four centres. The results indicate that the number of spores of V. albo-atrum in and above infected stands of lucerne is sufficiently high to suggest that the spread of the disease in this crop may occur by means of wind-blown spores.

332. DAVIS, J. F., R. E. LUCAS and L. N. SHEPHERD. Mint grown on organic soils. Better Crops 41 (10): 28-36. 1957. (Hort. Abstr. 28: 261. 1958.)  
Yields of mint are depressed by wilt disease (V. albo-atrum) in Michigan. Large responses to fertilizers were obtained. Under dry or frosty conditions irrigation is advisable and this may induce wilt attack. Transplanting is less effective than planting roots because wilt injury is more likely. Wilt increases with prolonged production without rotation.
333. EDGINGTON, L. V. Temperature and nutritional studies on Verticillium and Fusarium wilts of tomato. Diss. Abstr. 17: 22-23. 1957. (Rev. Appl. Mycol. 37: 316. 1958.)  
A decrease in either B or Ca caused an increase in susceptibility of tomato plants to F. oxysporum lycopersici, but when B was increased to 10 ppm to give toxicity symptoms wilt became more severe than with the optimum (0.05 ppm). In a water culture experiment both a deficiency and an excess of Mn increased susceptibility.
334. ELENKOV, E. (Morphological changes in sweet peppers affected by Verticillium wilt.) Bull. Plant Prot., Sofia 3 (1954): 39-41. 1955. (Rev. Appl. Mycol. 37: 435. 1958.)  
A disease of sweet peppers (Capsicum) in S. Bulgaria caused dwarfing of the plants and losses up to 90 percent in 1951. The pathogen, V. albo-atrum, proved to be serious only when parasitizing young plants before transplanting. Diseased plants then attain only 1/4 the height of normal ones, produce little fruit, and often wither in hot weather.
335. ERWIN, DONALD C. Verticillium wilt of Cicer arietinum in southern California. Plant Disease Reprtr. 42: 1111. 1958.  
Since 1954 in the San Pedro Hills of Los Angeles County, California, a wilt disease of garbanzo bean plants (Cicer arietinum) incited by Verticillium albo-atrum Reinke & Berth. has occasionally been seen. Foliage of affected plants was yellow in color and eventually plants wilted and died. A light brown discoloration of the xylem tissue was also present in infected plants.
336. GREEN, RALPH J., Jr. Deep plowing for controlling Verticillium wilt of mint in muck soils. Phytopathology 48: 575-577. 1958.  
Verticillium albo-atrum var. menthae was absent below 12-18 inches or present in very low concentrations in muck soils. When the upper 12-14 inches of soil was dropped into the previous plow furrow before the remainder of the soil was turned to a depth of 28-32 inches, wilt incidence was reduced.
337. HARRIS, R. V. Plant Pathology. Progress in research on Verticillium wilt and virus diseases in hops in 1957. Rep. E. Malling Res. Sta., 1957: 22-27; 161-163. 1958. (Rev. Appl. Mycol. 37: 439. 1958.)  
In preliminary experiments Phytophthora cactorum affected the growth of susceptible apple varieties in infested soil by attacking the fibrous roots without actually causing collar rot. There was a definite seasonal activity of the fungus in the soil.  
Further studies on the mechanism of resistance in hop varieties tolerant of V. albo-atrum indicated that the deposition of suberin in the host cell walls may prevent cellulose-destroying enzymes produced by the pathogen from attacking the walls. Complete exclusion of V. albo-atrum could not be achieved by this means alone owing to the zone of immature cells near the



root tip which would lack suberin at this stage. Following the death of infected plants, V. albo-atrum sporulated over the root surface and occasionally on soil particles adhering to the root, but mycelial growth into the soil was very limited. In inoculations of the susceptible variety Fuggle, wilt symptoms developed more rapidly when bine fragments were used than with spore suspensions and the rate of development was related to inoculum concentration. Conidia of the wilt fungus remained viable in soil for the duration of a 14-day test. Every soil investigated inhibited the germination of conidia.

338. HUGHES, C., N. D. FULTON and B. A. WADDLE. Irrigation and Verticillium wilt incidence in cotton. *Arkansas Farm Research* 7 (2): 4. 1958.

Data showed a significant increase in wilt incidence in irrigated replications of 5 varieties. Increases in wilt ranged from 15 to 26 percent.

339. KIESSIG, R. and RENATE HALLER-KIESSIG. Beitrag zur Kenntnis einer infektiösen Welkekrankheit der Luzerne (Verticillium albo-atrum R. et B.). (Contribution to the knowledge of an infectious wilt disease of Lucerne (Verticillium albo-atrum R. et B.).) *Phytopath. Z.* 31: 185-222. 1957. (Rev. Appl. Mycol. 37: 416-417. 1958.)

A comparison of the symptoms of arid wilt with those of the three known wilt diseases of lucerne at Jena, Germany, showed that there was considerable agreement between it and Fusarium wilt (Fusarium sp.) and with Verticillium wilt. Each of these diseases produces a number of symptoms that are similar for all three, whereas the root symptoms of arid wilt are quite different from those produced by an infection with Corynebacterium insidiosum. The root symptoms of arid wilt are indistinguishable from those of the Fusarium and Verticillium wilts. However, numerous isolation and infection tests proved that V. albo-atrum is the pathogen. Four strains of V. albo-atrum produced two toxins with different effects and properties.

340. MOREAU, MIREILLE. (The development of the lignifying complex in the cultivated carnation during attack by Phialophora cinerescens.) *Rev. Mycol., Paris*, 22: 155-165. 1957. (Rev. Appl. Mycol. 37: 86. 1958.)

Attack of carnation by Phialophora (Verticillium) cinerescens produced an effect on lignification that inhibited locally the formation of the woody ring and caused a regression of the tissues already lignified. At a distance, lignification was increased with an accompanying weak but normal differentiation and lignification of the vessels of new tissues. Gummosis seems to be a defence reaction of the host. As gummosis spreads in living tissues, the annular arrangement of the lignified tissues may prevent it from exerting a fatal effect on the cells and allow the development of subero-phelloderm which may, temporarily at least, hinder the advance of the parasite. This may explain the different degrees of resistance of varieties previously classified according to the anatomical character of their xylem, the growth of which and the induration of the parenchyma associated with gummosis account for the stiff, brittle habit of infected carnations.

341. MOREAU, MIREILLE. (The ligneous tissue of the collar and susceptibility of the cultivated carnation to vascular parasites.) *Bull. Soc. bot. Fr.*, 104: 257-259. 1957. (Rev. Appl. Mycol. 37: 481. 1958.)

Four types of distribution of woody tissues are distinguished: in type I, where the tissues are in continuous concentric rings surrounded by sclerified cells, an effective mechanical barrier is presented to heavy attack by Phialophora (Verticillium) cinerescens; in type IV lignification is reduced and the woody tissues are in islands running radially. Varieties were found to be differentially susceptible to fusariosis and to verticilliosis.

342. NATTI, J. J. Verticillium wilt of broccoli and cauliflower in New York. (Abstr.) *Phytopathology* 48: 264. 1958. (Rev. Appl. Mycol. 37: 612. 1958.)

Seedlings of 15 varieties of broccoli and three of cauliflower the roots

of which were dipped in a culture of V. albo-atrum isolated from tomato, developed yellowing, often unilateral, of the lower leaves and blackening of the vascular strands within 14-30 days in the greenhouse. Similar symptoms occurred in field plots known to be infested with this pathogen. Infected plants were not stunted nor were yields affected. Broccoli plants inoculated with isolates from naturally infested broccoli and cauliflower developed similar symptoms to those caused by the tomato strain.

343. NELSON, PAUL E. and STEPHEN WILHELM. Thermal death range of *Verticillium albo-atrum*. *Phytopathology* 48: 613-616. 1958.

Minimum exposure and lethal temperature in hot water for a rose and a tomato isolate of V. albo-atrum was 5 minutes at 47° C for hyphae and conidia and 10 min. at 50° C for microsclerotia. A 40-min. exposure at 47° C also killed microsclerotia. Microsclerotia exposed in dry atmosphere at 49-50° C survived 6 months whereas conidia succumbed within 3 days.

344. NOVELLO, C. Segnalazione di *Verticillium* sp. su *Cannabis sativa*. (Report of *Verticillium* sp. on *Cannabis sativa*.) *Ric. fitop. Campan.* 13-14: 161-163. 1957. (English summary.) (*Rev. Appl. Mycol.* 37: 356. 1958.)

An unidentified *Verticillium* sp. causing wilt of hemp near Naples is the first recorded report in Italy.

345. PAPAIOANNOU, A. J. Une hadromycose du pistachier (*Pistacia vera* L.) causée par le *Verticillium albo-atrum* Reink. and Berth. *Ann. Inst. Phytopath. Benaki* 10: 25-27. 1956. (*Biol. Abstr.* 32: 1778. 1958.)

P. vera is reported as a new host of V. albo-atrum for the first time in Greece.

346. PHILLIPS, D. H. Report of the Mycological Dept., 1955. Rep. States Jersey 1955: 31-42. 1957. (*Rev. Appl. Mycol.* 37: 4. 1958.)

More outbreaks than usual of *Verticillium* wilt (mostly V. albo-atrum) were noted on glasshouse tomatoes.

347. PRATT, M. J. Occurrence, behavior and control of *Verticillium albo-atrum* Reinke and Berth. on small fruits. *Diss. Abstr.* 18: 36-37. 1958. (*Hort. Abstr.* 28: 562. 1958.)

*Verticillium* wilt was found to be an important disease of black raspberries and strawberries in Oregon. Plant remains in the soil are a serious source of infection but incidence of *Verticillium* in propagation stock was low. Complete control in the top 10 inches of soil was obtained in field trials with allyl bromide, chloropicrin, Mylone, and Vapam at about 400 lb./acre.

348. RAABE, ROBERT D. and STEPHEN WILHELM. *Verticillium* wilt of garden stock (*Matthiola incana*). *Phytopathology* 48: 610-613. 1958.

*Verticillium* wilt of garden stock, *Matthiola incana*, was prevalent in northern and southern California. Symptoms, including a yellowing and wilting of the lower foliage, are very similar to those of K deficiency, and in some ways resemble those of *Fusarium* wilt, *Rhizoctonia* foot rot, bacterial blight, and *Phytophthora* foot rot.

349. ROBINSON, D. B., R. H. LARSON and J. C. WALKER. *Verticillium* wilt of potato in relation to symptoms, epidemiology and variability of the pathogen. *Wisconsin Agric. Expt. Sta. Res. Bull.* 202: 1-49. 1957. (*Biol. Abstr. D.* 32: 1176. 1958.)

In this research program on *Verticillium* wilt of potato a severe tuber lesioning was shown to be associated with *Verticillium* wilt. Evidence was obtained that these tuber lesions were incited by a species of *Pseudomonas*.

350. ROSS, J. P. Studies on the chemotherapy and physiology of the *Verticillium* diseases of peppermint and chrysanthemum. *Diss. Abstr.* 17: 11. 1957. (*Rev. Appl. Mycol.* 37: 286-287. 1958.)

Healthy chrysanthemums and peppermint plants previously inoculated with V. albo-atrum by allowing them to take up spores from a suspension were tested with 27 chemotherapeutants absorbed through the freshly-cut basal ends. Fungichromin and Nabam proved most effective. The amino-N content of healthy and infected cuttings was compared.

351. SEWELL, G. W. F. and J. F. WILSON. Weed hosts of the "progressive" hop strain of Verticillium albo-atrum Reinke and Berth. Rep. E. Malling Res. Sta. 1957, pp. 126-128. 1958. (Rev. Appl. Mycol. 37: 498. 1958.)

Isolates of V. albo-atrum, very virulent on hop, were isolated from four common weeds, Chenopodium album, Senecio vulgaris, Solanum nigrum, and annual nettle (Urtica urens), in badly wilted hop gardens. After the first appearance of wilt in these gardens the weeds are usually allowed to grow unchecked until picking time, when they are cut down and ploughed in, because repeated cultivation has been found to increase spread. Two conflicting factors concerned are the beneficial effect of an annual weed flora in reducing the period of survival of V. albo-atrum in dead tissues, and the possible harmful effect of living hosts in which the pathogen can persist.

352. SKOTLAND, C. B. and J. D. MENZIES. Two peppermint diseases found in the Yakima Valley of Washington. Plant Disease Repr., 41: 493. 1957. (Biol. Abstr. 32: 2955. 1958.)

In 1955 a wilt disease of peppermint, Mentha piperita, associated with Verticillium albo-atrum caused considerable damage in one field in the Yakima Valley. This is the first reported occurrence of the typical strain in Washington, and on the genus Mentha.

353. STEPANTSEV, I. N. (Diseases causing cotton wilt and their control.) Bull. Bur. nat. Sci. Tadzhik S.S.R. 21: 89-107. 1957. (Rev. Appl. Mycol. 37: 662-663. 1958.)

A detailed study in 1941-1954 on cotton wilt in the Leninabad region caused by Verticillium (dahliae) showed that temperature and humidity play the most important role in its development. 25.2°C is opt., and 36.8° max. With 13.5-19.3 percent humidity the disease becomes epidemic. With the thin lint cotton varieties the wilt caused by Fusarium (vasinfectum) appears only when the temperature is less than 36.8°, the opt. being at 29°. Rotation of cotton and lucerne proved very successful. Irrigation must be done before the temperature reaches 38.7°. B and Mn applied before sowing increased the respiratory capacity of plants and their resistance to wilt.

354. TALBOYS, P. W. Mechanisms contributing to Verticillium-resistance in the hop root. Trans. Brit. Mycol. Soc. 1958, 41: 227-241. (J. Sci. Food Agr. 9: ii-169. 1958.)

Invasion of the host root is retarded by cell-wall lignification and by occlusion of invading hyphae by sheathing deposits. Suberization of the endodermis excludes the fungus from the stele.

355. TALBOYS, P. W. Some mechanisms contributing to Verticillium-resistance in the hop root. Degradation of cellulose by Verticillium albo-atrum. Association of tylosis and hyperplasia of the xylem with vascular invasion of the hop by Verticillium albo-atrum. Trans. Brit. Mycol. Soc., 41: 227-241; 242-248; 249-260. 1958. (Rev. Appl. Mycol. 37: 673-674. 1958.)

The reactions of the hop cultivar tolerant of virulent and mild strains of V. albo-atrum and the sensitive Fuggle were studied. Observations on host-parasite interactions in the determinative phase are described in detail. Exclusion of the fungus from the stele apparently depends on suberization of the endodermis. The defence mechanism in the hop is of a type found in other plants, related, it is suggested, to the presence of foreign organisms.

In the second paper is reported the secretion of a cellulase system by the fungus in liquid media containing cellulose or cellobiose as the sole C sources. From results obtained it is suggested that the presence of sugars, starch, etc. in roots invaded by V. albo-atrum can inhibit cellulase production and general cell-wall destruction, though traces of cellulase still



aid fungal penetration.

In the third paper tylosis was shown to be stimulated by the presence of small amounts of mycelium and low concentration of the metabolites secreted by the pathogen but is inhibited by higher concentration. Tylosis and hyperplasia are also induced in the hop by V. dahliae and other fungi and by wounding. Leaf necrosis and the preceding chlorosis and browning of mesophyll cells adjacent to terminal tracheidal elements are probably due to fungal toxins in both mild and acute syndromes.

356. ZALESKI, A. Reactions of lucerne strains to *Verticillium* wilt. *Plant Path.* 6: 137-142. 1957. (Rev. Appl. Mycol. 37: 297-298. 1958.)

Twelve lucerne strains became naturally infected by V. albo-atrum, some more severely than others. Symptoms became more conspicuous towards the end of the season and the disease spread more as the stands aged.

357. THIRTY-FIRST ANNUAL REPORT OF THE DEPT. OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW ZEALAND, 1957. (Rev. Appl. Mycol. 37: 7. 1958.)

Although *Verticillium* wilt of tobacco spreads very slowly it is becoming an increasingly important problem.

#### Fungi -- *Verticillium* -- Resistance

358. ELENKOV, E. (On the relation between sweet pepper varieties and *Verticillium* wilt.) *Bull. Plant Prot.*, Sofia 6: 32-37. 1957. (Rev. Appl. Mycol. 37: 435. 1958.)

The relative resistance of 115 varieties of sweet pepper to *Verticillium albo-atrum* was determined in inoculated soils under greenhouse conditions or by dipping the split roots of plants into a culture suspension.

359. MILLER, P. W. and G. F. WALDO. Relative resistance of some strawberry varieties and selections to powdery mildew at Corvallis, Oregon. *Plant Disease Repr.* 41: 23-24. 1957. (*Biol. Abstr.* 32: 880. 1958.)

Most clones of the native strawberry species, *Fragaria chiloensis*, are resistant or tolerant to *Verticillium* wilt caused by V. albo-atrum.

360. NEWTON, W. and M. C. J. VAN ADRICHEM. Resistance to *Verticillium* wilt in  $F_1$  generations of self-fertilized species of *Fragaria*. *Can. J. Botany* 36: 297-299. 1958. (*Biol. Abstr.* 32: 2669. 1958.)

The  $F_1$  generations of selfed plants of *Fragaria chiloensis*, *F. ovalis*, and *F. ykonensis* contained seedlings resistant to the *Verticillium* wilt disease. Selfed *F. orientalis* plants yielded seedlings that carried considerable tolerance, but selfed *F. vesca*, *F. bracteata*, and *F. virginiana* plants yielded neither tolerant nor resistant seedlings. Asexually propagated plants of the seven species were all susceptible to the disease.

361. PUTT, E. D. Note on resistance of sunflowers to leaf mottle disease. *Canad. J. Pl. Sci.* 38: 274-276. 1958. (Rev. Appl. Mycol. 37: 549. 1958.)

At Morden, Manitoba, 40 varieties and lines of sunflower were grown in soil infected with V. albo-atrum. A low percentage of leaf mottle was recorded on three lines. Preliminary results indicated the complex nature of the inheritance of resistance to this disease.

362. VAN ADRICHEM, M. C. J. and W. R. ORCHARD. *Verticillium* wilt resistance in the progenies of *Fragaria chiloensis* from Chile. *Plant Disease Repr.* 42: 1391-1393. 1958.

Seedlings of *Fragaria chiloensis* collected in Chile were tested for resistance to the *Verticillium* wilt disease caused by V. albo-atrum Reinke & Berth. Resistant plants were found in three of eight collections and tolerant plants in all but one. The suggestion is advanced that the resistance in certain cultivated varieties may have been introduced through *F. chiloensis* from North and South America and that by selfing certain cultivated varieties resistant lines may be isolated.

## INSECTICIDES

See also 690

363. ERWIN, DONALD C. and H. T. REYNOLDS. The effect of seed treatment of cotton with Thimet, a systemic insecticide, on *Rhizoctonia* and *Pythium* seedling diseases. *Plant Disease Reptr.* 42: 174-176. 1958.

In soil infested with *Rhizoctonia solani* Thimet as a seed treatment increased the percentage emergence and appeared to be fungitoxic. In soil infested with *Pythium debaryanum* Thimet did not increase the percentage of emergence. Treatment of seed with a Thimet-captan mixture or with Thimet following an initial seed treatment with captan was found to induce a satisfactory stand of cotton in non-sterilized soil.

## METHODS AND TECHNIQUES

364. BARTON, R. Occurrence and establishment of *Pythium* in soils. *Trans. Brit. Mycol. Soc.* 41: 207-222. 1958.

In studies at Botany Dept., University of Manchester, of 25 soil samples from different parts of Britain, *P. mammillatum* was isolated from 2 (vegetable garden and oat fields), *P. debaryanum* from 3 (flower garden, greenhouse and potato fields), and *P. ultimum* from 4 (vegetable garden, wheat field and beds), using susceptible seedlings as "baits". The behaviour of *Pythium* in relation to pH, moisture content, nutritional status, and texture of cultivated soils and acid woodland soils was investigated by means of susceptible host baits and glass fibre tape technique. The presence of suitable host plants proved an important factor in establishing *Pythium* in soils. It was indicated that pH affects the life cycle of *Pythium* in soils.

365. BROWN, M. E. Preliminary studies on the inoculation of selected microorganisms into partially sterilized soils. *J. Gen. Microbiol.* 18: 239-247. 1958.

At the end of 1 year *Nocardia cellulans* was still present in high numbers in partially sterilized soils while it disappeared from an untreated soil in 6 months.

366. BUTLER, EDWARD E. and RICHARD B. HINE. Use of novobiocin for isolation of fungi from the soil. *Soil Science* 85: 250-254. 1958.

Novobiocin, sodium acid salt, when used in a concentration of 100  $\mu\text{g}/\text{ml}$  in potato-dextrose agar, pH 5.6-6.1 excluded bacteria and actinomycetes from soil dilution plates but allowed fungi to grow. The only fungi which failed to produce colonies on novobiocin-PDA were a limited number of species in the genera *Phytophthora* and *Pythium*.

367. CHINN, S. H. F. and R. J. LEDINGHAM. Application of a new laboratory method for the determination of the survival of *Helminthosporium sativum* spores in soil. *Can. J. Botany* 36: 289-295. 1958.

A laboratory method is described for determining the survival of *Helminthosporium sativum* spores in soil.

368. GILMOUR, C. M., L. DAMSKY and W. B. BOLLEN. Manometric gas analysis as an index of microbial oxidations and reductions in soil. *Can. J. Microbiol.* 4: 287-293. 1958.

A manometric procedure for the determination of microbial oxidations and reductions in soils is described.

369. GOULD, CHARLES. J. The use of tiles for studies on soil-borne fungi. *Plant Disease Reptr.* 42: 811-813. 1958.

The use of concrete sewer tiles has proven very useful for certain types of field studies on soil-borne pathogens of gladiolus; namely *Stromatinia gladioli* (Dray.) Whet., *Sclerotium rolfii* Sacc., and an unnamed (black rot) fungus. This equipment was used to study longevity of pathogens in different soil types, the effectiveness of different kinds of fungicides, the effectiveness

of different methods of fungicide application, and the persistence of fungicidal action in the soil.

370. ISHIZAWA, S. et al. Studies on microbial population in the rhizosphere of higher plants, with special reference to the method of study. Soil and Plant Food (Tokyo) 3: 85-94. 1957. (Chem. Abstr. 52: 7950 (i). 1958).

Fungi counts were generally greatest in the rhizosphere of timothy and least in the rhizosphere of alfalfa.

371. JAMES, N. Soil extract in soil microbiology. Can. J. Microbiol. 4: 363-370. 1958.

In this study soil extract was considered critically in so far as various treatments affect numbers of bacteria developing on soil-extract agar.

372. KERR, A. The use of cellophane in growth studies on soil fungi. Trans. Brit. Mycol. Soc. 41: 14-16. 1958.

A cellophane disk technique is described which has been used to demonstrate a stimulation of Pellicularia praticola by fresh grass cuttings. The technique has limitations, in that the behaviour of a fungus between sheets of cellophane may be very different from that in the surrounding substrate.

373. KLOTZ, L. J. and T. A. DeWOLFE. Techniques for isolating Phytophthora spp. which attack citrus. Plant Disease Repr. 42: 675-676. 1958.

P. citrophthora, P. parasitica, and P. syringae have been isolated from soil samples in the laboratory (Univ. of Calif. Citrus Expt. Sta., Riverside) by saturating with water, placing clean lemons on the surface to trap the zoospores, and incubating at 20°C. In the field a lemon or an orange is placed in a can with a drain hole and wire bail, buried 6-12 in. under the soil surface or in irrigation furrows. Depending on soil temperature, 4-10 days after irrigation or rain the cans are pulled out and isolations made from fruits with brown rot.

374. MacFARLANE, I. A solution-culture technique for obtaining root-hair, or primary, infection by Plasmodiophora brassicae. J. Gen. Microbiol. 18: 720-732. 1958.

Primary infections were obtained by growing cabbage seedlings in a modified-Hoagland's solution in which resting spores of P. brassicae were suspended. A roughly linear relationship was found between the logarithm of number of infections/roots and the logarithm of spore concentration in the medium. Infection was not affected by changing from pH 5 to 6 but was greatly decreased at pH 8.

375. MACURA, J. and I. MALET. Continuous-flow method for the study of microbiological processes in soil samples. Nature 182: 1796-1797. 1958.

The method described makes it possible to introduce into the soil continually any desired amount of substrate the transformation of which is studied. Basically it is an application of the continuous-flow method of culture microorganisms to the study of microbiological processes in the soil.

376. MALOY, O. C. and M. ALEXANDER. The "most probable number" method for estimating populations of plant pathogenic organisms in the soil. Phytopathology 48: 126-128. 1958.

A technique involving the use of the most probable number method was adapted to the estimation of two plant pathogenic fungi, Fusarium solani f. phaseoli and Thielaviopsis basicola, in the soil.

377. MENZIES, J. D. A dipper technique for serial dilution of soil for microbial analysis. Soil Sci. Soc. Amer., Proc. 21: 660. 1957.

A stainless steel cup of 1-ml capacity is used in place of pipettes for serial dilutions of soil suspensions in test tubes.

378. PARK, D. The saprophytic status of Fusarium oxysporum causing vascular wilt of oil palm. Ann. Botany, N.S. 22: 19-35. 1958.



The droplet method described, especially when used in conjunction with a baiting technique, facilitates the demonstration of Fusarium oxysporum in soil.

379. PETERSON, E. A. Observations on fungi associated with plant roots. Can. J. Microbiol. 4: 257-265. 1958.

The soil fungal flora associated with plant roots is influenced by the age of the plants and the soil type.

380. SLANKIS, V. An apparatus for surface sterilization of root tips. Can. J. Botany 36: 837-842. 1958.

An apparatus for surface sterilization of root tips is described. This apparatus makes sterilization more accurate and considerably more efficient compared with methods previously employed. It can be successfully used under field conditions.

381. STENTON, H. Colonization of roots of *Pisum sativum* L. by fungi. Trans. Brit. Mycol. Soc. 41: 74-80. 1958.

The colonization of pea roots by soil fungi was investigated by sowing surface-sterilized seeds in pots of garden soil and sampling at intervals over a period of 87 days. Over 40 different fungi were isolated. Cylindrocarpum was the most abundant, occurring 635 times and equally frequent on upper and lower root sections. Species of Fusarium were isolated 278 times, Pythium 119, Gliocladium roseum 107, Mortierella 73.

382. STEVENSON, I. L. The effect of sonic vibration on the bacterial plate count of soil. Plant and Soil 10: 1-8. 1958.

Treating the first dilution of a soil-plating series by high-frequency vibrations resulted in initial increases in the numbers of bacteria, actinomycetes, and fungi appearing on plates.

383. THORNTON, R. H. A soil fungus trap. Nature 182: 1690. 1958.

An improved screened immersion-plate method for isolating soil fungi is described.

384. WAID, J. S. Distribution of fungi within the decomposing tissues of rye grass roots. Trans. Brit. Mycol. Soc. 40: 391-406. 1957.

Rye grass roots, classified according to the degree of visible decomposition of the cortex, were plated. The progress of root degradation was paralleled by an increase in fungal activity in each zone. The most active population originated from the root surface of intact roots.

#### NEMATODE CONTROL

See also 628

#### Nematode control -- Crop Rotation

See also 428

385. MASLENIKOV, I. P. (Control of onion nematode) (Russian) Sad i Ogorod. 5: 27-28. 1958. (Hort. Abstr. 28: 604. 1958)

Control of onion nematode by crop rotation, hot water treatment of the seed, ammonium nitrate top dressing, or soil treatment with dichloroethane was discussed.

386. MEIJNEKE, C. A. R. and M. OOSTENBRINK. Tagetes ter bestrijding van aaltjesaantastingen. Overdruk uit Mededelingen Directeur van de Tuinbouw 21: 283-290. 1958.

It is shown that several cultivars of Tagetes patula and T. erecta reduce the population of certain root infesting nematodes such as Pratylenchus spp., Tylenchorhynchus spp., Rotylenchus robustus, and probably Meloidogyne spp. The application of this nematocidal effect of Tagetes

is discussed in terms of nurseries, ornamental gardens and orchards exhibiting "replant problems".

#### Nematode control -- Heat Therapy

387. BIRCHFIELD, WRAY and H. M. van PELT. Thermotherapy for nemas of ornamental plants. (Abstr.) *Phytopathology* 48: 341. 1958.
388. BIRCHFIELD, W. and H. M. van PELT. Thermotherapy for nematodes of ornamental plants. *Plant Disease Repr.* 42: 451-455. 1958.  
The tolerance of 24 ornamental plants to 10 minutes exposure at 50° C (a bare-root treatment) is recorded, as well as the degree of control of Meloidogyne incognita infesting the roots of these plants.
389. BRANDE, J. VAN DEN and A. GILLARD. Control of root nematodes by electric soil heating. (Flemish) *Tuinbouwber* 21: 63-64. 1957. (Hort. Abstr. 28: 384. 1958.)  
Soil heating by electricity has given cheaper nematode control in green-houses than steaming. When wire netting at a depth of 10-17 cm had raised the temperature of the top soil to 55-60° C nematodes were killed.
390. MAI, W. F. Effectiveness of di-electric heat in killing encysted golden nematode larvae. *Plant Disease Repr.* 42: 449-450. 1958.  
Di-electric heat treatments of burlap bags containing potato-root eel-worm (Heterodera rostochiensis) cysts showed that temperatures reaching 205° to 230° F killed nematode larvae. The cost of equipment required to generate the heat makes the process impractical.
391. PÄÄSUKKE, M. Jordgubbsnematoden och dess bekämpning. (Strawberry nematode and its control.) *Fruktodlaren*, 29: 45-48. 1958. (Hort. Abstr. 28: 384. 1958)  
After hot water treatment survival of the strawberry variety NorthWest was about 50 percent, Konigin Louise 50-60 percent, and Macherauchs Frühernte 60-70 percent.

#### Nematode control -- Nematocides -- Application and Mechanism of Action

392. BENEDICT, S. H. Fertilizer-nematocide mixtures can be profitable. *Agr. Chem.* 13 (9): 25-26. 1958.  
Economic advantage of applications of fertilizer-nematocide mixtures are discussed.
393. BESEMER, A. F. H. and M. OOSTENBRINK. Comparison of some soil-disinfectants with nematocidal properties. (Flemish) *Ghent. Landbhogesch. Meded.* 22: 387-398. 1957. (Bibl. Agr. 22(6): 18. 1958.)
394. BISHOP, DAPHNE. A technique for screening antibiotics against eelworms. *Nematologica* 3: 143-148. 1958. (Helminth. Abstr. 27: 48. 1958)  
The influence of a number of antibiotics on the ability of the root-nematode to invade and develop in tomato roots was studied. Experiments failed to give any evidence that the antibiotic tested affected the nematodes.
395. BROWN, A. L., J. J. JURINAK and P. E. MARTIN. Relation of soil properties to Br uptake by plants following soil fumigation with ethylene dibromide. *Soil Sci.* 86: 136-139. 1958.  
Tomato and tobacco plants had marked increases in Br content as a consequence of soil fumigation. Clay content of soil had a highly significant effect on uptake of Br by plants, there being an increase in Br with increasing clay.
396. CHRISTIE, J. R. and V. G. PERRY. A low-phytotoxic nematocide of the organic phosphate group. *Plant Disease Repr.* 42: 74-75. 1958.  
Dichlorophenyl-diethyl-phosphorothioate was found to control populations

of plant-parasitic nematodes when applied to soil as a drench. The chemical was found to have pronounced residual properties and to have little phytotoxic activity. This chemical also has the additional advantage of controlling some soil inhabiting insects.

397. DONA DALLE ROSE, A. (Mechanization of nematocide treatment of sugar beets.) (In Italian.) *Macch. & Motori Agr.* 16 (2): 67-76. 1958. (*Bibl. Agr.* 22 (8): 141. 1958.)
398. GERTLER, S. I., JULIUS FELDMESSER and R. V. REBOIS. Screening tests on bromoacetates as nematocides. *J. Agr. Food Chem.* 6: 843-844. 1958.

Many of the 53 bromoacetates synthesized and tested as nematocides against *Rhabditis* sp. and *Panagrellus* sp. were found to exhibit high activity. About two-thirds of the esters gave an LD 95 of less than 20 ppm and about one half less than 10 ppm. The effect of the structural variation in the alcohol position of the ester is discussed. Several of the compounds show sufficient promise to warrant further testing.
399. HOLLIS, J. P. and MAX J. FIELDING. Population behavior of plant parasitic nematodes in soil fumigation experiments. *Louisiana St. Univ. Agr. Exp. Sta. Bull.* 515. 30 pp. 1958.

The occurrence and activities of common plant parasitic nematodes on important crop plants in Louisiana were investigated in 21 soil fumigation experiments in 1955-56. The results of this paper emphasize the generic differences in population trends and reactions to fumigants. The relationship between fumigant vapor-pressure and population recovery of nematodes following fumigation is also discussed.
400. HOLLIS, JOHN P. Specifications for ideal nematocides. *Plant Disease Repr.* 42: 291-307. 1958.

An attempt has been made by Hollis to collect all the available knowledge about a restricted area in Louisiana, relevant to the problem of nematocide application. Empirical facts based on field experiments have been collected and placed on a rational basis. With this information at his disposal Hollis attempts to specify the physical properties of the ideal nematocide. Vapor pressure, activity, water solubility, phytotoxicity, mammalian toxicity, residual effects, stability, and chemical life in the soil are considered.
401. JURINAK, J. J. and D. H. VOLMAN. Thermodynamics of ethylene dibromide vapor adsorption of Ca-montmorillonite and Ca-kaolinite. *Soil Sci.* 86: 6-12. 1958.

The adsorption of E.D.B. was studied in high vacuum system and a technique is described for measuring pressures as low as  $2 \times 10^{-2}$  mm with little uncertainty. The differential free energy, enthalpy, and entropy of adsorption was calculated at various surface concentrations from isotherm data obtained, at 28.0° and 15.6°C. These data indicate that, in the region of multi-layer adsorption, the adsorbate assumes liquid-like properties in both montmorillonite and kaolinite systems. In both systems, multi-layer formation was initiated before  $\theta = 1$ . In the kaolinite system the thermodynamic functions suggest that the adsorptive forces for E.D.B. vapor are less energetic but more homogeneous over a large  $\theta$  range when compared with the montmorillonite system.
402. KENAGA, EUGENE E. Calibration of thermal conductivity units for use with commodity fumigants. *Down to Earth* 14: 6-7, 16. 1958.

Information is given for the calibration of the Gow-Mac Gasmaster on the Fumiscope with various concentrations of methyl bromide, carbon tetrachloride, and other gases. The information is especially useful to those who work with field and laboratory units where it is difficult to calibrate the units without special gas-handling equipment.
403. LOOS, C. A. Certain fatty acids and hexadecylamine as nematocides. *Plant Disease*



Reptr. 42: 1179-1186. 1958.

Fatty acids (heptanoic-undecylenic) are nematocidal within the range of 25 to 1000 ppm when applied in aqueous emulsion to surface, as judged by laboratory contact tests. However, they lose their effectiveness by passage through soil, and are no longer active nematocidal agents. They may have exceptional value as disinfectants of farm machinery, containers, etc.

404. LOOS, C. A. and G. J. STESSEL. A comparison of two contact nematocide test methods. Plant Disease Reptr. 42: 1187-1191. 1958.

Two contact test methods of screening chemicals for nematocidal activity were studied. A method utilizing an aeration-agitation apparatus is described and is compared with the method developed by A. C. Tarjan and P. C. Cheo. The merits and disadvantage of each method are discussed from the standpoint of time and labor, testing of nematodes in various stages of the life cycle, and variability of the results within and between both methods.

405. MARTIN, J. P. and P. F. PRATT. Fumigant, fungicides and the soil. J. Agr. Food Chem. 6: 345-348. 1958.

406. MILLER, P. M. and E. M. STODDARD. Increasing the hatching of eggs of cyst and rootknot nematodes with nabam. Science 128: 1429-1430. 1958.

Nabam in water solution retards hatching of Meloidogyne eggs. In soil nabam increases egg hatching of Meloidogyne and Heterodera tabacum, indicating that a decomposition product in soil is a hatching factor. Because of this attribute, combining nabam with a nematocide increases control of Meloidogyne by exposing more larvae to the nematocide while it is at maximum efficiency.

407. PARRIS, G. K. Soil fumigants and their use: a summary. Plant Disease Reptr. 42: 273-278. 1958. (Helminth. Abstr. 27: 54. 1958.)

A revision of a previous publication dealing with recent developments in soil fumigation. The nature and action of the various fumigants, chloropicrin, D-D, ethylene dibromide, methyl dibromide, Nemagon, Vapam, V-C 13 Nemacide, Terraclor, Mylone, and Telone, are discussed individually. A final section indicates changes in concept of soil fumigation during the last 5 years. In regard to the control of Actinomycetes in the soil, Terraclor, whose active ingredient is pentachloronitrobenzene (PCNB) is said to be very effective against Streptomyces (Page 277 of the review).

408. SHER, S. A., IVAN J. THOMASON, and R. R. McCASLIN. Chisel application of methyl bromide for root-knot nematode control. Plant Disease Reptr. 42: 288-290. 1958.

Injections of methyl bromide at 150 and 200 lb./acre with a chisel applicator gave good control of Meloidogyne incognita and increased the yield of sweet basil. Similar results were obtained when the fumigant was confined in the soil either with a tarp, or by rolling and sprinkling.

409. TURLIGINA, E. S. (Effect of certain chemicals on the reproduction of saprobiotic nematodes (Rhabditella sp.)) (Russian: English summary.). Zoologicheskii Zhurnal 36: 1145-1149. 1957. (Helminth. Abstr. 26: 312 b. 1958)

A number of chemicals were shown in laboratory tests to inhibit the reproduction of a saprophytic species of Rhabditella by decreasing fertility and prolonging ontogenesis. They may be divided into those that are very toxic and can only be used on ornamental plants, i. e. systox, pyrophos, and octomethyl, and those that are not strongly toxic and can be used on vegetables, i. e. sodium salicylate, potassium rhodanate, and ammonium selitre.

410. VIEL, G. and J. GIBAN. (The retention of dibromoethane in soils.) Phytiatric-Phytopharm. 7: 61-66. 1958. (Chem. Abstr. 52: 20858. 1958.)

The authors report that dibromoethane is retained several weeks in soil. After 8-9 weeks with soil temperatures below 15°C approximately 1 mg of

dibromoethane remains per gram of soil. The level at which the material is still effective but not phytotoxic is also given.

411. WARREN, G. F. Growers solve fumigation equipment problem in Indiana. Down to Earth 13 (4): 12. 1958. (Hort. Abstr. 28: 429. 1958)  
A description is given of a 2-row soil fumigation unit, which can be used 7-10 days before transplanting melons.
412. YOUNG, V. H., Jr. Activity of V-C 13 Nemacide, a nonfumigant type nematocide. Agr. Chem. 13 (2): 30-31. 1958.  
Nematocide V-C 13, lacking the physical property of a high vapor pressure, is uniquely different from most of the other nematocides. Because of low volatility it has good chemical stability and residual action on a number of nematode genera. Some disadvantages stemming from this low vapor pressure are the need of mechanical mixing or watering into soil, a slow killing action, and a failure to give adequate control of cyst nematodes. A decided advantage is its low phytotoxicity to a wide number of crop plants.
413. FUMIGATORE DEL TERRENO DI PRATICA REALIZZAZIONE. (A soil fumigator of practical design.) Inf. fitopat. 8: 141. 1958. (Hort. Abstr. 28: 527. 1958.)  
The description for the design of a practical soil fumigator is given in detail.

Nematode control -- Nematocides -- Crops

See also 555

414. BAINES, R. C., T. A. DeWOLFE, and R. H. SMALL. Control of the citrus nematode, *Phytophthora* spp. and weeds by Mylone 85W when applied by different methods. Plant Disease Repr. 42: 876-880. 1958.  
The effectiveness of Mylone 85W for control of the citrus nematode, *Phytophthora* spp., and a number of weeds, when applied with different amounts of water, was determined in microplots on a sandy loam soil. Mylone 85W applied at the rate of 400 pounds active ingredient per acre in 6 and 8 acre-inches of water killed the citrus nematode in the top 4 feet of soil, and *Phytophthora* spp. in the surface 3 feet of soil. Mylone showed good stability in moist soil and moved downward when water was applied at periods up to 72 hours.
415. BAINES, R. C. et al. Nematode control on bearing trees. Calif. Citrogr. 43: 328-329. 1958. (Hort. Abstr. 28: 640. 1958)  
Dibromochloropropane, applied around lemon and tangerine trees, has effectively controlled citrus nematode (*Tylenchulus semipenetrans*) and increased yields of lemons and tangerines. Control was most effective on sandy soils and was moderately good on two silt loam soils. Applications by chisel 8-9 inches deep was most satisfactory. Lack of response in two orange orchards may have been due to lack of vigour.
416. BÖHM, OTTO. Beitrag zur Kenntnis einer durch Nematoden hervorgerufenen Krankheit der Sellerie. (A nematode-induced disease of celery.) Pflanzenschutzber. 16 (1/3): 1-20. 1956. (Biol. Abstr. 32: 1779, entry 21162. 1958.)  
The application of DD in large quantities, soil fumigation, and regular rotation of crops is effective in control of soil sickness. In the field only the last method is economic.
417. BRANDE, J. VAN DEN, J. D'. HERDE, and R. H. KIPS. Distribution of dichloropropane-dichloropropene in different kinds of soil. (Flemish.) Ghent. Landbhogesch. Meded. 22: 377-386. 1957. (Bibl. Agric. 22 (6): entry 49716. 1958.)  
The control of potato root eelworm, *Heterodera rostochiensis*, in different soil types with the fumigant D-D is discussed.
418. CHRISTIE, J. R. and A. L. TAYLOR. Controlling nematodes in the home garden. U.S.

D. A. Farmers' Bull. 2048, 10 pp. 1958.

419. CLAYTON, C. N. Peaches after peaches. *Research & Farming* 27: 12. 1958.  
Peach trees were successfully replanted in root-knot-nematode-infested soils after soil fumigation with D-D and ethylene dibromide.
420. COLBRAN, R. C. Nematode control in pumpkins. *Queensland Agr. Jour.* 83: 499-501. 1957. (Biol. Abstr. 32: 1779, entry 21163. 1958.)  
Soil fumigation with EDB by injection into the soil was found to give suitable control of three root-knot nematode species attacking pumpkins.
421. De HAAN, I. and G. A. DeZOETEN. Control of eelworm in orchards extremely difficult. *Farming So. Africa* 34 (8) 36-38. 1958.
422. ENDO, B. Y. and J. N. SASSER. Soil fumigation experiments for the control of the soybean cyst nematode, *Heterodera glycines*. *Phytopathology* 48: 571-574. 1958.  
Soil fumigants were evaluated for control of the soybean cyst nematode (D-D, Telone, Nemagon, and methyl bromide). Plant growth, root nodulation, soybean yields were all increased as a result of the nematocide treatment. Although nematode populations were reduced by fumigation, these population differences were no longer significant at harvest time, indicating a rapid increase of nematode populations during the growing season.
423. FARRAR, LUTHER L. Oat yields as affected by chemical treatment of nematode infested soil. *Down to Earth* 14: 15-16. 1958.  
The author studied the response of oat yields following application of various nematocides to soil known to be nematode-infested. Using moderate to high dosage rates, he found definite responses to fumigation and differences between fumigants. There were few significant differences between rates of application.
424. FOSTER, H. H. and D. FRED COHOON. Post-plant fumigation for the control of peach root-knot in South Carolina. (Abstr.) *Phytopathology* 48: 342. 1958.  
Soil fumigation experiments were conducted, using liquid and granular Nemagon around root-knot-infested peach trees. The liquid form at the rate of 8 gal. of active ingredient per acre gave root-knot control, and was more effective than the granular Nemagon. Recent data would indicate that Nemagon may be effective for at least 2 years after fumigation.
425. GOFFART, H. and A. HEILING. Nebenwirkungen bei der Nematodenbekämpfung mit Shell D-D und verwandten Mitteln. *Nematologica* 3: 213-228. 1958.  
The authors investigated a secondary growth-stimulating effect of D-D on sugar beets, over and above its nematocidal action. Sugar beets were grown on fumigated and nonfumigated plots known to be free of nematode species injurious to sugar beets. The authors observed the difference between beets grown on these plots for water content and surface area of leaves, osmotic pressure of the sap, ash content, and other qualitative differences. They concluded that since these differences in the plant and soil correspond to specific function of the Cl-ion, it is probable that the secondary action of this nematocide is due to its chlorine content.
426. GOOD, J. M. and A. E. STEELE. Control of sting nematodes for two growing seasons by soil fumigation. *Plant Disease Repr.* 42: 1364-1367. 1958.  
Of the nematocides tested for the control of sting nematodes infesting cotton- and corn-growing soils in Georgia, only dibromochloropropane gave significant control for two crop seasons.
427. GOOD, J. M. and A. E. STEELE. Soil fumigation for controlling root-knot nematodes on tomatoes for transplanting and for fresh fruit production. *Plant Disease Repr.* 42: 1173-1177. 1958.  
Soil fumigation with certain chemicals to control root-knot nematodes



on tomatoes did not give sufficient control to satisfy requirements for certification of tomato transplants as being root-knot-free. These materials, however, did give economic control in fields grown for fruit production.

428. GRAINGER, J. The field control of potato root eelworm. *Scottish Agr.* 37: 223-224, 1958. (Biol. Abstr. 32: 3504, entry 42138. 1958.)

The author offers advice on how to prevent a build-up of population or spread of potato root eelworm. The use of D-D for the control of eelworm in first early crops, and of fine-particle mercury dusts is briefly mentioned.

429. HALLER, H. L. Soil fumigation, a new and expanding market. *Agr. Chem.* 13 (11): 33, 108-109. 1958.

A general discussion of the growth in the use of nematocides. Reference is made to the fumigants used in the past. The extent to which new and old fumigants are being used currently in control of nematode plant diseases, and the possible future market for nematocides are discussed.

430. JENKINS, W. R. Wipe out nematodes. Plant, fumigate, and fertilize all at one time with new nematicide. *Am. Veg. Grower & Mkt. Growers J.* 6 (5): 30. 1958.

431. KANTZES, J. G., O. D. MORGAN and W. R. JENKINS. The possible use of 1,2-dibromo-3-dichloropropane ("Nemagon" and "Fumazone") on vegetable crops. *Md. Agr. Exp. Sta. Misc. Article* 314: 2 pp. 1958.

This fumigant offers promise in the control of root-knot nematode on various crops. The granular form can be mixed with fertilizer and applied to soil containing seed or living plants of certain kinds of crops.

432. KELSHEIMER, E. G. Control of nematodes in gladiolus corms. *Gladiolus Mag.* 22: 13-15. 1958. *Proc. Florida State Hort. Soc.* 68: 348-350. 1955. (Chem. Abstr. 52: 20847. 1958.)

The most effective treatment found by the author in controlling nematodes on gladiolus corms was a parathion emulsion containing 4 lbs. parathion/gal. at the rate of 1 pt. to 100 gallons. Details of methods of application and safety precautions in using the dip are also given.

433. KELSHEIMER, E. G. and A. J. OVERMAN. Nematodes affecting Florida chrysanthemums and their control. *Proc. Florida State Hort. Soc.* 70 (1957): 350-352. 1958. (Hort. Abstr. 28: 455, entry 2879. 1958.)

The methods and materials used in controlling soil-inhabiting nematodes on chrysanthemum are given.

434. KUIPER, K. and E. DRIJFHOUT. Bestrijding van het wortelaaltje *Hoplolaimus uniformis* Thorne 1949 bij de teelt van peen. (Control of root nematode in carrot growing.) (In Flemish.) *Meded. Landbhogesch. Ghent.* 22: 419-426. 1957. (Hort. Abstr. 28: 592. 1958.)

Soil fumigation with D-D and with formalin appeared to give 90 percent control of Hoplolaimus uniformis and improve carrot growth.

435. LANGE, A. H. and O. V. HOLTZMANN. Papaya responds to soil fumigation. *Hawaii Fm. Sci.* 6: 6-7. 1958. (Hort. Abstr. 28: 653. 1958.)

Several nematocides have improved papaw growth and/or yields in greenhouse and field experiments. Where nematodes (Rotylenchulus reniformis) are the primary cause of poor growth, applications of Nemagon, D-D, or EDB are recommended. In other conditions methyl bromide may be effective.

436. LANGE, A. H. Response of papaya to soil fumigation. *Down to Earth* 14 (1): 4-5. 1958. (Hort. Abstr. 28: 653-654. 1958.)

The author reports increased growth and/or yields of papaya from trees planted on soil treated with fumigants for nematode control. In some of the trials significant increases in growth were not followed by increases in yield, which suggests that factors other than nematode control may be involved.

437. LEAR, BERT and D. J. RASKI. Control by soil fumigation of root-knot nematodes affecting sugar beet production in California. *Plant Disease Repr.* 42: 861-864. 1958.

Broadcast application of D-D, EDB, Telone, and Nemagon resulted in good root-knot nematode control and increased sugar beet yields. Telone appeared more effective than an equal volume of D-D. In row treatments one plot indicated that 8 gal. per acre was necessary for the minimum economic control of root-knot. Row treatment with Nemagon and Telone was less effective than the broadcast method.

438. LEWIS, G. D. and W. F. MAI. Chemical control of *Ditylenchus dipsaci* (Kühn) Filipjev in organic soils of southern New York. *Plant Disease Repr.* 42: 1360-1363. 1958.

Organic soils used for onion culture in southern New York and infested with *Ditylenchus dipsaci* (Kühn) Filipjev were fumigated with D-D at rates of 50 or more gallons per acre. All treatments resulted in excellent control. No infested onions have been found in the fields for 2 years. No injury resulted in onion crops following fumigation even with a total rate of 110 gallons of D-D per acre.

439. LORDELLO, L. G. E. Experimentos com os nematicidas D.D., E.D.B. e brometo de metilo no combate aos nematódeos causadores de galhas em raízes de plantas (*Meloidogyne* spp.) (Experiments with D-D, EDB, and methyl bromide for control of nematodes (*Meloidogyne* spp.) in the roots of plants.) *An. Esc. Sup. Agr. Queiroz.* 12/13: 167-177. 1955/1956. (*Hort. Abstr.* 28: 425, entry 2707. 1958.)

Neither D-D, ethylene dibromide, nor methyl bromide at standard rates gave complete control of nematodes in tomato root galls after 5-30 days of rotting in soil, but, unless thick woody roots are present, soil fumigation with any of the substances should be economic for practical purposes.

440. LOWNSBERRY, B. F. and S. A. SHER. Root-lesion nematode on walnut. *Calif. Agr.* 12 (5): 7, 12. 1958. (*Hort. Abstr.* 28: 384. 1958.)

Pre-plant fumigation with Shell D-D, Dowfume W85, or Shell Nemagon improved the initial growth of black walnut seedlings. Populations of root-lesion nematodes increased rapidly after fumigation, but growth improvements were maintained by annual soil injections of Nemagon.

441. MILLER, P. M. Fumigation when transplanting nursery stock. *Plant Disease Repr.* 42: 1178. 1958.

The advantages are stated, and methods given for the use of nematocides when nursery stock is being transplanted.

442. MILLER, P. M. and G. S. TAYLOR. Superior control of tobacco stunt nematodes with a nematocide mixture. (*Abstr.*) *Phytopathology* 48: 264. 1958.

Dorlone (a mixture containing 19 percent ethylene dibromide and 75 percent 1,3-dichloropropene) gave better control of tobacco stunt nematode than either of the materials separately. The authors concluded that a combination of nematocides improved the control of mixed nematode populations.

443. MORGAN, O. D. Observations on fumigation of tobacco soils. *Plant Disease Repr.* 42: 316-317. 1958.

Observations were made over a 3-year period on the control of root-knot nematode by D-D, EDB, and Nemagon fumigants. The dosage rates of the three nematocides which were found to give some nematode control are given; none of these rates has a phytotoxic effect on tobacco. The incidence of *Fusarium* wilt was also reduced.

444. O'BANNON, J. H. Application of emulsifiable dibromochloropropane in irrigation water as a preplanting soil treatment. *Plant Disease Repr.* 42: 857-860. 1958.

An emulsifiable concentrate of DBCP was applied as a preplanting treatment in irrigation water to nematode-infested sandy loam soil. A

constant metering device on the centrifuge pumps discharged DBCP into the irrigation water, resulting in a reasonably uniform distribution and penetration of the material in rows 1250 ft. long and to a depth of at least 12 inches.

445. PERSING, C. O. Sodium N-methyldithiocarbamate in control of pests affecting tobacco. Congr. sci. intern. tabac, Prem. congr., Paris-Bergerac, 2: 669-673. 1955. (Chem. Abstr. 52: 20839. 1958.)

This dithiocarbamate was effective in soil treatments against the following species of nematodes: Tylenchorhynchus claytoni, Xiphinema americanum, Meloidogyne sp., Pratylenchus sp., Helicotylenchus sp. The material was also effective against a number of other fungus pathogens of tobacco as well as some insect pests.

446. PONTORIERO, P. L. Soil fumigation for outdoor vegetable growers. Ohio Veg. & Potato Growers Assoc. Ann. Proc. 42: 68-72. 1957.

The control of nematode diseases of plants by soil fumigants is discussed.

447. PUCCI, E. Le anguillulosi. (Nematode infestations.) Inf. fitopat. 8: 50-57, 71-77. 1958. (Hort. Abstr. 28: 465. 1958.)

Nematode diseases of narcissi, chrysanthemums, primulas, strawberries, citrus and other crops are discussed. Some consideration is also given to the control of these nematode diseases.

448. RASKI, D. J. and B. LEAR. Control of sugar-beet nematode. Calif. Agr. 12 (5): 8, 12. 1958. (Helminth. Abstr. 27: 18. 1958.)

Results of field tests with D-D and Nemagon and preliminary tests with Vapam indicate that chemical control of Heterodera schachtii on sugar-beet in California, where this crop is usually grown on clay loams or clays, is not an economic proposition.

449. RENNINGER, GEORGE, JOHN COFFEY, and BORIS SOKOLOFF. Effect of hydrogenated fish oils on citrus-tree destroying nematodes. Plant Disease Repr. 42: 1057-1065. 1958.

A water-soluble hydrogenated fish oil preparation, FOAH, was tested for its ability to control the burrowing nematode (Radopholus similis), which causes spreading decline of citrus trees. The material is sprayed on the soil surface. The theory is suggested that hydrogenated fish oil interfered with respiration and oxidation processes in the nematodes, thus suffocating them.

450. REYNOLDS, HAROLD W. and JOHN H. O'BANNON. The citrus nematode and its control on living citrus in Arizona. Plant Disease Repr. 42: 1288-1292. 1958.

The nematocide DBCP metered into irrigation water was effective in controlling the citrus nematode, Tylenchulus semipenetrans, in Arizona citrus groves.

451. REYNOLDS, HAROLD W. Control of the cotton root-knot nematode on extra-long-staple cotton. Plant Disease Repr. 42: 944-947. 1958.

The results of field-scale fumigation experiments on the control of root-knot nematode in cotton soils are reported.

452. RITTER, M. (Chloropicrin in the fight against root eelworms (Meloidogyne incognita) in truck gardens.) Phytiatric-Phytopharm. 7: 73-80. 1958. (Chem. Abstr. 52: 28043. 1958.)

Chloropicrin and D-D were compared for their efficacy in controlling root-knot nematodes in different soil types, using two methods of sealing the soil surface. The chloropicrin-treated soils had the greatest increase in tomato production.

453. RUI, D. and G. GIRALDI. Nematodi fitoparassiti e nematocidi. (Plant-parasitic nema-



todes and nematocides.) (English summary.) Ann. Sper. agrar. 12: 481-502. 1958. (Hort. Abstr. 28: 582. 1958.)

Cymag (a sodium cyanide product), D-D, and ethylene dibromide are discussed as to their ability for controlling root-knot nematode.

454. RUSSO, G. New synthetic organic antiparasitical products (insecticides, acaricides, nematocides) Naples U. Facol. Sci. Agr. Ann. (ser. 3) 22: 209-216. 1956/57. (Bibl. Agr. 22: entry 81296. 1958.) (not reviewed.)
455. SLEETH, B. Soil fumigation increases growth of citrus replants. J. Rio Grande Valley hort. Inst. 12: 53-56. 1958. (Hort. Abstr. 28: 640. 1958.)  
Increased growth of sour orange seedlings in screenhouse experiments was noted after soil fumigation with D-D. In field trials fumigation with EDB at 350 lb./acre increased the size of grapefruit and orange trees by an average of 20 percent over the first 5 years. Soil treatment with N, P, S, and minor elements failed to have any stimulatory effect on seedling growth.
456. STEELE, ARNOLD E. and J. M. GOOD. Evaluation of several nematocides for control of sting nematodes on lima beans. Plant Disease Reprtr. 42: 1284-1287. 1958.  
Five nematocides were evaluated by field plot tests for ability to control sting nematodes on lima beans.
457. TARJAN, A. C. Spray materials for decontaminating nematode-infested grove equipment. Proc. Fla. St. hort. Soc. 70 (1957): 85-90. 1958. (Hort. Abstr. 28: 480. 1958.)  
One percent caprylic acid, 2.6 percent sodium hypochlorite in water was used in freeing equipment of Radopholus similis.
458. THOMAS, P. R., P. WIGGELL and W. J. MOYSE. Observations on eelworm control in narcissus in the Isles of Scilly. Plant Path. 7: 49-50. 1958. (Hort. Abstr. 28: 628. 1958.)  
Two plots seriously affected by Ditylenchus dipsaci were each treated with EDB and with D-D at 100 or 200 gal./acre. No eelworm-infested plants were found in the first year after treatment; in the second year re-infestation had started, being more severe in the EDB treated plots than after D-D treatment.
459. TODD, F. A. and C. J. NUSBAUM. You can avoid fumigant injury. Res. & Farming, N. C. Agr. Expt. Sta. 16 (3): 3. 1958.  
Three rules of advice are suggested for the avoidance of fumigation damage in growing flue-cured tobacco.
460. TURLIGINA, E. S. A new method of gall nematode control. Priroda 47: 95-96. 1958. (Chem. Abstr. 52: 15817. 1958.)  
A single watering of cucumber plants infested by root-knot nematodes with 0.25 percent potassium thiocyanate or sodium salicylate and 1 percent  $\text{NH}_4\text{NO}_3$  solution is effective against nematodes, and substantially reduces the fertility of females.
461. WILSKI, A. (Investigations on the control of sugar-beet nematode (Heterodera schachtii Schmidt) with chemicals.) (In Polish.) Roczn. Nauk. Roln. Ser. A, Roślinna. 75: 645-666. 1957. (Bibl. Agr. 22: entry 49737. 1958.) (not reviewed)
462. WINSLOW, R. D. Eelworm control. Gt. Brit. Min. Agr. Fisheries & Food Agr. 65: 66-69. 1958. (Bibl. Agr. 22: entry 68341. 1958.) (not reviewed.)
463. WINSTEAD, N. N., J. C. WELLS and J. N. SASSER. Root-knot control in vegetable crops using D-D and EDB with and without vermiculite as a carrier. Plant Disease Reprtr. 42: 180-183. 1958.  
EDB and D-D were applied to the soil as liquids or on vermiculite as a carrier. Experiments showed that effective control of root-knot was obtained irrespective of method of application.
464. FOR SOIL FUMIGATION. World Crops 9: 507-508. 1957. (Helminth. Abstr. 26: 473. 1958.)  
Efficacy of Nemagon (1,2-dibromo-3-chloropropane) as a nematicide.

465. BAINES, R. C. et al. A difference in the pathogenicity of the citrus nematode from trifoliolate orange and sweet orange roots. (Abstr.) *Phytopathology* 48: 391. 1958.  
Citrus nematodes obtained from Poncirus trifoliata infested 90 percent of P. trifoliata seedlings severely whereas citrus nematode obtained from sweet orange roots slightly infested 1 percent of P. trifoliata seedlings, leaving 99 percent uninfested.
466. BIRD, ALAN F. The adult female cuticle and egg sac of the genus *Meloidogyne* Goeldi, 1887. *Nematologica* 3: 205-212. 1958.  
Both the chemical composition and structure of the adult female cuticle and egg sac of Meloidogyne hapla and M. javanica were studied. Sections showed that the cuticle consists of a thin, darkly staining surface layer covering a homogenous substance which is divided into three layers by two darkly staining bands of material. The egg sac is a tanned glycoprotein whereas the adult female cuticle consists of a thin tanned lipoprotein covering a thicker less resistant homogenous layer.
467. BRAUN, A. J. Plant-parasitic nematodes found in association with strawberry roots in the United States. *Plant Disease Repr.* 42: 76-83. 1958.  
In the northern states Pratylenchus is the predominant parasitic nematode in strawberry whereas Xiphinema, Tylenchorhynchus, and Helicotylenchus predominate in the southern states. Root-knot nematode was most prevalent in the north-central region.
468. BROWN, E. B. Observations on a race of *Ditylenchus dipsaci* attacking annual aster and sweet sultan. *Plant Path.* 7: 150-151. 1958.  
The first record of damage by D. dipsaci to these plants in England. The race of eelworm also attacked oats, onions, annual phlox, field beans, sugar beet (slightly), and asters. Carrots were not attacked.
469. BROWN, E. B. Pea root eelworm in the eastern counties of England. *Nematologica* 3: 257-268. 1958.  
It is suggested that the pea plant is very susceptible to Heterodera gottingiana and, therefore, even occasional plantings of pea or field bean maintain sufficient populations of the eelworm to result in failure of a pea crop.
470. CARROLL, K. K. Purification and properties of eelworm hatching factors. Hatching factors for the cabbage, hop and beet root eelworms (*Heterodera cruciferae*, *H. humuli*, and *H. schachtii* respectively). *Nematologica* 3: 197-204. 1958.  
Root leachings from black mustard, hop and sugar beets were used as sources of the hatching factors of cabbage, hop and beet eelworms respectively while the mustard leachings also furnished a hatching factor for beet eelworm. The experiments included studies on the bioassay of the hatching factors as well as some of their properties.
471. CAVENESS, FIELDS E. Two new geographic locations for the sugar beet nematode, *Heterodera schachtii*. *Plant Disease Repr.* 42: 280. 1958.  
Imperial County, California, and Butte County, South Dakota.
472. CHAPMAN, R. A. The effect of root-lesion nematodes on the growth of red clover and alfalfa under greenhouse conditions. *Phytopathology* 48: 525-530. 1958.  
The growth of red clover and alfalfa in soil infested with a root-lesion nematode population made up primarily of Pratylenchus penetrans and P. coffeae with some P. minyus was significantly less than that of control plants.
473. CHRISTIE, J. R. and WRAY BIRCHFIELD. Scribner's lesion nematode, a destructive parasite of amaryllis. *Plant Disease Repr.* 42: 873-875. 1958.  
Stunting of amaryllis associated with root infection by Pratylenchus scribneri. Symptoms on amaryllis are described as well as on other hosts

occurring in Florida.

474. COLE, C. S. and H. W. HOWARD. Observations on giant cells in potato roots infected with *Heterodera rostochiensis*. J. Helminth. 32: 135-144. 1958.

This is a study of the early formation of giant cells in potato roots infected with *H. rostochiensis*. Giant cells may be formed by cells of the cortex, endodermis, pericycle, and parenchyma cells of the central vascular strand. The first giant cells appear to be formed in the cortex and pericycle. Giant cell formation by the parenchyma cells of the central vascular strand leads to no cambium and hence no secondary xylem formation, resulting in an irregular appearance of the central vascular strand. Giant cells have granular cytoplasm and some may be multinucleate.

475. COURSEN, B. W., R. A. ROHDE and W. R. JENKINS. Additions to the host lists of the nematodes *Paratylenchus projectus* and *Trichodorus christiei*. Plant Disease Repr. 42: 456-460. 1958.

Of 101 plant species and varieties tested, 89 were found to be hosts of the pin nematode, *Paratylenchus projectus*. The known host range of the stubby root nematode, *Trichodorus christiei*, was extended with the addition of 66 more species and varieties.

476. COURSEN, B. W. and W. R. JENKINS. Host-parasite relationships of the pin nematode, *Paratylenchus projectus*, on tobacco and tall fescue. Plant Disease Repr. 42: 865-872. 1958.

General effects on tobacco, using large numbers of *P. projectus* as inoculum, include stunting of top growth, shortened internodes, and marked root proliferation. Similar symptoms occurred on tall fescue in addition to increased tillering. There was no visible evidence of damage on the roots of either host.

477. COURSEN, B. W. and W. R. JENKINS. Host-parasite relationships of the pin nematode, *Paratylenchus projectus*, on tobacco and tall fescue. (Abstr.) Phytopathology 48: 460. 1958.

(See abstract #476.)

478. DICKERSON, O. J. and D. A. SLACK. Parasitic nematodes associated with strawberries in Arkansas. (Abstr.) Phytopathology 48: 342. 1958.

High populations of *Pratylenchus coffeae* were recovered consistently in association with black root rot of strawberry plants growing on relatively heavy soil. With the other nematodes isolated during the survey no relationship could be determined between number of nematodes recovered and plant vigor.

479. DROPKIN, V. H. et al. Effect of osmotic concentration on hatching of some plant parasitic nematodes. Nematologica 3: 115-126. 1958.

The authors demonstrated negative correlation between osmotic concentration of a solution and emergence of nematodes from eggs. The inhibition is reversible and the length of time necessary for recovery from inhibition varies directly as the original osmotic concentration. Nematodes tested include *Heterodera rostochiensis*, *Meloidogyne arenaria*, *M. javanica*, and *Ditylenchus dipsaci*. The results are discussed in terms of the possible role of this relationship in the ecology.

480. EDGERTON, L. J. and K. G. PARKER. Cold hardiness of Montmorency cherry affected by nematode damage. Farm Research 24(2): 12. 1958.

In cold hardiness studies with Montmorency cherry trees, twigs from trees in plots treated for nematode control were found to be more cold resistant during the dormant season than twigs from trees in untreated soil.

481. ELLENBY, C. Day length and cyst formation in the potato root eelworm, *Heterodera rostochiensis* Wollenweber. Nematologica 3: 81-90. 1958.

With two of the varieties of potato tested, the greater number of cysts on



the roots were produced when the plants were grown under a "long day" rather than a "short day". However this difference did not occur with a third potato variety, suggesting different physiologic reactions of the different varieties to the change in the photoperiod.

482. ELLENBY, C. and A. B. GILBERT. Influence of certain inorganic ions on the hatching of the potato root eelworm, *Heterodera rostochiensis* Wollenweber. *Nature* 182: 925-926. 1958.

The authors subjected cysts to a pre-treatment in solutions of sodium chloride, potassium chloride, calcium chloride, and magnesium chloride, with a further lot soaked in distilled water. Two weeks later the cysts were washed and stimulated with inorganic-free hatching factor. Emergence from cysts first soaked in the salt solutions was about three times as high as the control. The differences were greatest and most persistent with potassium chloride and sodium chloride.

483. ELLENBY, C. Root diffusates of *Solanum tuberosum* and *Digitalis purpurea*. *Nature* 181: 920-921. 1958.

It has been shown previously that potato root eelworm hatching factor possesses certain affinities with the cardiac glycosides. Since cardiac substances occur in foxglove, diffusates from these two plants were compared. It was found that diffusates from potato and foxglove have many of the same properties including cardiotonic activity, colorimetric assay, and peroxide activity after concentration in a Tower's evaporator.

484. EPPS, J. M. and A. Y. CHAMBERS. New host records for *Heterodera glycines*; including one host in the Labiatae. *Plant Disease Repr.* 42: 194. 1958.

The new hosts reported include hemp sesbania (*Sesbania macrocarpa*), white lupine (*Lupinus albus*), and henbit deadnettle (*Lamium amplexicaule*). The last-named is a member of the Labiatae and is the first host reported outside the Leguminosae.

485. EPPS, JAMES M. Viability of air-dried *Heterodera glycines* cysts. *Plant Disease Repr.* 42: 594-595. 1958.

No viable larvae of the soybean cyst nematode, *Heterodera glycines* Ichinohe, were found in cysts after 1-month storage period in seed bags.

486. FASSULIOTIS, GEORGE. Effects of ionizing radiations on the golden nematode, *Heterodera rostochiensis*. (Abstr.) *Radiation Research* 9: 112-113. 1958.

Cysts were irradiated with X-rays and with  $\gamma$ -rays with doses ranging from 5 to 1280 kr. A dose of 160 kr. or above delayed onset of hatching and reduced the emergence. No larvae hatched after 640 kr. Abnormal body measurements were apparent after 80 kr. Chromosome aberrations in the form of fragments and bridges at anaphase were found in maturing eggs recovered from females which developed from irradiated larvae.

487. FELDMESSER, JULIUS. Burrowing nematode population samplings as affected by a number of variables. (Abstr.) *Phytopathology* 48: 393. 1958.

Relative soil moisture has little or no influence on numbers of nematodes recovered whereas soil temperature is highly correlated negatively with the number of nematodes found. Correlation between numbers of nematodes within the roots and upon the roots was significant at the 1 percent level.

488. FERRIS, VIRGINIA R. and R. L. BERNARD. Plant parasitic nematodes associated with soybeans in Illinois. *Plant Disease Repr.* 42: 798-801. 1958.

Mainly *Pratylenchus*, *Helicotylenchus*, *Paratylenchus*, and *Tylenchorhynchus*.

489. FERVER, A. F. and H. W. CRITTENDEN. Host-parasite relationships of *Avena sativa* and a root-knot nematode, *Meloidogyne incognita acrita*. *Phytopathology* 48: 461. 1958.

No differences in amino acids and sugars were noted between two resistant and two susceptible varieties. It was noted that the inner tangential endodermis cell wall is thicker in resistant varieties than in susceptible varieties.

490. FORD, H. W. and C. I. HANNON. The burrowing nematode, *Radopholus similis*, in roots of *Crotalaria spectabilis*. Plant Disease Repr. 42: 461-463. 1958.

The burrowing nematode is the primary cause of spreading decline of citrus. Although *Crotalaria spectabilis* has been recommended as a non-host cover crop in the control program, the present studies indicate that *R. similis* is capable of penetrating roots of *C. spectabilis* and laying viable eggs therein, casting some doubt on the value of this recommendation.

491. GASKIN, TIMOTHY A. Weed hosts of *Meloidogyne incognita* in Indiana. Plant Disease Repr. 42: 802-803. 1958.

Listing of common weed hosts of *Meloidogyne incognita* and *M. incognita* var. *acrita* in Indiana based on greenhouse tests.

492. GILL, D. L. Effect of root knot nematodes on *Fusarium* wilt of mimosa. Plant Disease Repr. 42: 587-590. 1958.

More wilting occurred in soil infested with *Fusarium oxysporum* f. *perniciiosum* and either *Meloidogyne incognita* or *M. javanica* in combination than in soil infested with *Fusarium* alone.

493. GOLDEN, A. MORGAN. Influence of leaf diffusate of sugar beet on emergence of larvae from cysts of the sugar-beet nematode (*Heterodera schachtii*). Plant Disease Repr. 42: 188-193. 1958.

It is shown that larval emergence from cysts in leaf diffusate of sugar beet was more than twice as great as the emergence in plain tap water, but approximately half that from cysts in root diffusate of sugar beet.

494. GOOD, J. M. et al. Studies of *Pratylenchus brachyurus* on peanuts. Phytopathology 48: 530-535. 1958.

Root lesion nematodes were found in the roots, pegs, and mature shells of peanuts but were most numerous in the shells where they colonized in dark necrotic lesions. Infested shells remained a source of inoculum after being cured and stored over winter.

495. GOODEY, J. B. and D. J. HOOPER. Observations on the effects of *Ditylenchus dipsaci* and *Anguina tritici* on certain wheat and barley varieties. Nematologica 3: 24-29. 1958.

It appears that, with the oat race of *D. dipsaci* occurring in Britain, either wheat or barley may be grown safely. It was also found that barley is, for all practical purposes, not attacked by *A. tritici*.

496. GRAHAM, C. W. A nematode genus new to Europe. Plant Path. 7: 114. 1958.  
*Naccobus* sp. on roots of tomato.

497. GRAHAM, T. W. Root knot and other nematodes in relation to the development of tobacco black shank. (Abstr.) Phytopathology 48: 343. 1958.

Mixture of *Phytophthora parasitica* var. *nicotianae* and *Meloidogyne incognita* var. *acrita* produced severe black shank on Dixie Bright 101. The fungus in combination with *Pratylenchus brachyurus* gave only traces of black shank as was also the case with *Rotylenchus brachyurus*. The fungus in combination with *Tylenchorhynchus claytoni* developed slight to moderate black shank. Root damage by the nematode did not appear to be correlated with the degree of black shank.

498. HAGUE, N. G. and J. J. HESLING. Population studies on cyst-forming nematodes of the genus *Heterodera*. Proc. Linnean Society of London 169: 86-92. 1958.

The rate of increase of *Heterodera rostochiensis* and *H. major* decreases the higher the initial population. Under given conditions a certain initial popu-

lation will produce the maximum final population. If the initial population is increased further the final population decreases. Relatively more large cysts are produced from low inocula, and the mean egg content of new cysts therefore appears to fall with increase of inoculum. From similar inocula of H. major relatively more large cysts are produced on barley than on oats.

499. HAHN, S. (Root gall eelworms as pests of lettuce and carrots grown out of doors.) (German.) *NachrBl. dtsh. PflSchDienst Braunschweig* 10: 123-126. 1958.  
Meloidogyne hapla on lettuce and carrots.
500. HEALY, A. J. Eelworm (*Anguina agrostis* (Steinb.) Filipjev) in *Agrostis tenuis* Sibth. in New Zealand. *New Zealand J. Agr. Res.* 1: 265-266. 1958. (Helminth. Abstr. 27: 45. 1958.)  
 Galled flowers of *Agrostis tenuis* in New Zealand were attributed to attack by *Anguina agrostis*.
501. HENDERSON, V. E. Relationship between some clovers and *Ditylenchus destructor* Thorne, 1945. *Nature* 181: 59-60. 1958.  
 It was shown that certain legumes increased the population of *D. destructor* in their rhizospheres. Root necrosis, probably of fungal origin, was evident in most of these plants. It is suggested the nematodes' increase is correlated with their feeding on the fungi in the necrotic roots.
502. HESLING, J. J. The efficiency of certain grasses as hosts of cereal root eelworm. *Plant Path.* 7: 141-143. 1958.  
 The following grasses were tested as hosts of *Heterodera major*: Italian ryegrass, *Lolium italicum*, perennial ryegrass, *Lolium perenne*, cocksfoot, *Dactylis glomerata*, and timothy, *Phleum pratense*. Timothy is a very poor host whereas the other three grasses increased the population, but not nearly to the same extent as on oats grown with similar inocula under similar conditions.
503. HESLING, J. J. *Heterodera major* O. Schmidt, 1930 -- population changes in the field and in pots of fallow soil. *Nematologica* 3: 274-282. 1958.  
 Barley produced an increase (up to five times) in the number of larvae per gram of soil. Under Italian ryegrass and cocksfoot (both hosts of this eelworm) the population fell, as it did under fallow or a non-host crop, the reduction being about 60 percent.
504. HEWITT, W. B. et al. Nematode vector of soil-borne fanleaf virus of grapevines. *Phytopathology* 48: 586-595. 1958.  
 It is demonstrated that fanleaf disease of grapevines in California is soil-borne and transmitted by the nematode *Xiphinema index*. This is the first report showing a nematode vector of a plant virus.
505. HOLLIS, JOHN P. Relations between root knot and fusarium vascular discoloration in cotton varieties. *Phytopathology* 48: 661-665. 1958.  
 The data presented enable separate ratings of varietal reactions to root knot and vascular discoloration and a statement of the problem of racial determinations within root-knot nematode species.
506. HOPPER, B. E. Plant-parasitic nematodes in the soils of southern forest nurseries. *Plant Disease Repr.* 42: 308-314. 1958.  
*Meloidodera* and *Tylenchorhynchus* were the only plant parasitic nematode genera found to be directly associated with seedling injury in the 35 nurseries included in the survey.
507. HUNTER, A. H. Nutrient absorption and translocation of phosphorus as influenced by the root knot nematode (*Meloidogyne incognita* var. *acrita*). *Soil Sci.* 86: 245-250. 1958.  
 Under the conditions of this experiment, in which the root system was continually bathed by the nutrient solution, the observed detrimental effects of the



root-knot nematode Meloidogyne incognita var. acrita on growth of tomato plants cannot be attributed to an interference with the absorption or translocation of the mineral elements N, K, Ca, Mg, Fe, or Cu.

508. JENSEN, HAROLD J. et al. Potato-rot nematode, Ditylenchus destructor Thorne 1945, found in dahlia roots. Plant Disease Repr. 42: 1357-1359. 1958.

Ditylenchus destructor was found on dahlia roots in Oregon. Diagnosis of infection is handicapped by lack of above-ground symptoms or characteristic root symptoms.

509. JOHNSTON, TITUS. The effect of soil moisture on Tylenchorhynchus martini and other nematodes. Proc. Louisiana Acad. Sciences 20: 52-55. 1958.

Optimum soil moisture levels for survival of T. martini ranged from 40 to 60 percent of field capacity. For other nematodes (not stated) in the same soil, the optimum moisture level for survival ranged from 75 to 100 percent of the field capacity.

510. KIRKPATRICK, J. D. and W. F. MAI. Pratylenchus penetrans; serious pest of fruit tree roots. Farm Research 24 (2): 11. 1958.

Affecting growth of cherry and apple.

511. KRUSBERG, L. R. and L. W. NIELSEN. Pathogenesis of root-knot nematodes to the Porto Rico variety of sweetpotato. Phytopathology 48: 30-39. 1958.

The influence of Meloidogyne incognita var. acrita on plant growth and histopathological changes in the root system were studied. Three major infection courts were evident, i.e. young root tips, lateral root ruptures, and the surfaces of cracks. After penetration the site of feeding of the larvae varied with the infection court. Larvae came to rest primarily in the stele in the region of cell elongation, in the cambial zone, or in the parenchyma, depending upon whether the infection court was young root tips, lateral root ruptures, or crack surfaces, respectively. Nematode feeding stimulated formation of giant cells, "abnormal xylem", hyperplastic parenchyma, and cork.

512. KRUSBERG, L. R. and HEDWIG HIRSCHMANN. A survey of plant parasitic nematodes in Peru. Plant Disease Repr. 42: 599-608. 1958.

A survey of plant-parasitic nematodes in several agricultural areas of the coast, mountains, and selva of Peru was made during July and August of 1957. A total of 208 collections contained 33 plant parasitic nematode species representing 14 genera. Meloidogyne spp. were most important on the coast and in the selva, and Heterodera rostochiensis in the mountains.

513. LEACH, R. Blackhead toppling disease of bananas. Nature 181:204-205. 1958.

Disease is caused by Radopholus similis, the variety Locatan being particularly susceptible. The nematode may be found in purplish streak lesions on young roots and also at the junction of diseased and healthy tissue near the surface of the corm.

514. LESTER, E. and E. C. LARGE. Surveys of clover rot with incidental observations on eelworm in clover: England and Wales, 1953-1955. Plant Path. 7: 115-124. 1958.

The survey carried out in England and Wales during the years 1953 to 1955 was primarily for clover rot, but in the course of the work the presence of eelworm was recorded in about 20 percent of the fields with the eelworm causing moderate to severe loss in about 7 percent of the fields each year.

515. LEWIS, G. D. et al. Reproduction of various Meloidogyne species in onion. Plant Disease Repr. 42: 447-448. 1958.

Onion roots were inoculated with Meloidogyne hapla, M. incognita, M. incognita acrita, M. javanica, M. arenaria and M. arenaria thamesi. All 6 species were able to cause knots on the roots. All 6 species were able to carry through 2 generations in onion roots, but the rate of reproduction in the case of M. arenaria thamesi was observed to be much lower than that of

the other 5 species.

516. LORDELLO, LUIZ GONZAGA E. and R. CESNIK. Alguns nematodeos do tomateiro. Rev. Brasil. Biol. 18: 159-165. 1958.  
 Roots of tomato plants collected in the State of São Paulo, Brazil, were attacked by Meloidogyne javanica and another species of Meloidogyne of the M. incognita group.
517. LORDELLO, LUIZ GONZAGA E. and A. P. L. ZAMITH. (Nematode parasites of soybean and cotton roots in the State of S. Paulo and its implication in crop rotation.) Revista de Agricultura 33: 161-166. 1958.  
Pratylenchus steineri damaging cotton and soybean, with cotton suffering greater damage than soybean.
518. LORDELLO, LUIZ GONZAGA E. and A. P. L. ZAMITH. (Nematodeos atacando cafeeiro no estado de São Paulo.) Revista de Agricultura 33: 59-62. 1958.  
Meloidogyne exigua on coffee in Brazil. (See abstract #519.)
519. LORDELLO, L. G. E. and A. P. L. ZAMITH. A note on nematodes attacking coffee trees in Brazil. Plant Disease Reprtr. 42: 199. 1958.  
Meloidogyne exigua appears to be an important detriment to coffee production in certain regions.
520. LORDELLO, L. G. E. Parasitismo de Aphelenchus avenae em raizes de cantalupe (Nematoda, Aphelenchidae). Revista Brasileira de Biologia 18: 33-36. 1958.  
 The author found an adult female and eggs of A. avenae in the roots of cantaloupe and concludes that this nematode is not a harmless form.
521. LOWNSEBURY, B. F. and D. R. VIGLIERCHIO. Mechanism of accumulation of Meloidogyne hapla around roots of tomato seedlings. (Abstr.) Phytopathology 48: 395. 1958.  
 Evidence is presented to show that larval accumulation around tomato roots is, in part, a response to a dialyzable agent, or agents, effective at a distance from the root surface.
522. MACHMER, J. H. Effect of soil salinity on nematodes in citrus and papaya plantings. J. Rio Grande Valley Hort. Inst. 12: 57-60. 1958. (Hort. Abstr. 28: 640. 1958.)  
 Nematodes, including Tylenchulus semipenetrans on citrus and Meloidogyne incognita acrita on pawpaws, will tolerate levels of salts which are high enough to damage, though not to kill, their host plants.
523. MacLAGAN, D. S. Pest control in cereal crops. Scottish Agriculture 37: 158-161. 1958. (Helminth. Abstr. 27: 58. 1958.)  
 For control of Ditylenchus dipsaci the author recommends weed suppression, the use of the resistant oat variety Milford, and a gap of 3 years between oat crops.
524. MARTIN, G. C. Root-knot nematodes (Meloidogyne spp.) in the Federation of Rhodesia and Nyasaland. Nematologica 3: 332-349. 1958.  
Meloidogyne javanica is the most common species and appears to be indigenous. M. incognita var. acrita also occurs on farm lands. M. hapla, as well as the above-mentioned species, occurs commonly in market gardens. M. arenaria has been found rarely to date.
525. McGUIRE, James M. et al. The relationship of root-knot nematodes to the development of Fusarium wilt in alfalfa. (Abstr.) Phytopathology 48: 344. 1958.  
 The fungus Fusarium oxysporum f. vasinfectum was combined separately with five species of root-knot nematodes and the percentage of alfalfa plants of the variety Buffalo developing wilt was determined experimentally as follows. Fungus plus Meloidogyne hapla, 95 percent; fungus plus M. javanica, 60 percent; fungus plus M. incognita, 50 percent; fungus plus M. arenaria, 50 percent;

fungus plus M. incognita var. acrita, 10 percent; fungus alone, 15 percent; nematode alone and check 0 percent.

526. MEAGHER, J. W. Nematodes as plant parasites. J. Aust. Inst. Agr. Sci. 24: 3-12. 1958. (Helminth. Abstr. 27: 38. 1958)  
This is a general account of plant parasitic nematodes in Australia. The role of nematodes in disease complexes is discussed and methods of control -- cultural, chemical and biological -- are mentioned.
527. MORETON, B. D. New host record for root-knot eelworms. Plant Path. 7: 114. 1958.  
Meloidogyne incognita (plus M. incognita acrita?) on pot-grown plants of Cyclamen persicum in England.
528. MOUNTAIN, W. B. and H. R. BOYCE. The peach replant problem in Ontario. V. The relation of parasitic nematodes to regional differences in severity of peach replant failure. Can. J. Botany 36: 125-134. 1958.  
Two peach producing areas in Ontario differ markedly in the incidence and severity of peach replant failure. It was found that peach soil populations of Pratylenchus penetrans can be correlated with the distribution of the disease since the average soil population was 3-4 times larger in the area where peach replant failure is more severe. The distribution of the nematode is related to soil type, being most common on coarse sandy soils.
529. MOUNTAIN, W. B. and H. R. BOYCE. The peach replant problem in Ontario. VI. The relation of Pratylenchus penetrans to the growth of young peach trees. Can. J. Botany 36: 135-151. 1958.  
The severity of peach replant failure is related to the soil population of Pratylenchus penetrans. Controlling this nematode with a nematocide increased the growth of replants and reduced mortality. The first nematode to attack newly developing peach roots was found to be P. penetrans. Ecto-parasites usually appeared later and could not be correlated with incidence of peach replant failure.
530. MULVEY, ROLAND H. Impregnation of Heterodera trifolii by males of H. schachtii (Nematoda: Heteroderidae). Can. J. Zool. 36: 839-841. 1958.  
A parthenogenetic nematode, H. trifolii, was impregnated by a bisexual nematode, H. schachtii, in mixed cultures of the two species. No males occurred among several hundred offspring.
531. MULVEY, ROLAND H. Parthenogenesis in a cyst forming nematode, Heterodera trifolii (Nematoda: Heteroderidae). Can. J. Zool. 36: 91-93. 1958.  
H. trifolii reproduced in the absence of males. Nematodes reared in the greenhouse from single larvae and from mass cyst culture were diploid-parthenogenic. During maturation only one polar body was produced. The diploid number (24?) of chromosomes was not reduced and no male was found.
532. NEWHALL, A. G. The incidence of Panama disease of banana in the presence of the root-knot and the burrowing nematodes (Meloidogyne and Radopholus). Plant Disease Repr. 42: 853-856. 1958.  
In one experiment which ran for 4 months at Changuinola, Panama, using steamed soil heavily infested with Fusarium oxysporum f. cubense, over 100 percent more Gros Michel banana plants came down with Panama disease when Radopholus similis was added to the soil. The addition of Meloidogyne sp. caused no increase in the disease during this period of time.
533. NORTON, DON C. The association of Pratylenchus hexincisus with charcoal rot of sorghum. Phytopathology 48: 355-358. 1958.  
Part of the damage in Texas often attributed to Macrophomina phaseoli is due to the activity of Pratylenchus hexincisus. The two incitants apparently act independently and their effects are greater under drouth conditions.



534. NUSBAUM, C. J. The response of root-knot-infected tobacco plants to foliar applications of maleic hydrazide. (Abstr.) *Phytopathology* 48: 344. 1958.  
Foliar application of maleic hydrazide inhibited the development of galls and reproduction of Meloidogyne incognita. Histopathological studies of the root material showed conspicuous lack of hyperplastic tissue, as well as small, poorly developed giant cells and degenerate female nematodes.
535. OOSTENBRINK, M. Enige bijzondere aaltjesaantastingen in 1957. *Tijdschr. Pl. Ziekt.* 64: 122. 1958.  
(not reviewed)
536. OOSTENBRINK, M. An inoculation trial with Pratylenchus penetrans in potatoes. *Nematologica* 3: 30-33. 1958.  
Potatoes were stunted the second year following inoculation but not the first year. Population of the nematode declined the first year and then markedly increased the second year.
537. PARKER, K. G. et al. Cherry and other fruit trees damaged by nematodes. *Farm Res.* 24(2): 10. 1958.  
Damage to cherry and apple trees on light-textured soils caused by Pratylenchus penetrans.
538. PERRY, VERNON G. A disease of Kentucky blue grass incited by certain spiral nematodes. (Abstr.) *Phytopathology* 48: 397. 1958.  
Certain species of spiral nematodes are said to be pathogenic to blue grass on the basis of greenhouse inoculation experiments, field control experiments, and pathological histological studies.
539. PERRY, V. G. Parasitism of two species of dagger nematodes (Xiphinema americanum and X. chambersi) to strawberry. *Phytopathology* 48: 420-423. 1958.  
Inoculation experiments showed that both species cause shrunken, reddish-brown lesions on strawberry roots that progress to an eventual blackening of the entire root system. Other organisms are involved in the eventual destruction of the roots.
540. PETERS, B. G. Symposium on plant parasitic Nematoda. *Proc. Linnean Soc. of London*. 169: 84-85. 1958. (*Helminth. Abstr.* 27: 54. 1958).  
(not reviewed)
541. PITCHER, R. S. and J. E. CROSSE. On a disease complex of strawberries involving a nematode and a bacterium. (Abstr.) *Proc. Linnean Soc. of London* 169: 105. 1958.
542. PITCHER, R. S. and J. E. CROSSE. Studies in the relationship of eelworms and bacteria to certain plant diseases. II. Further analysis of the strawberry cauliflower disease complex. *Nematologica* 3: 244-256. 1958.  
Pure culture studies show that there are two related but distinct diseases in eelworm infested field strawberries: 1) a true eelworm disease resulting in feeding areas, alamate leaves, and open-centered plants, caused by the nematodes alone (Aphelenchoides ritzemabosi and A. fragariae); 2) a predominantly bacterial disease, cauliflower, composed of a leafy gall initiated by the bacterium Corynebacterium fascians, and modified by the eelworms.
543. RASKI, D. J. and J. D. RADEWALD. Reproduction and symptomatology of certain ectoparasitic nematodes on roots of Thompson seedless grape. *Plant Disease Repr.* 42: 941-943. 1958.  
Xiphinema index, Criconemoides xenoplax, Paratylenchus hamatus, and Trichodorus christiei were tested on Thompson seedless rootings in sterile soil. T. christiei did not survive whereas the others multiplied and were parasitic. Root injury consisting of destruction, necrosis, or malformation of the feeder roots occurred only in the presence of X. index.

544. RITTER, M. and R. RITTER. Caractères du cycle évolutif d'un Meloidogyne, nématode parasite des racines de la tomate *Lycopersicum esculentum*, Mill. (Character of the life cycle of a Meloidogyne, a parasitic nematode on the roots of tomato *L. esculentum*.) Acad. Sci. C. R. 246: 1773-1776. 1958. (Tobacco Abstr. 2: 328. 1958.)

A study of life cycle and duration of larval stages of a nematode similar morphologically to Meloidogyne incognita var. acrita. No males were recovered. Total life cycle varies from 25-90 days.

545. RITTER, M. and R. RITTER. Influence de l'âge de la plante-hôte sur le développement de Meloidogyne incognita, nématode phytoparasite. (Influence of age of the host plant on the development of *M. incognita*, plant parasitic nematode.) Acad. Sci. C. R. 246: 2054-2056. 1958. (Tobacco Abstr. 2: 328. 1958)

Older plants are invaded earlier than young plants and permit more rapid development of Meloidogyne. The proportion of tomatoes not attacked is greater among the younger plant series.

546. RUEHLE, J. L. and J. R. CHRISTIE. Feeding and reproduction of the nematode *Hemicycliophora parvana*. Proc. Helminth. Soc. Wash. 25: 57-60. 1958.

H. parvana fed readily on the roots of corn and bean, feeding externally near the root tip. Feeding did not cause necrotic lesions. The most rapid reproduction occurred on corn, with an increase of about 1 to 85 in 5 months.

547. SAUER, M. R. Development of eggs before the final moults in *Pratylenchus*. Nature 181: 129. 1958.

Occasionally females of P. minyus were found carrying eggs outside the body but within a partly cast cuticle. It appears therefore, that this nematode may produce eggs before the final moult takes place.

548. SCHINDLER, A. F. Attempts to demonstrate the transmission of plant viruses by plant parasitic nematodes. Plant Disease Reptr. 42: 1348-1350. 1958.

Attempts to transmit tobacco mosaic virus and cucumber mosaic virus to tobacco and tomato by Meloidogyne spp. as well as carnation mottle virus to carnation by Helicotylenchus nannus and Pratylenchus spp. were unsuccessful.

549. SCHINDLER, A. F. Root-knot nematodes on the mimosa tree, *Albizia julibrissin*. Plant Disease Reptr. 42: 315. 1958.

Heavy galling with Meloidogyne hapla, moderate galling with M. arenaria and M. arenaria thamesi.

550. SHER, S. A. The effect of nematodes on azaleas. Plant Disease Reptr. 42: 84-85. 1958.

Tylenchorhynchus claytoni, Trichodorus christiei, Tylenchus sp., and Ditylenchus sp. are often found around poorly growing azalea plants in southern California. T. claytoni was the only species that caused a stunting of azalea plants in a greenhouse test.

551. SIMON, LUDWIG. Nematologische Untersuchungen an Hopfen. II. Zur Morphologie und Biologie von *Heterodera humuli* Filipjev, 1934. Nematologica 3: 269-273. 1958.

H. humuli is regularly found in the hop growing areas of southern Germany. The larvae appear in soil samples mainly in April and May, but continue to be found in a smaller number until September. The first ripe cysts are found towards the end of July.

552. SOUTHEY, J. F. New host records for root knot eelworms. Plant Path. 7: 114. 1958.

Meloidogyne incognita var. acrita on Hoya sp., M. hapla on Clematis hybrids, Antennaria dioica, and Diervilla x styriaca in England.

553. STOVER, R. H. and M. J. FIELDING. Nematodes associated with host injury of *Musa* spp. in Honduran banana soils. Plant Disease Reptr. 42: 938-940. 1958. (Also Plant Disease Reptr. 42: 1302. 1958; for correction.)

Twelve species of plant parasitic nematodes were obtained from banana soils and Musa spp. roots in Honduras. Four of these, Meloidogyne arenaria, Hoplolaimus sp., Radopholus similis, and Pratylenchus musicola, were encountered consistently and in abundance. Root injury was most prevalent in sandy loam soil. There were no abnormal growth symptoms.

554. SUDAKOVA, I. M. (The eelworm fauna of the Chuvash A.S.S.R.) In Russian. Zoolo-gicheski Zhurnal 37: 134-139. 1958. (Helminth. Abstr. 27: 68. 1958.)

The 45 eelworm species listed from 17 species of crops and weeds in Chuvash A.S.S.R. include Aphelenchoides scalacaudatus n. sp. from the roots of Raphanus sativus as well as the roots and leaves of species of Allium.

555. SUMMERS, T. E. and C. C. SEALE. Root knot nematodes, a serious problem of kenaf in Florida. Plant Disease Reprtr. 42: 792-795. 1958.

The nematodes Meloidogyne incognita and M. incognita acrita damage kenaf by killing small seedlings, causing stunting and premature death of older plants and reducing fibre yields. Fumigation of root-knot-infested soils, using 40 gal. /acre of chloropicrin, increased the yields of kenaf.

556. TAYLOR, A. L. and EDNA M. BUHRER. A preliminary report on distribution of root-knot nematode species in the United States. (Abstr.) Phytopathology 48: 464. 1958.

South of the latitude of Washington, D. C. the most common root knot nematodes are Meloidogyne incognita and M. incognita acrita. North of this latitude M. hapla occurs most frequently. M. hapla and M. arenaria are quite common in peanut fields in areas where this crop is grown commercially. M. javanica occurs in scattered locations in southern and southwestern states. M. arenaria thamesi has been found only in Florida. No other species of Meloidogyne have been found in the U. S.

557. TAYLOR, DONALD P., ROGER V. ANDERSON and WILLIAM A. HAGLUND. Nematodes associated with Minnesota crops. I. Preliminary survey of nematodes associated with alfalfa, flax, peas, and soybeans. Plant Disease Reprtr. 42: 195-198. 1958.

A number of nematodes were identified from fields of alfalfa, flax, peas and soybeans.

558. THOMAS, PAUL R. Severe eelworm (Ditylenchus dipsaci (Kühn) Filipjev) infestation of the narcissus variety Soleil D'Or. Nematologica 3: 72-78. 1958.

During 1954, several instances of premature, slimy decay were noted in this variety of narcissus growing on the Isles of Scilly. There were very heavy infestations of D. dipsaci.

559. THOMASON, IVAN J. The effect of the root-knot nematode, Meloidogyne javanica, on blackeye bean wilt. (Abstr.) Phytopathology 48: 398. 1958.

The resistance of the variety Grant to Fusarium oxysporum f. trachei-philum was reduced when the roots of the plants were infected with M. javanica.

560. TODD, E. H. and JOHN G. ATKINS. White tip disease of rice. I. Symptoms, laboratory culture of nematodes, and pathogenicity tests. Phytopathology 48: 632-637. 1958.

The disease is caused by an ectoparasite, Aphelenchoides besseyi. The nematode is seed-borne and in stored seed is viable for 23 months. The nematodes were cultured on fungi growing on steamed, unhulled rice and could not be cultured in the absence of the fungi. Suspensions of nematodes from cultures consistently produced white tip symptoms.

561. TOWNSHEND, J. L. The effect of Pratylenchus penetrans on a clone of Fragaria vesca. Can. J. Botany 36: 683-685. 1958.

In the presence of small numbers of P. penetrans, the net increase in the number of petioles, petiole length, and fresh weight of F. vesca plants was significantly less than that of the controls, indicating, by analogy, that the nematode may be an important primary parasite in the strawberry root-rot complex.



562. TRACEY, M. V. Cellulase and chitinase in plant nematodes. *Nematologica* 3: 179-183. 1958.

It is demonstrated that both chitinase and cellulase are produced by *Ditylenchus dipsaci*, *D. destructor*, and *D. myceliophagus*. There is some indication that polygalacturonase is produced by *D. dipsaci*.

563. VAN GUNDY, S. D. The life history of the citrus nematode *Tylenchulus semipenetrans* Cobb. *Nematologica* 3: 283-294. 1958.

Characteristics are described which separate male and female at the second larval stage. Unfertilized females produced both male and female larvae. No anus was observed in the female larva. An anal opening was observed in the male larva which becomes the genital opening.

564. VAN GUNDY, S. D. The pathogenicity of *Hemicycliophora arenaria* on citrus. (Abstr.) *Phytopathology* 48: 399. 1958.

At a soil temperature of 30°C gall formation and nematode reproduction on lemon roots were greater than at a soil temperature of 25°C. No galling occurred on sweet orange roots. The formation of galls on rough lemon roots is a hyperplastic response to the feeding of the nematodes. The cells adjacent to the stylet of the nematode showed hypertrophy of the nuclei.

565. WALLACE, H. R. Movement of eelworms. I. The influence of pore size and moisture content of the soil on the migration of larvae of the beet eelworm, *Heterodera schachtii* Schmidt. *Ann. Appl. Biol.* 46: 74-85. 1958.

Experiments on migration of the beet eelworm through soil fractions at different pressure deficiencies or at saturation showed that the nematode attains maximum speed when pore diameters were between 30 - 60  $\mu$ . Speed of the eelworm increased as lateral displacement of the body was restricted by external resistance acting perpendicularly to the body axis. By ascertaining pore size distribution the probable behaviour of beet eelworm larvae in the medium can be predicted.

566. WALLACE, H. R. Movement of eelworms. II. A comparative study of the movement in soil of *Heterodera schachtii* Schmidt and of *Ditylenchus dipsaci* (Kühn) Filipjev. *Ann. Appl. Biol.* 46: 86-94. 1958.

Studies of mobility in different soil fractions and different suctions showed that the optimum particle size for movement of *H. schachtii* and *D. dipsaci* was 150-200 and 250-500  $\mu$ , respectively. The effect of pore size upon mobility is discussed and it is suggested that there is a simple relationship between body length, particle size, and speed.

567. WALLACE, H. R. Movement of eelworms. III. The relationship between eelworm length, activity and mobility. *Ann. Appl. Biol.* 46: 662-668. 1958.

It was found that the product of length and activity of an eelworm divided by its speed is a constant. This supports the hypothesis that the speed of the eelworm among water droplets is a function of its length and activity. The principle can only be applied to movement in soil where the length of the eelworm is less than about three times the particle diameter. Under such conditions the eelworms move in thin films or water droplets over particles. With increasing eelworm length there is an increase in soil particle size for maximum mobility.

568. WALLACE, H. R. Observations on the emergence from cysts and the orientation of larvae of three species of the genus *Heterodera* in the presence of host plant roots. *Nematologica* 3: 236-243. 1958.

It is suggested that four factors influence rate of emergence of larvae from cysts and their attraction to host plant roots:

1) the concentration of root diffusate secreted by the roots; 2) the rate of diffusion of the diffusate from root to cyst; 3) gradients of moisture content in the sand caused by uptake of water by the roots; 4) inhibition of larval emergence at high suctions caused by thin water films at the oral and vulval openings of the cyst.

569. WIDDOWSON, ELIZABETH et al. Observations on the development of *Heterodera rostochiensis* Woll. in sterile root cultures. *Nematologica* 3: 308-314. 1958.

Eggs were sterilized in hydrogen peroxide and transferred to a tomato root culture in White's medium. Larvae emerging from the eggs concentrated at the root tip or at isolated points along the main roots where lateral rootlets later emerged. There was very high nematode mortality in the agar but some succeeded in penetrating root tips, usually accompanied by localized swelling. Mature females developed but contained no eggs.

570. WIDDOWSON, E. and G. H. WILTSHIRE. The potato-eelworm hatching factor. *Ann. Appl. Biol.* 46: 95-101. 1958.

The hatching factor from potato root diffusate has many of the properties of eclepic acid from tomato root and *Solanum nigrum* as well as the same biological activity. It was found that the potato preparations which are freely soluble in water are simultaneously inactivated and rendered insoluble by brief exposure to caustic alkali. The product of alkali treatment has been crystallized.

571. WIDDOWSON, ELIZABETH. Potato root diffusate production. *Nematologica* 3: 6-14. 1958.

Tests were made to assess the effects of plant age, variety and infestation with the potato root eelworm on the activity of potato root diffusate produced by potted potatoes.

572. WIDDOWSON, ELIZABETH. The production of root diffusate by potatoes grown in water culture. *Nematologica* 3: 108-114. 1958.

Diffusate was produced by potatoes growing in 1 litre of nutrient solution without aeration, but for at least the first 4 weeks of growth it was less active than that from potatoes in pots, suggesting slower initial growth of potato in nutrient solution.

573. WINNER, CHR. Untersuchungen über die Eigenschaften der auf *Heterodera schachtii* Schmidt aktivierend wirkenden Wurzelexsudate von *Brassica rapa oleifera* D. C. *Nematologica* 3: 315-326. 1958.

The active principle of the exudate from turnip rape can be partially destroyed by various physical and chemical means as well as by bacterial degradation. The active principle is dialysable and can be dried *in vacuo* at 35°C successfully. The active material occurs in higher concentration in roots than in exudate and can be extracted from the roots without difficulty.

#### Nematodes -- Resistance

574. BAIN, DOUGLAS C. Reaction of red and white clover introductions to root knot nematodes. (Abstr.) *Phytopathology* 48: 341. 1958.

Results suggest the possibility of selecting white clovers resistant to *Meloidogyne incognita* var. *acrita* and *M. javanica* and red clovers resistant to *M. arenaria* and *M. javanica*.

575. CRITTENDEN, H. W. Histology and cytology of susceptible and resistant soybeans infected with *Meloidogyne incognita acrita*. (Abstr.) *Phytopathology* 48: 461. 1958.

Histological and cytological characteristics of susceptible varieties include: large number of giant cells, large size of giant cell area, very dense cytoplasm and great number of enlarged nuclei in the giant cells, great enlargement of pericycle. Almost none of these characteristics occurred in the roots of resistant varieties.

576. DROLSOM, P. N. et al. Inheritance of resistance to root-knot nematodes in tobacco. *Phytopathology* 48: 686-689. 1958.

Results support the hypothesis that a single dominant factor, or a block behaving as a single factor, controls resistance to the *Meloidogyne incognita* var. *acrita* populations used.

577. DROLSOM, P. N., and E. L. MOORE. Reproduction of *Meloidogyne* spp. in flue-cured tobacco lines of root-knot resistant parentage. *Plant Disease Repr.* 42: 596-598. 1958.

Data indicated that breeding lines were highly resistant in the presence of *Meloidogyne incognita* and *M. incognita acrita* and relatively susceptible with *M. javanica*, *M. arenaria*, and *M. hapla*.

578. FEDER, W. A. et al. Citrus varieties, species, and relatives susceptible to attack and damage by the burrowing nematode, *Radopholus similis*. *Plant Disease Repr.* 42: 934-937. 1958.

Nearly 400 varieties, species and relatives were found to be susceptible.

579. GILBERT, J. C. et al. Tobacco mosaic virus resistance combined with root knot resistance in new tomato hybrids. *Hawaii Farm Sci.* 6: 7-8. 1958. (*Hort. Abstr.* 28: 603. 1958.)

Not reviewed.

580. GILES, J. E. and E. M. HUTTON. Combining resistance to the root-knot nematode, *Meloidogyne javanica* (Treub) Chitwood, and *Fusarium* wilt in hybrid tomatoes. *Australian J. Agr. Res.* 9: 182-192. 1958. (*Helminth. Abstr.* 27: 11. 1958.)

The authors report the production of tomato strains resistant to root knot nematodes (*M. javanica*) and *Fusarium* wilt (*Fusarium bulbigenum* var. *lycopersici*). Four lines derived from *Lycopersicon peruvianum* bred in Hawaii for root-knot resistance were bred in various ways with 12 Australian commercial varieties. All of the Hawaiian lines were highly resistant to *Fusarium* whereas the resistance to the nematode varied in the different lines.

581. GOLDEN, A. MORGAN and THELMA SHAFER. Differential response of *Heterodera schachtii*, the sugar beet nematode, to selections of *Chenopodium album*. *Plant Disease Repr.* 42: 184-187. 1958.

Of six selections of *Chenopodium album* tested for susceptibility to the sugar-beet nematode, one was found to be moderately infected while five were found not to be infected indicating at least two races of this plant species.

582. GOLDEN, A. MORGAN. Interrelationships of certain *Beta* species and *Heterodera schachtii*, the sugar beet nematode. *Plant Disease Repr.* 42: 1157-1162. 1958.

The studies concerned three wild species of *Beta* (*B. patellaris*, *B. procumbens*, and *B. webbiana*). All produced a strong hatching factor and larvae of the sugar beet nematode penetrated their roots but mature females and cysts did not develop. None of the *Beta* species were affected by nematode attack. The possible nature of this resistance is discussed.

583. GOLDEN, A. MORGAN and THELMA SHAFER. Unusual response of *Hesperis matronalis* to root-knot nematodes (*Meloidogyne* spp.). *Plant Disease Repr.* 42: 1163-1166. 1958.

In laboratory and greenhouse tests, *Hesperis matronalis*, a cruciferous plant which might be used as a trap plant for use in biological control of the sugar beet nematode, was determined not to be a host for any of the root-knot nematodes known to occur in the United States. Root-knot nematode larvae were found to enter the roots and form typical swellings but did not develop to maturity.

584. JONES, F.G.W. Resistance-breaking populations of the potato root eelworm. *Plant Path.* 7: 24-25. 1958.

In 1957, 25 populations of *Heterodera rostochiensis* were tested on a range of resistant potato material, including  $F_1$  and  $B_1$  hybrids of *Solanum tuberosum* spp. *andigena* and also *S. vernei*. Seventeen populations were aggressive to the *S. andigena* hybrids and none to *S. vernei*.

585. MANKAU, R. A. Pathological disturbances caused by *Heterodera trifolii* in susceptible and resistant plants. (*Abstr.*) *Phytopathology* 48: 395. 1958.



It was found that the syncytium that develops in the stele adjacent to the head of the nematode is formed by the coalescing of adjoining cells, producing a continuous, multinucleate protoplast. It increases in size by inclusion of cells at its advancing margins. The size of the female at maturity is closely related to the size of the syncytium and rate of development of the nematode is dependent upon rate of development of the syncytium.

586. MCGLOHON, NORMAN E. and L. W. BAXTER. The reaction of *Trifolium* species to the southern root-knot nematode, *Meloidogyne incognita* var. *acrita*. Plant Disease Repr. 42: 1167-1168. 1958.

Twenty-five species of *Trifolium* were tested for susceptibility to *M. incognita* var. *acrita* and all became severely galled.

587. MCGUIRE, D. C. and R. W. ALLARD. Testing nematode resistance in the field. Plant Disease Repr. 42: 1169-1172. 1958.

Successful field trials in Hawaii for testing the resistance of varieties and lines of lima beans to root-knot nematode were due to at least three factors: 1) a benevolent climate of the test areas both to the host and the pathogen; 2) relative freedom from other pathogens to complicate the tests; 3) relative uniformity of root-knot nematode infestation in the plots. Results in California and Hawaii were in close agreement suggesting that the same physiological races of root-knot nematodes were involved.

588. PATE, J. B. et al. Resistance of *Hibiscus eetveldianus* to root-knot nematodes and the possibilities of its use as a source of resistance in kenaf, *Hibiscus cannabinus*. Plant Disease Repr. 42: 796-797. 1958.

*Hibiscus eetveldianus* has been found resistant and kenaf, *H. cannabinus*, susceptible to root-knot nematodes in south Florida. Attempts are being made to combine the root-knot resistance of the former with the plant type of kenaf in a single fertile line.

589. POWELL, N. T. and C. J. NUSBAUM. The effect of root-knot nematode resistance on the incidence of black shank in tobacco. Phytopathology 48: 344. 1958.

The studies indicate that the loss from black shank in resistant varieties of tobacco grown in the presence of both the fungus *Phytophthora parasitica* var. *nicotianae* and the nematodes *Meloidogyne incognita* and *M. incognita* var. *acrita* would be reduced by combining root-knot resistance with black shank resistance.

590. RIGGS, R. D. and N. N. WINSTEAD. Attempts to transfer root-knot resistance in tomato by grafting. Phytopathology 48: 344. 1958.

The experiments show that the resistance or susceptibility factor(s) is inherent in individual cells in both the roots and tops of plants and either is not translocated or does not cross the graft union.

591. ROHDE, R. A. and W. R. JENKINS. Basis for resistance of *Asparagus officinalis* var. *altilis* L. to the stubby-root nematode *Trichodorus christiei* Allen 1957. U. of Md. Agr. Expt. Sta. Bull. A-97. June 1958.

The resistance of asparagus variety Martha Washington to attack by *T. christiei* is dependent on an active force. The deleterious effects of asparagus on soil populations is more pronounced as fleshy storage roots are formed. A substance toxic to the nematode was isolated from asparagus, mainly from the storage roots. Some properties of this chemical are described.

592. ROHDE, R. A. and W. R. JENKINS. The chemical basis of resistance of asparagus to the nematode *Trichodorus christiei*. Phytopathology 48: 463. 1958.

Juice extracted from the roots of *Asparagus officinalis* was toxic to *T. christiei* and other nematodes at a dilution of 1: 10, causing non-reversible paralysis of nematodes in water solutions of 100 ppm or less. Populations of *T. christiei* around tomato roots were reduced either by spraying the leaves or drenching the root zone with 1000-ppm solution of the toxic compound isolated from asparagus roots.

593. ROSS, J. P. Host-parasite relationship of the soybean cyst nematode in resistant soybean roots. *Phytopathology* 48: 578-579. 1958.  
In the resistant variety there is a hypersensitive necrotic reaction to the nematode (*Heterodera glycines*), resulting in disorganized necrotic cells about the head of the female nematode in contrast to the formation of giant cells in the susceptible roots. The development of males is normal in both resistant and susceptible varieties.
594. SHARPE, R. H. Okinawa peach shows promising resistance to root-knot nematodes. *Proc. Florida State Hort. Soc.* 70: 320-322. 1958. (*Hort. Abstr.* 28: 351. 1958.)  
Seedlings introduced from Okinawa are highly resistant to *Meloidogyne incognita*, *M. incognita acrita*, and *M. javanica*.
595. SMITH, OLIVER F. Reactions of some alfalfa varieties to the stem nematode. *Phytopathology* 48: 107. 1958.  
Infection by *Ditylenchus dipsaci* of varieties of alfalfa in field plots varied from 2 percent in the resistant variety Lahontan to 100 percent in the highly susceptible varieties.
596. SPRUYT, F. J. Susceptibility of Seradella to root-knot nematodes. *Plant Disease Repr.* 42: 897. 1958.  
Seradella, *Ornithopus sativus* Brot., is not resistant to five species of root-knot nematode, *Meloidogyne javanica*, *M. arenaria*, *M. hapla*, *M. incognita*, *M. incognita* var. *acrita*.
597. STANFORD, E. H. et al. Sources of resistance in alfalfa to the northern root-knot nematode, *Meloidogyne hapla*. *Phytopathology* 48: 347-349. 1958.  
Of 21 varieties of alfalfa, five related *Medicago* species, 54 Foreign Plant Introductions, and 200 lines of material from the California breeding program, only the alfalfa variety Vernal and a strain Hilman were highly resistant to *M. hapla*.
598. SUMMERS, T. E. et al. Extent of susceptibility within kenaf, *Hibiscus cannabinus* L., to root-knot nematodes. *Plant Disease Repr.* 42: 591-593. 1958.  
All kenaf varieties, introductions and selections tested were susceptible to *Meloidogyne incognita* and *M. incognita acrita*, but some exhibited variation, particularly between plants within lines.
599. WILLIAMS, T. D. Potatoes resistant to root eelworm. *Proc. Linnean Soc. of London* 169: 93-104. 1958. (*Helminth. Abstr.* 27: 54. 1958.)  
Not reviewed.

#### Nematodes -- Technique

600. CARROLL, K. K. et al. The potato eelworm hatching factor. 7. Further methods for concentration of the factor. *Nematologica* 3: 154-167. 1958.  
Large quantities of potato and tomato root leachings were concentrated rapidly in *vacuo* at temperatures below 45°. An alternative method under investigation is to absorb the active factor by a strongly basic ion exchange resin and subsequently displacing it by mineral acid.
601. CHAPMAN, RICHARD A. An evaluation of methods for determining the number of nematodes in soil. *Plant Disease Repr.* 42: 1351-1356. 1958.  
The inverted flask method provided good yields adequate for many quantitative purposes with lower variability than either the Baermann funnel or the sieving-Baermann funnel.
602. DEN OUDEN, H. A new method for culturing plants enabling the observation of nematodes on growing roots. *Tijdschr. Pl. Ziekt.* 64: 269-272. 1958  
A method for growing plants in thin layers of agar is described. The agar contains a large amount of air bubbles and is enclosed between two sheets of polythene. The method can be used for the observation of nematodes and other

root parasites requiring a well-aerated medium while attacking growing roots.

603. DUGGAN, J. J. Testing soil samples for beet root eelworm (*Heterodera schachtii* Schmidt). Econ. Proc. of the Royal Dublin Soc. 4: 83-89. 1957. (Helminth. Abstr. 27: 21. 1958.)

By growing beet seedlings in glass tubes, the author was able to show that an infection of one cyst per 200 cc soil could be detected by observing new cysts on the roots. The test was also found to be satisfactory in winter when the seedlings were given artificial heat and light.

604. ELLENBY, C. Preliminary observations on the colorimetric assay of the hatching factor of the potato-root eelworm, *Heterodera rostochiensis* Wollenweber. J. Helminth. 32: 219-226. 1958.

Promising results in the colorimetric assay of potato-root eelworm hatching factor has been obtained with picric acid and 3: 5-dinitrobenzoic acid. Both of the reagents are used for the assay of cardiac glycosides with which the hatching factor may have affinities.

605. ELLENBY, C. and A. B. GILBERT. Solutions of potato root diffusate of low ion content. Experimentia 14: 109. 1958.

The authors give two reasons why it is desirable to obtain root diffusate solutions of very low ionic content. They report that root diffusate, virtually ion-free, can be obtained if the thoroughly washed root system is placed in a litre of ion exchange water in a polythene bucket for 24 hours.

606. FEDER, W. A. Aseptic culture of the burrowing nematode *Radopholus similis* (Cobb) Thorne on excised okra root tissues. Phytopathology 48: 392-393. 1958.

The nematode was surface sterilized in 1:1000 mercuric chloride and successfully cultured on excised okra root tissues growing on modified White (1943) culture medium.

607. FENWICK, D. W. and ELIZABETH WIDDOWSON. The conduct of hatching tests on cysts of the potato-root eelworm *Heterodera rostochiensis* (Woll.). J. Helminth. 32: 125-134. 1958.

The general principles underlying the conduct of hatching tests are described. Methods for collection of material, and for its preliminary assay are described. The information gained in this way is then used in designing hatching tests. The interpretation of the data resulting from such tests is described and limits are set between which interpretation is possible.

608. FERRIS, VIRGINIA R. and J. M. FERRIS. A simple method for making rapid routine photographs of nematodes. Plant Disease Repr. 42: 1192-1193. 1958.

The nematode, mounted on a slide, is placed on the stage of a monocular compound microscope in a darkened room and the image of the nematode is focused on a piece of photographic enlarging paper held about 10 inches above the ocular lens. The prints actually are negative but the features are quite distinct.

609. FORD, H. W. and W. A. FEDER. Procedures used for rapid evaluation of citrus for resistance to certain endoparasitic nematodes. Proc. Amer. Soc. Hort. Sci. 71: 278-284. 1958.

Preliminary screening of test seedlings carried out in tanks and greenhouse in presence of high soil populations of the burrowing nematode. Seedlings with low root population and little root damage were then studied in Petri dishes filled with sterile sand by inoculating roots with known numbers of nematodes. The population build-up was determined after 5 days and 35 days.

610. HAGUE, N. G. The concentration of potato root diffusate under reduced pressure. Nematologica 3: 149-153. 1958.

A technique is described for concentrating potato root diffusate under reduced pressure during which very little loss of activity occurred. Studies on



the concentration-response relationship showed a hump-shaped curve. This indicates that two widely spaced concentrations of the stimulant may produce similar responses thus complicating the bioassay method of determining the activity.

611. HOLLIS, J. P. Induced swarming of a nematode as a means of isolation. *Nature* 182: 956-957. 1958.

A method for the isolation of Tylenchorhynchus martini from a mixed population in a soil sample.

612. MAI, W. F. Small field plots for experiments involving plant pathogenic nematodes. (Abstr.) *Phytopathology* 48: 263. 1958.

The use of small (5 x 8 ft.) plots bounded by 12-in. redwood boards is described for nematode experiments where uniformly infested areas are necessary.

613. SHEPHERD, AUDREY M. Experimental methods in testing for resistance to beet eelworm, *Heterodera schachtii* Schmidt. *Nematologica* 3: 127-135. 1958.

This paper describes a technique for testing the resistance of sugar beet plants to *Heterodera schachtii*. Seedlings are transplanted at the cotyledon stage to 2 1/2-inch pots of sterile compost and 2 weeks later 2000 larvae are added to each pot and watered into the soil. Those plants which develop less than 10 cysts on the peripheral root system are retained. These are replanted and reinoculated with nematodes and plants still showing less than 10 cysts are saved for seed.

614. TINER, JACK D. A preliminary in vitro test for anthelmintic activity. *Experimental Parasitology* 7: 292-303. 1958.

An in vitro micro method was developed for preliminary evaluation of the antinematode effects of chemicals. A 0.01-ml volume of a volatile solvent containing a test substance is applied to dried E. coli cells. After the solvent has evaporated a suspension of nematode inoculum is introduced. The numbers and stages of nematodes which then develop are recorded and compared with a standard control. New techniques developed in connection with the procedure are discussed.

615. WIDDOWSON, ELIZABETH. Observations on the collection and storage of potato root diffusate. *Nematologica* 3: 173-178. 1958.

It has been found that the major portion of the leachate in a 6 1/2-inch pot is removed by the first 50 ml of water put through the pot. Stronger diffusate was obtained from potatoes growing in soil than in sand with or without nutrients. It is also suggested that one stock of diffusate adequate for all requirements be collected and stored in bulk each season because of the variable rate of breakdown of samples stored individually.

## NUTRITION

### Nutrition -- Hosts

See also 229

616. CHRISTIE, T. Effect of some major plant nutrients on resistance of hop plants to *Phytophthora cactorum* (L. and C.) Schroet. A. R. Cawthron Inst. 1956-1957, 1957, pp. 34-35. (Hort. Abstr. 28: 444. 1958.)

In a limited trial there were indications that NPK and NK applications to hop plants increased their susceptibility to infection by P. cactorum. The omission of K<sub>2</sub>O and, to a lesser degree, of N appeared to check infection.

617. EDGINGTON, L. V. and J. C. WALKER. Influence of calcium and boron nutrition on development of *Fusarium wilt* of tomato. *Phytopathology* 48: 324-326. 1958.

Bonny Best tomato plants inoculated with Fusarium oxysporum f. lycopersici showed a progressive decline in severity of wilt symptoms with increase

of calcium from 5 to 500 ppm. Boron levels in a range of 0.001-10 ppm affected the trend, but not progressively: with calcium at 5 ppm, the disease was very severe at both 0.001 and 10 ppm boron; with calcium at 100 ppm, the disease index decreased significantly from 0.001 to 0.25 ppm boron; with calcium at 500 ppm, the index increased consistently, and usually significantly, with increase in boron from 0.001 to 0.25 and to 10 ppm.

#### Nutrition -- Organism

See also 333

### SOIL FUNGICIDES

618. GROSSMAN, F. Untersuchungen über die innertherapeutische Wirkung organischer Fungizide. I. Thiocarbamate und Thiram. (Studies on the internal therapeutic effect of organic fungicides. I. Thiocarbamates and thiram.) Z. PflKrankh. 64: 718-728. 1957. (Rev. Appl. Mycol. 37: 449-450. 1958.)

Nine fungicides of the thiocarbamate-thiram group were examined, at University of Göttingen, for systemic fungicidal activity in Bonny Best tomato. The plants were raised in sand culture with Hoagland's medium, to which the fungicides, in solution or in suspension in acetone, were applied. Inoculation with Fusarium oxysporum f. (F. bulbigenum var.) lycopersici was secured by clipping the roots back and dipping in a homogenized culture suspension. Fusarium wilt was reduced by pre- but not post-infection treatments with compounds of the dimethyldithiocarbamate group, including thiram, which caused severe phytotoxic effects. By contrast the ethylenebisdithiocarbamates, causing at most minor phytotoxic effects, were ineffective.

#### Soil Fungicides -- Cereals

619. DE TEMPE, J. Aspecten van ontsmetting met Kwikhoudende middelen bij Zomergranen. (Aspects of mercurial seed dressing of spring-sown cereals.) Tijdschr. PlZiekt. 64: 150-162. 1958. (English summary) (Rev. Appl. Mycol. 37: 714. 1958.)

Studies were made on the action of mercurial seed dressings on spring wheat infected with Fusarium spp. and spring barley infected with Helminthosporium sativum. The effects of the treatments were usually but not always favorable. Thiram, which was tested later, gave far better increases in emergence. With disease-free seed the protective action of the Hg was normally outweighed by the injurious effects.

620. PORZHENKO, V. V. (New materials for the control of seed rotting and seedling loss of flax in Ukraine.) Trud. Ukr. nauk-issled. Flax Inst., Zashch. Rast. Kiev. 1956: 32-45. 1956. (Rev. Appl. Mycol. 37: 285. 1958.)

Various fungi are listed as causal agents of seed rotting and seedling loss in Ukraine. Granosan dust at 10 kg/ton seed proved very effective in control. Formalin was ineffective.

621. ROANE, C. W. and T. M. STARLING. Effects of a mercury fungicide and an insecticide on germination, stand, and yield of sound and damaged seed wheat. Phytopathology 48: 219-223. 1958.

In various experiments with seed wheat injured by a mercury fungicide the authors found that sound seeds germinated better and yielded more grain than either cracked or chipped seed. The fungicide Ceresan M proved to be severely phytotoxic to chipped seeds, slightly toxic to cracked seeds, and nontoxic to sound seeds. The application of the insecticide Pyrenone to seed wheat had no apparent effect on seed germination or yield of grain.

#### Soil Fungicides -- Cotton

See also 90

622. ASHOUR, W. A. Effect of sulphuric acid, fernasan and combined treatments on emergence of cotton seeds. Ann. agric. Sci., Cairo 2: 251-255. 1957. (Rev. Appl. Mycol. 37: 722. 1958.)

At the Ain Shams University 0.25 percent fernasan seed treatment and the same preceded by 4 min. in  $H_2SO_4$  significantly increased survival of Giza 30 fuzzy cotton, with averages of 222.56 and 190.67 plants compared with 157 for untreated and 127 for  $H_2SO_4$  alone. No such increase was obtained with the non-fuzzy Ashmouny.

623. BIRD, L. S., et al. Evaluation of fungicides mixed with the covering soil at planting as a control measure for the cotton-seedling-disease complex. *Plant Disease Repr.* 41: 165-173. 1957.

624. RANNEY, C. D. and L. S. BIRD. Influence of fungicides, calcium salts, growth regulators and antibiotics on cotton seedling disease when mixed with the covering soil. *Plant Disease Repr.* 42: 785-791. 1958.

Some of the fungicides, as well as other materials, were effective in controlling the disease. It was indicated that several of the fungicides do not give the same response over a relatively wide pH range. One combination of fungicides gave a uniform response over the range encountered in the tests.

625. RANNEY, C. D. and L. S. BIRD. In-the-furrow application of chemicals as a control for the cotton seedling disease complex. *Phytopathology (Abstr.)* 48: 345. 1958.

Fungicides and other chemicals mixed with the covering soil at the time of planting for controlling the cotton seedling disease complex were tested on sandy and clay soils in Texas in 1957. On a state-wide basis two materials were particularly effective: a mixture of 1 1/2 lb. 50 percent captan, 1 1/2 lb. 75 percent PCNB and 2 lb. 65 percent zineb per acre consistently gave a high stand at all locations. A 5-ppm solution of the potassium salt of gibberellic acid applied to the covering soil at 10.5 gal./acre was effective in increasing the stand at the .05 level.

626. SINCLAIR, J. B. et al. Field screening of various fungicides for control of cotton seedling damping-off. *Plant Disease Repr.* 42: 1372-1375. 1958.

Tests were conducted in 1957 and 1958 and results varied. In 1957 PCNB plus captan showed the most promise for controlling cotton seedling damping-off. In 1958 the following treatments were most effective: PCNB plus captan plus zineb; captan plus zineb; PCNB plus captan; PCNB plus dichlone; PCNB plus nabam; and calcium chloride plus nabam. Mylone tended to be phytotoxic in both 1957 and 1958 field tests.

627. SINCLAIR, J. B. Reaction of four *Rhizoctonia solani* isolates to certain chemicals. *Phytopathology (Abstr.)* 48: 398. 1958.

Certain chemicals determined by greenhouse assay to be effective against damping-off of cotton seedlings were placed in out-field tests in 1957. Significant differences in stand count were noted only in the field plot from which the culture of *R. solani* used in the greenhouse tests was originally isolated. Greenhouse studies to test disease control by two chemical combinations (captan plus PCNB and nabam plus PCNB) against four isolates of *R. solani* were then carried out. Highly significant differences in percentage of healthy seedlings were found between the four isolates within both chemical treatments.

#### Soil Fungicides -- Evaluation

628. BAINES, R. C. et al. Nematode and Phytophthora control by Vapam. *Citrus Leaves* 37: 6-8, 24, 32-33. 1957.

Vapam (sodium n-methyl dithiocarbamate) is water soluble and possesses both nematocidal and fungicidal properties. The citrus nematode (*Tylenchulus semipenetrans*) was effectively controlled when 272 to 475 lb. Vapam per acre was applied in 6-12 surface inches of water in basins. The low doses were effective on sandy loams and the high doses on loam soils. Brown rot fungi (*Phytophthora* spp.) were killed by 400 lb. Vapam per acre applied in 5-6 surface inches of water in basins on sandy loam soils. Neither citrus nematodes nor brown-rot fungi were controlled satisfactorily by injecting Vapam into soil followed by various methods of handling. For preplanting treatment of tree sites



it is recommended that Vapam be applied in basins 8 x 8 ft. or larger.

629. DOMSCH, KLAUS H. Die Prüfung von Bodenfungiciden. I. Pilz-Substrat-Fungicid-Kombinationen. (English summary) *Plant and Soil* 10: 114-131. 1958.

Principles for the assay of soil fungicides are interpreted from the inter-relationship of soil fungus-substratum-fungicide complex. From preliminary experiments it was concluded that (a) Spores are more sensitive than mycelium, (b) the age of the mycelium, within limits, has no substantial effect on sensitivity, (c) the type of substratum on which the fungus is introduced to the experiment has a considerable effect on fungicidal action. A comparison was made of six different assay procedures using three test fungi (*Pythium* sp., sp., *Rhizoctonia solani*, and *Fusarium culmorum*) and three fungicides (8-quinolin sulphate, captan and TMTD). Main results are discussed from the point of view of fungistatic and fungitoxic action. All assay methods that allow measurement of partial inhibition of fungal mycelium were found to gain significance.

630. DOMSCH, KLAUS H. Die Prüfung von Bodenfungiciden. II. Pilz-Boden-Wirt-Fungicid-Kombinationen. (English summary) *Plant and Soil* 10: 132-146. 1958.

Experimental conditions for the assay of soil fungicides are described in which crop plants serve as indicators of the degree of control. The suitability of various types of fungi and also the most appropriate time for a soil inoculation with *Pythium* sp. and *Rhizoctonia* sp. were determined. The method of application of the fungicide influenced the success of the control as well as the accuracy of the results. Captan, PCNB and an organic mercurial compound were used as representative fungicides.

631. DOMSCH, K. H. Die Wirkung von Bodenfungiziden. I Wirkstoffspektrum. (The action of soil fungicides. I Active material spectrum.) *Z. PflKrankh.* 65: 385-405. 1958. (English summary) (*Rev. Appl. Mycol.* 37: 758. 1958.)

At Kiel-Kitzeberg, Germany, 29 products were examined for their fungitoxic and fungistatic activity against *Pythium* sp., *Rhizoctonia solani*, and *Fusarium culmorum* by three different methods. Among the soil disinfectants chloropicrin, vapam, and methyl bromide were best while among the products harmless to growing plants captan, thiram, and zineb, each active against at least two of the pathogens, were best.

632. FAWCETT, C. H., D. M. SPENCER and R. L. WAIN. Investigations on fungicides. IV. (Aryloxythio) Trichloromethanes. *Ann. Appl. Biol.* 46: 651-661. 1958.

Twenty (aryloxythio) trichloromethanes were examined for *in vitro* fungicidal activity against six fungi. All compounds showed a direct fungistatic effect and some exhibited a marked fumigant action. When supplied to plants through their roots, eight conferred significant systemic fungicidal protection against *Alternaria solani* in tomato but there was no significant protection against *Botrytis fabae* in broad beans.

633. GONDO, M. and T. KUBO. (Effect of some fungicides on *Helicobasidium mompa* Tanaka in soil.) *Bull. Fac. Agric. Kagoshima Univ.* 6: 101-107. 1957. (English abstract) (*Rev. Appl. Mycol.* 37: 677. 1958.)

The effect of methoxyethyl mercuric chloride, phenyl mercuric urate, ethyl mercuric phosphate, and n-methyldithiocarbamate hydrate on *H. mompa* in different soils was investigated. The results indicated a decrease in fungicidal effect except in sand owing to adsorption by soil particles.

634. HAUKE-PAEWICZOWA, T. H. (Influence of the insecticide BHC on soil microflora.) *Roczniki Nauk Rolniczych Ser. A*, 76: 641-657. 1957. (Chem. Abstr. 52: 18991. 1958.)

Microbiological investigations of the soils of fields treated with BHC in the autumn of 1954 and spring of 1955 were made three times during the growing season. No effect of BHC was observed on the total number and qualitative composition of soil microflora. Only slight stimulation of *Azotobacter*

development was noted after the application of 25 g BHC/acre. A slight stimulation of nitrifiers and of Azotobacter development was noted after applications of BHC at 60 g/acre.

635. MEULI, LLOYD J. Fungicidal compositions containing 1,4-dibromo-2-butyne. (Chem. Abstr. 52: 17603. 1958.) (U.S. 2836536).

Fungicidal compositions containing  $\text{BrCH}_2\text{C}::\text{CCH}_2\text{Br}$  are effective against soil fungi. Test organisms used were Fusarium solani, Pythium spp., and Rhizoctonia solani.

636. MEULI, LLOYD J. Fungicidal soil treatment (to Dow Chemical Co.). (Chem. Abstr. 52: 20864. 1958.) (U.S. 2840501).

Alkali metal salts of mono- and dihalogen-substituted hydroxypropane-sulfonates are used in the fungicidal treatment of soil and growth media. Sandy loam soil samples heavily infested with Fusarium solani, Pythium spp., and Rhizoctonia were treated or untreated with compounds in various concentrations and seeded with lima beans. The compounds have the advantage that the soil can be treated and seed sown immediately. They may be used either as dusts or sprays.

637. MILLER, ROBERT E. Aryl (arylcyclohexyl) cyclohexanole as fungicides. (to Monsanto Chemical Co.) (Chem. Abstr. 52: 3246e. 1958.) (U.S. 2,809,998 Oct. 15, 1957).

A compound useful as a fungicide against Aspergillus niger and tomato wilt at 1:1000 dilution is prepared by condensing arylcyclohexanols in the presence of  $\text{K}_3\text{PO}_4$  and a Cu chromite-Ni catalyst. The aryl group is preferably a phenyl group substituted on the 2, 3, 4 or 5 position; a  $\text{CH}_2$  group must be connected to the carbonyl C group.

638. MUNNECKE, DONALD E. Biological assay of nonvolatile diffusible fungicides in soil. Phytopathology 48: 61-63. 1958.

Plugs of soil treated with a nonvolatile diffusible fungicide are placed upon potato dextrose agar media seeded previously with spores of Myrothecium verucaria. After 48 hrs. the clear zones of inhibition surrounding the soil plugs are measured. The zones provide a quantitative index of the concentration of the fungicides. The technique is reproducible and dependable. The standard error of individual measurements varies with the concentration and type of fungicides used.

639. MUNNECKE, DONALD E. and R. A. SOLBERG. Inactivation of Semesan in soil by fungi. Phytopathology (Abstr.) 48: 396. 1958.

Semesan applied as an aqueous suspension to soil in cotton-stoppered flasks is inactive after 2-3 weeks in nonsterile soil but still active after 2 months in steamed soil. The inactivation is biological rather than chemical. Fungi and bacteria increased in Semesan-treated soil as the fungicidal activity decreased. Several isolates of Penicillium, Aspergillus, and Trichoderma proved to be tolerant of Semesan in agar. Inactivation of the fungicide in soils inoculated with these fungi was studied.

640. STANĚK, MILOSLAV. (The action of hexachlorocyclohexane upon soil microflora.) (In Czech.) Sbornik Českoslov. Akad. Zeměděl. věd, Rostlinná výroba 31: 375-394. 1958. (Chem. Abstr. 52: 18990. 1958.)

Preparations with hexachlorocyclohexane (I) were found to stimulate, at low doses, the growth of a few of the soil microorganisms but all are inhibited if the doses of I are higher. They are only rarely killed off completely. Curves of the action of I were not always reproducible. The action of I is quite prolonged in the soil but varied according to external conditions. The doses of I used ordinarily for insecticidal purposes in tropical applications would not ordinarily introduce into the soil enough I to cause damage.

641. STARK, C. Zur phytotoxischen Wirksamkeit des Chloropikrin. (Phytotoxic effect of chloropicrin.) Nachrbl. Deut. Pflanzenschd. 10(2): 23-25. 1958. (Tobacco Abstr.

2: 323. 1958.)

A general summary of the effect of chloropicrin on various types of plants. In Nicotiana tabacum var. Samsoun younger plants were much more sensitive than older plants.

642. TAKEUCHI, H. and H. IDE. Studies on the soil fungicides. I. Fungicidal action of the organic mercury compounds in the soil. Ann. Phytopath. Soc. Japan 22: 4-5; 197-200. 1957. (Japanese. Abs. from English summary) (Rev. Appl. Mycol. 37: 758. 1958.)

Four organic Hg compounds were assayed against Ophiobolus sativus as soil-fungicide mixtures and the soil and filtrate were assayed again after washing. The results suggested that methyl mercury iodide combined with soil without losing fungicidal activity. Ethyl mercury phosphate was fairly fungicidal initially but lost its activity after washing.

643. TIMS, EUGENE C. Treatment of pink-root-infested soil with Vapam and Mylone. Phytopathology (Abstr.) 48: 398. 1958.

Soil from two sources heavily infested with the pink root fungus Pyrenochaeta terrestris, as well as soil or sand artificially inoculated with the fungus, was used in greenhouse tests. Vapam and Mylone were used at different rates. Vapam gave almost complete control of the disease in naturally infested soil at all the rates used. Mylone gave good control at the heavier rates but at the lower rates there was some pink root development.

644. TOPPS, J. H. and R. L. WAIN. Investigations on fungicides. III. Fungitoxicity of 3- and 5- alkyl-salicylanilides and para-chloroanilides. Ann. Appl. Biol. 45: 506-511. 1957. (Chem. Abstr. 52: 4091. 1958.)

At a concentration of 4 ppm the compounds had little effect on the mycelial growth of Pythium ultimum, Verticillium albo-atrum, Alternaria solani, Aspergillus niger, and Botrytis cinerea, but they were active against Monilia fructigena. The chloroanilides usually induced less retardation than the corresponding anilides. Salicylanilide gave the greatest over-all inhibition of the fungi.

645. BAYER 22555. Chemagro Corporation, New York. Agr. Chem. 14: 41. 1959.

An experimental soil fungicide and seed treatment. Chemically P-di-methylamino benzenediazo sodium sulfate. Reported to exhibit special merit as a seed treatment chemical on sugar beets, peas and beans. Also effective for some uses as a soil fungicide.

646. NEW SOIL FUMIGANT FOR SEED BEDS. Tobacco U.S.A. 145: 18-19. 1957. (Coresta No. 1: 1182. 1958.)

A report of Crag Mylone as a new soil fumigant sold as a wettable powder (85percent). It may be used dry or in water solution (drench or spray) at the rate of 30 g/m<sup>2</sup>. Treatment of seedbed soil must be in autumn when soil is still warm and may be left uncovered and sown not less than 1 1/2 months after treatment. The product controls weeds, cryptogams, and nematodes.

#### Soil Fungicides -- Forage Crops

647. DAVIDE, ROMULO G. Effects of several fungicides for seed treatment of corn. Philippine Agriculturist 41: 295-305. 1957. (Chem. Abstr. 52: 17593. 1958.)

Phytomycin and Panogen as liquids and Arasan, Granosan, Phygon, PCNB, Gy-cop (a Cu fungicide) and dieldrin as dusts when used as seed treatments of corn seed gave increased yields of yellow flint and white flint corn. Arasan gave the highest yields. No phytotoxic effects were observed on the seedlings.

648. LEONT'EVA, MME. Y. A. and B. S. GERASIMOV. (Timing of treatment of maize grain with mixture of granosan with hexachlorane and mercuran.) Izv. Kuybysh. s.-kh. Inst. 12, pp. 73-79. 1957. (Rev. Appl. Mycol. 37: 473. 1958.)

Treatment of maize grain with mercuran or a mixture of granosan and hex-



achlorane immediately before sowing reduced root rot caused by Diplodia.

649. NEMLIENKO, F. E. (Control of maize diseases during the pre-sowing and sowing periods.) *Zasch. Rast. (Plant Prot., Moscow)* 1957, 2, pp. 32-35. 1957. (Rev. Appl. Mycol. 37: 280. 1958.)

The damage by fungi to stored maize is reviewed. Granosan proved the best seed treatment with mercurane next. The latter gave much better results with seed sown in black soil. In dry brown humus soil 1 kg/ton granosan and 1.5 kg/ton mercurane are effective but in black and podsolized soils 1.5 kg and 2 kg respectively were better.

#### Soil Fungicides -- Fruit

650. KLOTZ, L. J., PO-PING WONG and T. A. DeWOLFE. Damping-off of sweet orange seedlings by Rhizoctonia solani controlled with biphenyl. *Plant Disease Repr.* 42: 464-466. 1958.

The authors found that biphenyl vapors control damping-off of citrus caused by Rhizoctonia solani but is not useful where other organisms are involved.

#### Soil Fungicides - Laboratory Tests

651. ENDE, G. v. d. and K. VERHOEFF. (Willie Commelin Scholten, Baarn, Neth.) Action of copper compounds on fungus growth in vitro. *Tidjdschr. Plantenziekten* 63:200-208. 1957. (German summary).

Various fungi growing in potato agar and Czapek-Dox agar containing 0.1 to 2.0 percent  $\text{CuCO}_3$  (I) or Cu oxychloride (II) produced acidic metabolic products which converted the Cu compounds to a colorless insoluble crystalline substance. Fusarium oxysporum grew well in all concentrations of I and II but Cercospora beticola grew well only in media containing 0.1 and 0.3 Cu.

652. WELVAERT, W. and R. VELDEMAN. Invloed van chemische grondontsmettings- middelen op de grondschemmelflora. (Influence of chemical soil disinfectants on the soil fungus flora.) *Meded. LandbHogeschool, Gent*, 22: 499-504. 1957. (English summary) (Rev. Appl. Mycol. 37: 757. 1958.)

Tests of normal garden soil were made before and three days after treatment with six commercial products used as soil disinfectants against fungi by plating samples on a mineral salts-peptone-dextrose agar plus rose bengal. The chemicals used varied in effectiveness but practically complete elimination of fungi was obtained with chloropicrin, formalin, and chlorobromopropene.

#### Soil Fungicides -- Ornamentals

653. ANZALONE, L. Jr., and A. G. PLAKIDAS. Control of flower blight of camellias in Louisiana with fungicides. *Plant Disease Repr.* 42: 804-806. 1958.

Two soil drenches, each of 300 lb/acre, of Terraclor on plots artificially infested with sclerotia of Sclerotinia camelliae from camellia completely inhibited the development of apothecia.

654. BEAUMONT, A., J. P. CLEARY and J. H. BANT. Control of damping-off of zinnias caused by Alternaria zinniae. *Plant Path.* 7: 53-54. 1958.

In seed treatment tests dry treatments showed marked superiority over the wet. Hot water treatment at 125°F for 25 minutes reduced the germination by 14 percent in the variety Polar and by 26 percent in Grenadier. In general, thiram dust treatment gave satisfactory control and was regarded as the most convenient and safest treatment.

655. CIFFERRI, R. and A. CORTE. In proceedings of the second Convention on non-copper fungicides, Turin, 17 November 1956.) *Notiz. Malatt. Piante*, 1957, 40-41, pp. 1-211. 1957. (Rev. Appl. Mycol. 37: 16-18. 1958.)

Good control of Fusarium yellows (F. orthoceras (F. oxysporum) f. gladioli) was given by soil fumigation with Vapam at 240-480 kg/ha.

656. DE BOER, S. Ziekten by clematis en rododendron veroorzaakt door schimmels uit de bodem. (Soil-borne fungus diseases of clematis and rhododendron.) Tijdschr. PlZiekt. 64: 120-121. 1958. (Hort. Abstr. 28: 462. 1958.)

Soil treatment with TMTD and zineb has shown some reduction in infection of clematis by Phytophthora spp. Present recommendations for Phytophthora control on clematis and rhododendron are the destruction of infected plants and soil sterilization with formalin.

657. OLSEN, C. M. and M. M. AFANASIEV. Root rot of sweet peas. Proc. Mont. Acad. Sci. 16: 37-38. 1956. (Rev. Appl. Mycol. 37: 239. 1958.)

A root rot of sweet peas has become prevalent in Bozeman, Montana. The plants grow normally at first, but when in bloom yellowing occurs, followed by necrosis of the vascular tissues and complete drying up of the plant. In 12 plots pre-planting applications of CBP (chlorobromopropene) at 1.5 ml/hole spaced 1 ft. apart, and Vapam 4-S at 1520 ml/100 sq. ft., diluted in water and sprinkled on top of the soil, both followed by a water seal, gave 70.1 and 72.7 percent healthy plants respectively, compared with 58.9 percent and 39.8 percent in the untreated plots. All the 22 isolates from diseased plants proved to be Fusarium spp.

658. PETERSEN, L. J. and RALPH BAKER. Dips and drenches for the control of Fusarium stem rot of carnations. Phytopathology (Abstr.) 48: 397. 1958.

Carnation cuttings infested with Fusarium roseum f. cerealis were dipped 10 minutes in various solutions and suspensions of fungicides in attempts to eradicate this inoculum from cuttings. Results indicated that Panodrench 4 (3.0 ppm cyano (methylmercuri guanidine)), Panogen experimental material No. 13849 (3.0 ppm active ingredient) and ferbam (1000 ppm ferric dimethyl-dithiocarbamate) were effective in control.

659. STESSEL, G. J. Botrytis control in stored rose stocks. Plant Disease Repr. 42: 396-398. 1958.

Laboratory and storage experiments to evaluate various chemicals for effectiveness in controlling gray mould of dormant rose bushes in cold storage caused by Botrytis sp. Of the non-volatile chemicals tested in the laboratory Captan 50W produced greatest inhibition of Botrytis growth in culture; of the volatile chemicals biphenyl was most effective. The most effective dip treatments were Dovicide A and Mycostatin. The volatile chemicals and Terraclor and captan dust were also effective.

#### Soil Fungicides -- Special Crops

See also 91

660. CLEARY, J. P. Control of cobweb disease of mushrooms. Plant Path. 7: 74-75. 1958.

Dusting of beds with PCNB was effective in reducing damage from the cobweb disease caused by Dactylium dendroides. PCNB was applied twice at the rate of 1 lb. 20 percent PCNB per 1000 sq. ft. without injury to the mushrooms. If the dust was mixed with the casing material (peat-chalk mixture) mushroom production was almost entirely suppressed.

661. GOODMAN, R. N. The effect of pentachloronitrobenzene (PCNB) on mushroom production. Plant Disease Repr. 42: 444-446. 1958.

It was found that PCNB applied at 250 ppm or higher to mushroom beds 24 hrs. after casing delayed and curtailed production. When the material was applied after harvest of the first break, concentrations as high as 1000 ppm did not affect yield adversely.

662. GOSS, ROBERT C. Studies on the control of Verticillium wilt of peppermint with CBP-55. Plant Disease Repr. 42: 177-179. 1958.

Satisfactory commercial control of Verticillium wilt of peppermint was obtained, as evidenced by the total plot areas free from infection. In the non-treated plots 61.4 percent of the area was estimated to be free from infection, while 75.1, 79.1, and 85.4 percent of the 40-, 80-, and 120-gallon per acre

plots, respectively, were free from infection.

663. HARRISON, A. L. and G. M. WATKINS. Terraclor for the control of southern blight of peanuts. *Phytopathology* (Abstr.) 48: 343. 1958.  
Applications of Terraclor (75 percent pentachloronitrobenzene) as a spray to the crown of Spanish peanuts with each cultivation, for the control of southern blight (*Sclerotium rolfsii*), gave significant increases in yield of nuts at the 1 percent level in 1956 and 1957. Zineb and captan applied in the same manner were ineffective. Terraclor gave some indication that it may reduce southern blight when mixed in the soil before planting.
664. STEFANOV, D. and VYLCHEV, S. Massnahmen zur Bekämpfung der Pilz- und Bakterienkrankheiten bei Tabaksetzlingen. (Control measures for fungous and bacterial tobacco seedling diseases.) *Bulgar Tiutun* 3: 12-15. (Bulgarian.) (Tobacco Abstr. 2: 567. 1958.)
665. TOMLINSON, J. A. Crook root of watercress: The control of the disease by zinc-fritted glass and the mechanism of its action. *Ann. Appl. Biol.* 46: 608-621. 1958.  
Zinc, used as zinc sulphate at 0.5 ppm, was found to inhibit the growth of *Spongospora subterranea* (Wallr.) Lagerh. f. sp. *nasturtii* Tomlinson, the cause of crook-root disease of watercress. A relatively insoluble finely powdered glass frit containing zinc oxide (zinc frit) largely prevented infection by this fungus when added, at 0.2g/350 ml, to water in which watercress was growing.
666. TOMLINSON, J. A. Crook root of watercress. I. Field assessment of the disease and the role of calcium bicarbonate. *Ann. Appl. Biol.* 46: 593-607. 1958.  
The discovery, occurrence, and symptoms of the disease caused by *Spongospora subterranea* (Wallr.) Lagerh. f. sp. *nasturtii* Tomlinson are described. Water from certain natural sources contained a factor which inhibited crook root and which was shown to be calcium bicarbonate. In laboratory tests, increasing concentrations of calcium bicarbonate from 62 to 540 ppm gave an increasing degree of control of the disease. The same effect was shown in a small field test.

#### Soil Fungicides -- Technique

667. GASIORKIEWICZ, E. C. Bioassay test for the detection of pentachloronitrobenzene. *Phytopathology* (Abstr.) 48: 261. 1958.  
In phytocidal and fungicidal tests with PCNB inhibition of the common wood sorrel (*Oxalis repens* Thunb.) was noted. *O. repens* was found to be a diagnostic bioassay test plant for determining the persistence of PCNB in treated soils.
668. JOHNSON, F. R. and A. M. HILLIS. A fluorescent mineral tracer technique to determine fungicide placement in the soil profile. *Plant Disease Repr.* 42: 287. 1958.  
A synthetic fluorescent mineral, zinc orthosilicate, was found to be a good tracer to use in evaluation of equipment for proper application of fungicides in soil treatment. Cross-sections of the treated soil profiles were compared for proper location of the fungicide and on the basis of these comparisons it was found possible to make recommendations.
669. LINDEN, G. and P. SCHICKE. Untersuchungen über die fungizide und herbizide Wirkungen von Vapam im Boden und Berücksichtigung von Eindringtiefe, Adsorption und Karenzeit. (Studies on the fungicidal and herbicidal action of Vapam in the soil in respect to depth of penetration, adsorption and waiting time.) *Meded. LandbHogesch. Gent*, 22: 399-418. 1957. (English summary.) (*Rev. Appl. Mycol.* 37: 703. 1958.)  
Vapam was applied at 100 ml/sq. m. by drenching, mixing in, and injection into soil contained in glass cylinders inoculated with various soil organisms. Drenches are limited to the upper layers of soil, not penetrating below 20 cm even when the soil is dry. Lettuce is particularly susceptible to Vapam and could be used as an indicator of Vapam residues.



670. LINDSTRÖM, OLLE. Mechanism of liquid seed treatment. Vapor action and adhesion, radioactive studies of initial liquid distribution and investigations with radioactive Panogen formulations. J. Agr. Food Chem. 6: 283-298. 1958.

The mechanism of liquid seed treatment using Panogen was studied by physical and chemical methods. The processes were studied by means of volatile and non-volatile tracers and the distribution was characterized by statistical methods. Panogen mercurials penetrate the fruit coat rapidly but diffusion stops at the endosperm. Liquid seed treatment may be improved further by reduction of the liquid volume.

671. MUNNECKE, DONALD E. The persistence of nonvolatile diffusible fungicides in soil. Phytopathology 48: 581-585. 1958.

Solutions or suspensions of four nonvolatile, diffusible fungicides were added to flasks containing sterilized or untreated mixtures of peat moss and sand plus fertilizers. Samples of the soil were bioassayed for diffusible fungicidal activity at intervals up to 150 days after the fungicides were applied. Under the conditions provided captan was very stable. Semesan was rapidly inactivated biologically and nabam and ferbam were inactivated nonbiologically. Semesan also declined nonbiologically, a slow-acting factor being operative in the absence of microorganisms.

672. NEWHALL, A. G. An improved method of screening potential soil fungicides against *Fusarium oxysporum* f. *cubense*. Plant Disease Repr. 42: 677-679. 1958.

The fungicidal capacity of different chemicals was tested by percolation through a column of soil in which discs of the fungus were placed at different depths and later removed for viability tests. Many of the usually effective fungicides were found to be rendered ineffective on their way through soil. Of 36 materials tested four were found to have unusual capacity to penetrate and kill *F. oxysporum* f. *cubense* at depths down to 7 inches at dilution of 200 ppm.

673. RANNEY, C. D. and A. M. HILLIS. A study of the distribution of in-the-furrow applied fungicides. Phytopathology (Abstr.) 48: 345. 1958.

A study was conducted of the distribution of fungicides applied at planting to the seed furrow as dusts and sprays. A fluorescent indicator was used to determine the placement and degree of dispersion of the fungicide in the furrow and covering soil. Various distribution patterns were obtained and the study indicated the necessity of using an opening device that produces a seed furrow with a narrow bottom. Results indicate that a surface coverage of a fungicidal material may reduce postemergence losses.

#### Soil Fungicides -- Trees

674. HODGES, C. S. Jr. Black root rot (cause unknown). Proc. Assoc. Southern Agr. Workers, 54th Annual Convention, Birmingham, Alabama, Feb. 1957. (Plant Disease Repr. Suppl. 251: 71. 1958.)

A summer survey was conducted in 1956 covering 16 pine nurseries in six southern states to determine the prevalence of black root rot. The disease was found in four of the 16 nurseries. Its cause is not known. Fumigation with methyl bromide at several nurseries not only controlled root rot but increased the size and vigor of the seedlings as well. Vapam also gave good control in test treatments.

675. MILLER, H. N. Annual Report of the Agr. Exp. Sta. Florida for the year ending June 30, 1957, 397 pp.

Of the soil fungicides tested in nursery plots the most effective against *Pythium* root rot of Chinese evergreen (*Aglaonema modestum*) was Vapam at 109 gal/acre, while Crag Mylone (300 lb.) gave the best control of *Rhizoctonia* root rot of *Philodendron*.

676. VOLGER, C. Probleme der Bekämpfung von pilzparasitären Keimlingskrankheiten bei Nadelbäumen. (Problems in the control of parasitic fungal seedling diseases of conifers.) Meded. LandbHoges. Gent, 22: 517-525. 1957. (English summary.) (Rev.

Appl. Mycol. 37: 743. 1958.)

Of 15 preparations tested at Göttingen University, Germany, only thiram seed dressing effectively protected pine seedlings raised in soil from a seed bed infected with spp. of Rhizoctonia, Fusarium, and Botrytis and inoculated with Pythium debaryanum. It appeared to have a systemic action.

#### Soil Fungicides -- Turf

677. ZUMMO, NATALE and A. G. PLAKIDAS. Brown patch of St. Augustine grass. Plant Disease Repr. 42: 1141-1147. 1958.

The authors report a study of the cause and control of brown patch of St. Augustine grass. Evidence is presented that the disease is caused by Rhizoctonia solani Kuehn. Of various fungicides tested for control of the disease Terraclor gave perfect control in every test at all rates ranging from 20 g to 136 g per 100 sq. ft. At the higher rate it was phytotoxic. Puratized 177 and Puratized Agricultural Spray also gave promising but variable results. All the other fungicides were ineffective at the rates tested.

#### Soil Fungicides -- Vegetables

See also 14, 314

678. ASHOUR, W. A. and M. M. EL-KADI. (Damping-off disease of tomato seeds and its control.) Ann. Agr. Sci. Cairo 1: 111-126. 1956.
679. BARTZ, J. F. and K. C. BERGER. Urea-formaldehyde concentrate-85, a promising control for potato scab. J. Agr. Food Chem. 6: 675-677. 1958.
- Urea-formaldehyde concentrate-85 (UF-85) when applied broadcast at a rate of 150 gal. per acre, was effective for controlling common scab (Streptomyces scabies) on the Irish Cobbler variety in 1956 and the Chippewa variety in 1957. Stands were reduced by 42 percent when potatoes were planted immediately after the UF-85 had been applied broadcast at a rate of 250 gal. per acre, while rates of 50 and 150 gal. had no effect on stand. At a rate of 150 gal. per acre, UF-85 reduced the scab index from 14.5 in the check to 0.8 in 1956 and in 1957 this rate reduced the scab from 22.0 to 1.5. Pentachloronitrobenzene was also tested. Scab incidence with the 50-gal. rate of PCNB was higher than with the previously mentioned treatment.
680. BLANCO, LEOFIN C. Comparative effects of Arasan, Granosan and Semesan dust treatments on vegetable seeds as a control for damping-off. Araneta J. Agr. 4: 57-64. 1957. (Chem. Abstr. 52: 4915. 1958.)

Under field conditions Arasan, Granosan and Semesan were effective protectants for cabbage, cauliflower and mustard; Arasan and Semesan for radish; and only Arasan for lettuce.

681. BROOK, M. and C. G. C. CHESTERS. The use of tetrachloronitrobenzene isomers on lettuce. Ann. Appl. Biol. 46: 159-166. 1958.

Field experiments were carried out on winter lettuce grown in boxes under glass and in the open, and on commercial crops in unheated greenhouses. Each of the three isomers of tetrachloronitrobenzene, applied as 5 percent dusts at 1/4 and 1/2 oz. per sq. yd. of bed, gave significant protection against Botrytis, but the 2:3:4:5 isomer was inferior to the other two, and they all delayed the hearting of the crop.

682. BURGIS, D. S. and A. J. OVERMAN. Chemicals which act as combination herbicides, nematocides and soil fungicides. I. Effect on field-seeded tomatoes. Proc. Fla. hort. Soc. 70: 137-139. 1958. (Rev. Appl. Mycol. 37: 681. 1958.)

In an experiment at the Gulf Coast Experiment Station, Bradenton, with fumigants applied before planting to spring tomato beds, Pellicularia (Sclerotium) rolfsii appeared in the field late in the season. Untreated plots suffered a 40 percent loss of plants while those given DD and AA (allyl alcohol) or ethylene dibromide had only 11 percent and 16 percent loss, respectively. Popula-

tion studies of Trichoderma and Fusarium in treated soils indicated that Vapam-4S, Crag Mylone 40 WP, AA plus DD, and drenches of AA or V-C13 were all effective fungicides. In spring Vapam, Crag Mylone, and AA, alone and mixed with EDB or DD, reduced the numbers of colonies of Fusarium for at least 61 days; EDB alone also reduced the fungal populations. The mixtures appeared to increase the fungicidal ability of AA. Invariably, the soil treatments which proved to be the best herbicide-nematocide-fungicides produced the greatest yields.

683. BUSCH, L. V. Silver scurf on muck potatoes. *Plant Disease Reptr.* 42: 441-443. 1958.  
In laboratory assays of 21 fungicides for toxicity to the potato silver scurf organism, Helminthosporium atrovirens, only five proved satisfactory, namely, Puraseed, Semesan Bel, Karathane, Terraclor, and Manzate. The possible value of seed-piece treatment in controlling the disease is discussed.
684. CETAS, R. C. The use of sodium methyl dithiocarbamate for the control of clubroot of crucifers. *Plant Disease Reptr.* 42: 324-328. 1958.  
Sodium methyl dithiocarbamate (31 percent) applied either as a drench, by broadcasting, or by seed treatment resulted in good control of clubroot of crucifers as well as satisfactory control of weeds.
685. CHAMBERS, S. C. Control of target spot, Alternaria solani Ell. & Mart., on potatoes. *J. Dept. Agr. Vict.* 55: 110-114. 1957.  
Target spot was controlled most effectively by the application of maneb or zineb (2 lb. per 100 gal. per acre) as soon as the disease appeared on the crop, followed by treatments every 7-14 days for a further 4-6 weeks. Yields were increased by the treatments.
686. DEKKER, J., O. M. VAN ANDEL and A. KAARS SIJPESTEIJN, Internal seed disinfection with pyridine-2-thiol-N-oxide and a derivative. *Nature* 181: 1017. 1958. (Chem. Abstr. 52: 17595. 1958.)  
2-Pyridinethiol N-oxide (I) and (2-pyridyl N-oxide) isothioureia-HBR (II) proved to be fungicidal agents for pea and bean seeds infected with Ascochyta pisi and Colletotrichum lindemuthianum. Though volatility of I facilitated penetration into seeds; II is not volatile and may give rise to I under physiological conditions.
687. FINK, HARRY C. Potato seed-piece treatments. *Phytopathology (Abstr.)* 48: 261. 1958.  
Results from 3 years' experiments with potato seed-piece treatments indicated that combinations of fungicides and streptomycin sulfate may result in stands and yields significantly lower than those obtained when no treatments were used. Inclusion of a third pesticide in the combination may add to or negate the ill effects. In all eleven fungicides were tested alone or in combination with streptomycin sulfate or with dieldrin and streptomycin sulfate.
688. LOPEZ, M. A. Efectividad de varios fungicidas en la represión del "damping-off" y de la pudrición de semillas de frijol (Phaseolus vulgaris L.). (Effectiveness of various fungicides in the control of damping-off and seed decay in beans (Phaseolus vulgaris L.)) *Acta agron. Palmira* 7: 141-163. 1957. (English summary.) (*Rev. Appl. Mycol.* 37: 692. 1958.)  
A review of recent literature dealing with seed treatment to control damping-off with special reference to bean seeds. Sclerotium sp., Fusarium sp., and Rhizoctonia sp. were found to be the most prevalent fungi associated with this in the Cauca Valley (Colombia) and agrox, ortho seed guard and orthocide 75 (all at 2 oz. per 100 lb. seed) gave significantly better stands than the controls or six other chemicals tested.
689. MENZIES, J. D. Dosage rates and application methods with PCNB for control of potato scab and Rhizoctonia. *Am. Potato J.* 34: 219-226. 1957.



Potato scab (Streptomyces scabies) was controlled in an irrigated sandy loam by application of pentachloronitrobenzene at 50 lb. per acre broadcast before planting and mixed by disking or rotary tillage. Mixing of the chemical in the top 2 in. of soil proved ineffective even at 80 lb. of the chemical per acre. The stem-canker stage of Rhizoctonia was controlled with 10-20 lb. per acre and the tuber sclerotia stage was controlled with 40-50 lb. per acre.

690. NATTI, J. J. et al. Value of insecticide-fungicide combination treatments as protectants for seed of cucumber and winter squash. *Plant Disease Reptr.* 42: 127-133. 1958.

Insecticide-fungicide combination treatments (captan and thiram, each at two dosage rates combined with dieldrin, heptachlor, and lindane), regardless of dosage of the pesticides, gave better total stands, in most instances, than treatments with fungicides alone.

691. OVERMAN, A. J. and D. S. BURGIS. Chemicals which act as combination herbicides, nematocides and soil fungicides. II. Effect on soil microorganisms. *Proc. Fla. hort. Soc.* 70: 139-143. 1958. (*Rev. Appl. Mycol.* 37: 681. 1958.)  
See abstract No. 682.

692. POTTER, H. S., C. K. CLONINGER and A. DROST. Foliar and soil applications of chemicals for the control of pink rot of celery. *Quart. Bull. Mich. Agr. Exp. Sta.* 40: 734-739. 1958. (*Rev. Appl. Mycol.* 37: 693. 1958.)

Four organic fungicides were applied to the soil in 11 different combinations before planting the variety Utah 16 to control Sclerotinia sclerotiorum. Best results were obtained with dust applications of 20 percent Terraclor at 75 lb./acre (7.5 percent infection) or two sprays of 75 percent wettable powder at 20 lb./150 gal./acre (3.5 percent).

693. WATKINS, G. M., H. C. MOHR and P. A. YOUNG. Control of southern blight in tomatoes in northeast Texas. *Phytopathology (Abstr.)* 48: 346. 1958.

At a site in northeast Texas various degrees of control of southern blight (Sclerotium rolfsii Sacc.) resulted in 1957 from applications of PCNB, Vapam, calcium nitrate, or mixtures of PCNB with captan. Materials were tested both in dry and wet form.

694. WILHELM, STEPHEN, L. C. BENSON, and J. E. SAGEN. Studies on the control of broomrape on tomatoes. Soil fumigation by methyl bromide is a promising control. *Plant Disease Reptr.* 42: 645-651. 1958.

Satisfactory control of Orobanche ramosa L. was obtained by the use of methyl bromide applied either by a mechanical circulator under polyethylene tarpaulins or by a tractor and chiselled into the soil and followed immediately by tarping.

695. YOUNG, ROY A. and W. J. TOLMSOFF. Current season and residual effects of Vapam soil treatments for control of Verticillium wilt of potatoes. *Plant Disease Reptr.* 42: 437-440. 1958.

Over a period of 3 years Vapam at rates of 160 or more pounds per acre was effective in controlling Verticillium wilt of potatoes. When Vapam was blade-injected into the soil 6 inches deep at rates of 160, 165, or 190 pounds per acre increases of more than 5 tons per acre resulted. Yields from soil treated during the previous year with 190 or 165 pounds of Vapam per acre were approximately 50 sacks per acre greater than yields from the untreated check plots.

696. ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATIONS FLORIDA FOR THE YEAR ENDING JUNE 30, 1957. 397 pp. (*Rev. Appl. Mycol.* 37: 699-702. 1958.)

W. D. Moore and R. A. Elliston found that Vapam, pentachloronitrobenzene, and a combination of 36 percent PCNB plus 25 percent captan significantly reduced post-emergence damping-off of beans (Phaseolus vulgaris) due to

Pythium, and stem lesions caused by Rhizoctonia and Pythium. Surface applications of the PCNB-captan combination after sowing greatly increased stands of capsicum. In experiments by R. O. Magie a thimerosal dip controlled Fusarium oxysporum f. gladioli and Curvularia trifolii on gladiolus corms.

#### SOIL INSECTS AND FUNGI

697. DICKASON, E. A., C. M. LEACH, and A. E. GROSS. Control of the clover root curculio on alsike clover. J. Econ. Ent. 51: 554-555. 1958.

In Oregon, the clover root curculio, Sitona hispidula (Fabr.), is believed to be a major cause of decline in alsike clover seed yields because of reduction in plant vigor and stand and possibly increased fungus root-rot injury associated with the insect injury. Emulsifiable concentrate heptachlor, at 4 lb. actual toxicant per acre, was applied in the spring. Oats were sown and the stubble was seeded in late autumn with alsike. In the two following seasons injury to alsike roots by the insect was greatly reduced. There were no marked differences between treated and untreated plots in the incidence or severity of root rots of 2-year-old plants.

698. KIRKPATRICK, R. A. and G. M. DUNN. Observations on insects and fungi associated with taproot survival of white clover in New Hampshire. Plant Disease Repr. 42: 819-820. 1958.

Trifolium repens L. seeded in the spring of 1956 had a few roots diseased by Fusarium oxysporum (Schlecht.) in the fall. A heavy attack by clover root curculio larvae, Sitona spp., occurred in the spring of 1957. Thereafter root rot developed rapidly, mainly due to F. oxysporum. Study of the relationship of curculio larvae to the root rot complex and the persistence of white clover is being continued.

699. TARR, S. A. J. Experiments in the Sudan Gezira on control of wilt of Dolichos bean (Dolichos lablab) associated with attack by cockchafer grubs (Schizonycha sp.). Ann. Appl. Biol. 46: 630-638. 1958.

Wilt of the dolichos bean appeared to be due primarily to cockchafer grubs attacking the hypocotyls or roots of plants for as long as 6 weeks after sowing. Many wilted plants also showed symptoms of ashy stem blight (Macrophomina phaseoli), which probably was a secondary invader that rotted roots weakened or damaged by unfavourable soil conditions or cockchafer grubs. A powdered seed dressing containing 1 percent mercury and 20 percent dieldrin was recommended for control.

#### TOXINS AND OTHER SUBSTANCES OF BIOTIC ORIGIN

##### Microbial Origin -- Affecting Plants

700. BRIAN, P. W. The role of toxins in plant disease. Outlook on Agriculture 2 (1): 27-32. 1958.

Examples were discussed to indicate the kind of evidence available and to illustrate the fact that the evidence of intervention by toxins is fairly conclusive in some diseases, though less convincing in others. It seems probable that it shall be found that toxins do play a part in producing disease symptoms, but only a part, other mechanisms of importance also being involved. Many bacterial and fungal pathogens release pectin-degrading enzymes in plants, causing soft-rot. Pectic enzymes may also be concerned with symptom development of wilt diseases and may also have a direct toxic action on plant cells. Therefore, development of enzyme inhibitors may alleviate many plant diseases. However, a search for either fungicides or fungistatic agents may be more rewarding than a search for toxin antidotes.

701. CURTIS, R. W. Curvatures and malformations in bean plants caused by culture filtrate

of *Aspergillus niger*. *Plant Physiol.* 33: 17-22. 1958.

When the growing point of a bean plant is treated with the culture filtrate of a fungus identified as *A. niger* marked curvatures and malformations are produced on the developing shoot.

702. KRASIL'NIKOV, N. A. (Microbial antagonists and antibiotic substances as factors in increasing plant resistance to infection.) *Bull Acad. Sci. U.S.S.R., Ser. Biol.* 23: 170-182. 1958. (Rev. Appl. Mycol. 37: 574. 1958.)

It was demonstrated that micro-organisms may produce antibiotics at a high rate in soil containing organic matter. Antibiotics absorbed by plants increased their resistance to infection.

703. KRUPKA, L. Increased ascorbic oxidase activity induced by the fungal toxin, victorin. *Science* 128: 477-478. 1958.

Victorin, the toxin produced by *Helminthosporium victoriae*, caused three- to five-fold increases in respiration of oat tissues of susceptible oat varieties and failed to produce any appreciable effect on resistant varieties. The activity of the ascorbic oxidase system was also found to be four times as high in the susceptible varieties. This increase was produced by the victorin, and no effect on the ascorbic oxidase activity was noted in resistant varieties exposed to the victorin toxin.

704. LAKSHMANAN, M. and C. S. VENKATA RAM. Influence of *Fusarium* culture filtrates on respiratory changes in cotton. *Proc. Indian Acad. Sci. Sect. B.* 46: 131-137. 1957. (Biol. Abstr. 32: entry 35210. 1958.)

Culture filtrates of 21 species of *Fusarium* were tested for action on cotton tissue respiration.

705. LEAPHART, C. D. and O. L. COPELAND Jr. Root and soil relationships associated with the pole blight disease of western white pine. *Soil Sci. Soc. Amer. Proc.* 21: 551-554. 1957.

As the severity of pole blight increases, rootlet mortality increases and available water storage capacity and effective soil depth becomes less. These results indicate an edaphic relationship to the pole blight disease.

706. LOCHHEAD, A. G. Soil bacteria and growth-promoting substances. *Bacteriological Reviews* 22: 145-153. 1958.

Microbial growth-promoting substances in soil and organisms requiring or synthesizing them are discussed.

707. PREUSS, H. Untersuchungen zur Ökologie und Bedeutung der Tabakmykorrhiza. (Studies on the ecology and significance of tobacco mycorrhiza.) *Naturwissenschaften* 44: 592. 1957. (Rev. Appl. Mycol. 37: 248. 1958.)

Tobacco plants inoculated with endotrophic mycorrhiza developed better than uninoculated plants. The fungus spreads through the root filling the entire primary cortex with hyphae, arbuscules and vesicles. Root infection may be accomplished by means of either mycelium from root debris or germinating vesicles.

708. PRINGLE, R. B. and A. C. BRAUN. Constitution of the toxin of *Helminthosporium victoriae*. *Nature* 181: 1205-1206. 1958.

Further work showed that the toxin isolated from *H. victoriae* is very unstable. Victoxinine at  $2.5 \times 10^{-4}M$  completely inhibited the root growth of both toxin-susceptible and resistant oats. It may be responsible for the toxicity of the complete toxin, specificity being a function of the peptide portion.

709. STEPANOVA, L. N. and E. M. FISH. (On toxic bacteria in turf-podsol soils.) *Bull. Acad. Sci. U.S.S.R., Ser. Biol.* 23: 361-368. 1958. (Rev. Appl. Mycol. 37: 707. 1958.) (English summary)

Of 142 cultures of bacteria isolated from slightly cultivated ploughed



turf podsol, 42 inhibited wheat seedlings, particularly the development of the root system. Most of the toxic ones were sporogenous. Among those particularly abundant was Pseudomonas fluorescens.

710. TALBOYS, P. W. The possible significance of toxic metabolites of Verticillium albo-atrum on the development of hop wilt symptoms. Trans. Brit. Mycol. Soc. 40: 415-427. 1957. (Biol. Abstr. 32: page 2083, entry 24984, 1958.)

Culture filtrates of V. albo-atrum induced desiccation and necrosis in hop shoots, but the intensity of this action bore no relation to either the pathogenicity of the fungus or to the wilt tolerance of the host. From this observation and earlier evidence from intervarietal graft complexes it is suggested that in a determinative phase of the host-parasite relationship, the interactions which determine the degree of tolerance of the host and the pathogenicity of the fungus lead to the establishment of varying intensities of vascular invasion in the root system. In a secondary expressive phase, continued but sometimes restricted activity of the fungus results in the development of visual symptoms, possibly through a toxigenic mechanism in which symptom intensity depends on toxin dosage and is related to the amount of mycelium present in the vascular system.

711. TAMARI, K. and J. KAJI. Blast disease of rice plants. III. The effect of piricularin on the enzyme system of rice plants. Nippon Nogei-Kagaku Kaishi 31: 383-387. 1957. (Chem. Abstr. 52: 15658 (c). 1958.)

Piricularin, a toxic substance produced by Piricularia oryzae, gave a strong inhibitory effect on the respiration and growth of rice plants in concentrations above  $2 \times 10^{-6}$ ; it had an activating effect at a more dilute concentration.

712. TOLLE, R. and A. RIPPEL-BALDES. Untersuchungen über die Rhizosphäre von Gramineen. (Studies on the rhizosphere of Gramineae.) Zbl. Bakt. Abt. 2, 111: 204-217. 1958. (Rev. Appl. Mycol. 37: 523. 1958.)

Forty species of fungi were isolated with varying frequency from the rhizospheres of oats, wheat, rye and barley. Culture filtrates of the isolates from barley rhizospheres exerted a powerful inhibitory effect on wheat root growth, but at dilution 1:100 to 1:1000 were stimulatory. Filtrates from four strains of Penicillium were only slightly stimulatory at 1:1000, while causing marked retardation of root growth at the other dilutions. It is postulated that the culture filtrate contains both inhibitory and activating thermostable substances overlapping in their operation.

#### Toxins and Other Substances of Biotic Origin -- Plant Origin -- Affecting Micro-organisms

713. BOCHOW, VON H. Beiträge zur Frage des Einflusses einer organischen Düngung auf den Befall von Pflanzen durch parasitische Pilze. I. Über den Einfluss verschiedener Kompostgaben auf den Herniebefall. (Contributions to the question of the influence of organic manuring on the attack of plants by parasitic fungi. I. The influence of different doses of compost on attack by club root (Plasmodiophora brassicae Wor.)) Phytopath. Z. 33: 127-134. 1958.

In pot experiments it was shown that different amounts of compost added to a sandy soil infested with Plasmodiophora brassicae produced different effects on the club root attack in mustard. In mildly infested soil a small addition of compost (3-5 percent by weight) produced a slight increase in attack, whereas an increase in the amount of compost added caused a reduction in the degree of attack.

714. BUXTON, E. W. A change of pathogenic race in Fusarium oxysporum f. lini induced by root exudate from a resistant host. Nature 181: 1222-1224. 1958. (Rev. Appl. Mycol. 37: 615-616. 1958.)

A culture of race 1 of F. oxysporum f. pisi was induced to behave like race 2, in that it wilted Wilt-Resistant Alaska pea, by 14 days' incubation

of the spores in root exudates of that variety. Pathogenicity was increased more by a concentrated than by a dilute exudate.

715. BUXTON, E. W. Differential rhizosphere effects of three pea cultivars on physiologic races of *Fusarium oxysporum* f. *pisi*. Trans. Brit. Mycol. Soc. 40: 305-316. 1957.  
Pea cultivars Onward, Alaska, and Delwiche Commando, differential hosts for three physiologic races of *F. oxysporum* f. *pisi*, exert different effects on the soil microflora.
716. DE LAEY, P. and A. I. VIRTANEN. On antifungal factors in carrots. Suomen Kemistilehti 30B: 218. 1957. (in English.) (Chem. Abstr. 52: 12100 (i). 1958.)  
A 70 percent alcohol extract of carrots completely inhibited the growth of *Fusarium nivale* on agar. By paper chromatography, the identified active constituents are chlorogenic acid, caffeic acid, gallic acid, and  $\alpha$ -pinine.
717. ELAROSI, HUSSEIN. Fungal associations. III. The role of pectic enzymes on the synergistic relation between *Rhizoctonia solani* Kühn and *Fusarium solani* Snyder and Hansen, in the rotting of potato tubers. Ann. Botany, N.S. 22: 399-416. 1958.  
The role played by pectic enzymes upon the synergistic relation of *Rhizoctonia solani* and *Fusarium solani* on rotting potato tubers is discussed.
718. GRAHAM, J. H. Effect of gibberellic acid on damping-off of Ladino white clover. Plant Disease Repr. 42: 963-964. 1958.  
Gibberellic acid applied at 10 and 40 ppm to seed of Ladino white clover increased the amount of pre-emergence damping-off in soil infested with *Pythium debaryanum*. Post-emergence damping-off was increased significantly by gibberellic acid in soil infested with *P. debaryanum*, *Rhizoctonia solani*, and *Fusarium roseum*. Since the chemical had no measurable effect on the three fungi in culture it is assumed that the altered growth of the seedlings (spindly and light green) increased their susceptibility to the damping-off organisms.
719. HERZOG, W. and H. WARTENBERG. Untersuchungen über die Lebensdauer der Sklerotien von *Rhizoctonia solani* (Kühn) im Boden. (Investigations on the duration of life of sclerotia of *Rhizoctonia solani* in the soil.) Phytopath. Z. 33: 291-315. 1958.  
Decaying parts of plants such as remains of potato haulms and tubers have an inhibiting effect on *Rhizoctonia solani* since they provide an excellent substrate for fungistatic antibiotics. The action of the rhizosphere of higher plants seems to protect the *Rhizoctonia* against the antibiotics.
720. JACKSON, R. M. An investigation of fungistasis in Nigerian soils. J. Gen. Microbiol. 18: 248-258. 1958.  
The presence of a fungistatic factor in local soils was demonstrated by inoculating agar disks on filter-paper in contact with moist, non-sterile soil with spores of 19 species of fungi. The results suggest the occurrence in Nigerian soils of a material inhibitory to fungi, similar to that occurring elsewhere and probably universally present in soils.
721. JACKSON, R. M. Some aspects of soil fungistasis. J. Gen. Microbiol. 19: 390-401. 1958.  
Six out of seven different soils exhibited a spectrum of inhibition to a series of test fungi. The inhibitory effect decreased with increasing soil acidity. It is suggested that spores are most sensitive to soil fungistasis at an early stage in the process of germination.
722. JACKSON, R. M. Studies on fungistasis in soil. In Report of the Rothamsted Experimental Station for 1957, pp. 80-81. (Rev. Appl. Mycol. 37: 630-633. 1958.)  
The lowest inhibition of germination of a test fungus was produced by soil from a more acid plot and the highest from less acid. Evidence

suggested that aerobic, spore-forming bacteria may cause natural soil fungistasis.

723. KALYANASUNDARAM, R. Production of fusaric acid by *Fusarium lycopersici* Sacc. in the rhizosphere of tomato plants. *Phytopath. Z.* 32: 25-34. 1958.  
It was shown that an antibiotic-like fusaric acid could be synthesized in natural soils if there are favourable microhabitats.
724. LEE, S. and D. Le TOURNEAU. Chlorogenic acid content and *Verticillium* wilt resistance of potatoes. *Phytopathology* 48: 268-274. 1958.  
Varieties resistant to *Verticillium* wilt contained more chlorogenic acid in the roots than did susceptible varieties.
725. LOCKWOOD, J. L. *Streptomyces* spp. as a cause of natural soil fungitoxicity. (Abstr.) *Phytopathology* 48: 395. 1958.  
Mycelium of various fungi was lysed 1-2 weeks after agar cultures were covered with natural or organic soils.
726. MARTIN, P. Einfluss der Kulturfiltrate von Mikroorganismen auf die Abgabe von Scopoletin aus den Keimwurzeln des Hafers (*Avena sativa* L.). (Effect of culture filtrates of microorganisms on the secretion of scopoletin from the radicle of oats.) *Arch. Mikrobiol.* 29: 154-168. 1958.  
Scopoletin (6 methoxy-7-hydroxycoumarin) is excreted by the roots of oats under unfavorable conditions. This excretion is stimulated by culture filtrates of a bacterium species and *Fusarium moniliforme*.
727. NAIM, M. S. and HUSSEIN, A. M. Growth responses of *Fusarium oxysporum* to metabolites of some rhizospheric microflora of Egyptian cotton varieties. *Nature* 181: 578. 1958.  
Of the rhizospheres of different cotton varieties examined, a variety resistant to *F. oxysporum* wilt had the highest populations of *Bacillus subtilis*, while that of the susceptible variety had the highest numbers of *B. megaterium*. *B. subtilis* was highly antagonistic to *F. oxysporum* in culture while *B. megaterium* stimulated mycelial production.
728. RAIBLE, K. and A. I. VIRTANEN. (Antifungal factor from the whortleberry plant.) *Acta Chem. Scand.* 11: 1432-1434. 1957. (Chem. Abstr. 52: 7619 (h). 1958.)  
A highly active antifungal factor against *Fusarium nivale* was obtained from the green portions of the whortleberry plant (*Vaccinium myrtillus*).
729. SCHÖNBECK, F. Untersuchungen über den Einfluss von Wurzelabscheidungen auf die Entwicklung von Bodenpilzen. (Studies on the influence of root secretions on the development of soil fungi.) *Naturwissenschaften* 45: 63-64. 1958. (Rev. Appl. Mycol. 37: 398-399. 1958.)  
Of the various crucifers, legumes and cereals tested only oats produced a substance that inhibited the growth of *Byssoschlamys nivea* in the rhizosphere. On the basis of paper chromatographic analyses the substance is tentatively identified as a root-tip glucoside.
730. STARKEY, R. L. Interrelations between microorganisms and plant roots in the rhizosphere. *Bacteriological Reviews* 22: 154-172. 1958.  
The rhizosphere is the seat of active microbial development, it is here that the principal effects of the soil are expressed on the plant and it is here that the diverse activities of microorganisms have their greatest influence on plant development. There are suggestive results on the beneficial and injurious effects of the rhizosphere microorganisms on plants.
731. STOVER, R. H. Studies of *Fusarium* wilt of bananas. III. Influence of soil fungitoxins on behaviour of *F. oxysporum* f. *cubense* in soil extracts and diffusates. *Can. J. Botany* 36: 439-453. 1958.  
Germination, hyphal growth, sporulation and chlamydospore formation in culture were inhibited by different soil extracts and diffusates. The



alkaline clays being more fungitoxic than the acid loams there was a strong indication that the fungitoxins were associated with the bacterial soil flora.

732. VALLE, E. On anti-fungal factors in potato leaves. Acta Chem. Scand. 11: 395-397. 1957. (Rev. Appl. Mycol. 37: 210-211. 1958.)

Highly active anti-fungal extract was obtained from leaves of field-grown *Aquila* potato plants resistant to *Phytophthora infestans*. These substances also inhibited the growth of *Fusarium nivale*.

#### Toxins and Other Substances of Biotic Origin -- Plant Origin -- Affecting Plants

733. BÖRNER, H. Untersuchungen über den Abbau von Phlorizin im Boden. Ein Beitrag zum Problem der Bodenmüdigkeit bei Obstgehölzen. (Studies on the decomposition of phlorizin in the soil. A contribution to the problem of soil sickness in fruit trees.) Naturwissenschaften 45: 138-139. 1958. (Hort. Abstr. 28: page 556. 1958.)

The author suggests that phlorizin is one of the toxins in the soil causing soil sickness in apple. The substance is present in fairly large amounts in the bark of apple roots from which it diffuses into the soil.

734. BURKILL, I. H. Inhibition of germination of the white mustard by bryony juice. Proc. Linn. Soc. London 169: 62-63. 1958. (Biol. Abstr. 32: 3494, entry 42008. 1958.)

The germination of seeds of *Brassica alba* was inhibited and growth of seedlings stopped by juice of berries of *Tamus communis*. Juice from berries of *Solanum nigrum* also inhibited germination. It is suggested that saponin might be the active substance.

735. HAVIS, L., H. F. MORRIS, R. MANNING and T. E. DENMAN. Responses of replanted peach trees to soil treatments in field tests in Texas. Proc. Amer. Soc. Hort. Sci. 71: 67-76. 1958.

Young peach tree replanting tests at Brownwood, Tyler and Stephenville, Texas, were made on old peach sites. At Brownwood, where the replant problem was most serious, soil fumigation with methyl bromide gave striking benefits in new tree growth. Soil treatments with lime and various fertilizers failed to show any effects on the growth or survival. At Tyler and Stephenville several chemicals, as well as lime and fumigation treatments, failed to give significant benefits in growth of trees up to 3 years.

736. HIRANO, S. Studies on peach sick soil. IV. Effect of dilution of sick soil and of peach leaf extract on the growth of peach seedling. (Japanese, with English summary.) J. hort. Ass. Japan 26: 261-266. 1957. (Hort. Abstr. 28: page 375. 1958.)

Peach seedlings were grown in old peach soil diluted to varying extents with virgin soil. Growth improved with increasing proportions of virgin soil reaching a maximum at 1 part of peach soil to 999 parts virgin soil. Growth was inhibited with undiluted water extracts of peach leaves.

737. LAŠTŮVKA, Z. (Growth and metabolism of wheat and rye in mixed cultures.) (In Czech with English summary.) Folia Biol. (Prague) 4: 119-126. 1958. (Biol. Abstr. 32: 3492, entry 41992. 1958.)

The growth of wheat is inhibited in mixed cultures with rye, while the growth of rye is stimulated. It was assumed that all the changes are due to specific, mutually absorbed substances secreted by both species, the different degree of stimulation or inhibition being related to the concentration of these substances.

738. MARCELLI, E. (An interesting manifestation of "frenching" in association with symptoms of potassium deficiency in tobacco.) Ric. fitop. Campan., 13-14: 107-117. 1957. (English summary.) (Rev. Appl. Mycol. 37: 376-377. 1958.)

Virginia Bright tobacco plants developed frenching together with symptoms of K deficiency. Soil applications of K caused the deficiency symptoms to disappear and markedly reduced frenching. Stable manure also largely reduced frenching.

739. MARTIN, H. Chemical aspects of ecology in relation to agriculture. Publ. Dep. Agric. Can., Sci. Serv., 1015 (Res. Monogr. Sci. Serv. Lab.) 1957, 96 pp., Queen's Printer, Ottawa. 1958.

This book classifies and correlates information on the chemical factors involved in the symbiotic and antibiotic relations between plants, insects, the microflora, and the soil. The chapters include information on the production of phytotoxins by higher plants; the role of phytotoxins in plant pathology; the chemical basis of biological control; the ecological and practical significance of fungal antagonism; the practical utilization of fungicidal antibiotics; and the ecological chemistry of bacteria.

740. MARTIN, J. P. and J. O. ERVIN. Greenhouse studies on influence of other crops and of organic materials on growth of orange seedlings in old citrus soil. Soil Sci. 85: 141-147. 1958.

Studies were conducted in the greenhouse to determine (a) the variation in the reduced growth condition of southern California citrus soils; (b) whether growth of other plants was retarded in old citrus soils; and (c) the influence of organic materials, companion crops, and crop rotation on growth of orange seedlings in old citrus soils. Rotation crops exerted variable effects on growth of orange seedlings in two old citrus soils. The majority tended to increase growth; grass crops were more effective than legume crops. In Yolo sandy loam a rotation crop of brome grass was almost as effective as fumigation in stimulating growth.

741. PATRICK, Z. A. and L. W. KOCH. Inhibition of respiration, germination, and growth by substances arising during the decomposition of certain plant residues in the soil. Can. J. Botany 36: 621-647. 1958.

Substances capable of markedly inhibiting the respiration, germination, and growth of tobacco seedlings were obtained after residues from timothy, corn, rye or tobacco plants had been allowed to decompose under appropriate conditions in the soil. The toxic substances exhibited an inhibiting effect on respiration of tobacco seedlings after an exposure of less than 1 hour and also induced darkening and necrosis of root cells. Some extracts affected the cells of the apical meristem most severely while others affected only the cells of the elongation region. The toxic substances possessed antifungal activity also. It is believed that these toxins may perform a significant role in the field as the primary cause of some root rots and in predisposing plants to attack by organisms not normally regarded as pathogenic.

742. PEERS, F. G. Germination inhibitory substances in oat husk. W. African J. Biol. Chem. 2: 9-14. 1958. (Chem. Abstr. 52: 20448(d). 1958.)

Aqueous extracts of oat husk are inhibitory to germination of other seeds but not to oats. The activity is ascribed to organic acids, principally succinic, acetic, fumaric, and malic acids.

743. SCHANDER, H. Über die Bodenmüdigkeit beim Apfel und über Versuche, Marschböden auf Bodenmüdigkeit zu testen. (On soil sickness in apples and on experiments to test marshy soils for soil sickness.) Mitt. ObstVersuchsrings Jork 13: 188-195. 1958. (Hort. Abstr. 28: page 556. 1958.)

The article is largely a discussion on the problem of genuine soil sickness in deciduous fruits and on the possibility of diagnosing the malady by analysing the soil for the presence of certain glycosides.

744. STOLWIJK, J. A. J. and K. V. THIMANN. On the uptake of carbon dioxide and bicarbonate by roots, and its influence on growth. Plant Physiol. 32: 513-520. 1957.

Growth of roots of Pisum sativum, Vicia faba, Phaseolus vulgaris, and Helianthus annuus is completely inhibited if the root medium is aerated with 6.5 percent CO<sub>2</sub> in air. Avena sativa and Hordeum vulgare are almost unaffected by such a treatment.

## VIRUS

745. LIN, K. -H. Observations on yellow shoot of citrus. Etiological studies of yellow shoot of citrus. (Chinese, Abs. from English summary.) Acta Phytopath. Sinica 2: 1-42. 1956. (Rev. Appl. Mycol. 37: 41. 1958.)  
Symptoms include rotting of rootlets. In field experiments there was no evidence that it was caused by water injury or by nematodes. Fusarium spp. were not responsible but could invade weakened roots. Inoculation by budding indicated that the disease is of virus origin and transmitted naturally.
746. LIN, K. -H. and M. -L. CHU. The relation of Fusarium species to yellow shoot of citrus. Acta Phytopath. Sinica 3: 169-176. 1957. (Rev. Appl. Mycol. 37: 408. 1958.)  
Two of 14 tangerine orange trees in drums developed root rot and yellowing 4 months after soil inoculation with Fusarium, subsequent recovery by formation of new fibrous roots being followed by recurrence of the disease. It would appear that Fusarium spp. can attack the roots of citrus and augment the effects of yellow shoot virus disease.
747. NOORDAM, D. Tabaksnecrosevirus in samenhang met een oppervlakkige aantasting van aardappelknollen. (Tobacco necrosis virus associated with a superficial affection of potato tubers.) Tijdschr. Plantenziekten 63: 237-241. 1957. (Biol. Abstr. 32: 2086, entry 24924. 1958.)  
Tobacco necrosis virus caused three types of symptoms on various potato varieties; dark brown lesions with star-shaped or reticular cracks, somewhat resembling scab and only superficially present in the flesh; light brown lesions with or without cracks; and in storage blisters may develop changing into sunken areas.
748. WALKINSHAW, C. H. and R. H. LARSON. A soil-borne virus associated with the corky ringspot disease of potato. Nature 181: 1146. 1958.  
A sap-transmissible, rod-shaped virus carried in the soil was recovered from Sebago potato tubers affected by corky ring spot (spraing) at the University of Wisconsin, Madison, U.S.A. The virus, named "potato corky ringspot virus", was related serologically to the viruses of potato stem mottle and tobacco rattle but produced different symptoms.



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THE BOTANY AND PLANT PATHOLOGY DIVISION,  
CANADA DEPARTMENT OF AGRICULTURE







# THE PLANT DISEASE REPORTER

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AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

DOWNY MILDEW ON LIMA BEANS

Supplement 257

June 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

DOWNY MILDEW ON LIMA BEANS

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THE HISTORY AND ECONOMIC IMPORTANCE OF THE  
LIMA BEAN DOWNY MILDEW DISEASE

Frank App<sup>1</sup>

Downy mildew on lima beans was first reported by Prof. R. Thaxter in the Annual Report of the Connecticut Agricultural Experiment Station in 1889. Prof. Thaxter gave a scientific description of the fungus, Phytophthora phaseoli, and illustrated in detail the summer stage but did not discover the winter stage. His successor, Dr. W. C. Sturgis, reported successful control of the disease with Bordeaux mixture in 1898, along with some of the conditions that influenced the dissemination of the pathogen, such as insects and wind.

Dr. B. D. Halsted reported a serious outbreak of downy mildew on lima beans in Bergen County, New Jersey, in the Annual Report of the New Jersey Agricultural Experiment Station for 1897.

Dr. C. O. Smith, of the Delaware Agricultural Experiment Station, reported its appearance in that State in 1904.

Reports from the New Jersey Agricultural Experiment Station, beginning in 1914, show that the disease was present in the State nearly every year.

We must credit these botanists for their discovery and description of the disease and the associated pathogen long before it became of great economic importance. Lima beans, at that time, were mostly a garden crop. It was not until the early 1900's that they became economically important and were grown as a field crop, for processing as well as for sale on the fresh market. Although the early botanists and pathologists reported control with Bordeaux mixture, commercial growers failed to use controls because of cost, lack of equipment, or insufficient information as to timing and the need for thorough coverage. These early reports were for occurrence on Fordhook lima beans.

The first production of baby lima beans for processing in New Jersey was by Brakeley Bros. of Freehold. According to Mr. Duryee, the first County Agent in the county in which Freehold was located, this was sometime in the 1890's. Brakeley Bros. had developed an outstanding processing unit and at their peak were producing approximately 3,000 acres of lima beans, all of which were processed in the plant at Freehold. They liquidated their company in the winter of 1927-28. They were growing lima beans continuously, without rotation, and when downy mildew became a major factor in production they were unsuccessful in developing a satisfactory control. They renewed their operations in Delaware where downy mildew was not then a problem.

The Stevens Canning Co., of Bridgeton, New Jersey, began canning beans in 1897, and the Ayars Canning Co., also of Bridgeton, early in 1900. Both of these companies discontinued during or before the early 1930's. The operation at Seabrook Farms began in 1918. Downy mildew became a major problem in the 1940's.

Drs. J. W. Heuberger and D. F. Crossan, University of Delaware, reported that growers in Delaware in 1958 suffered an estimated loss from 11,675 acres of 2,510,884 pounds of lima beans, valued at \$175,762. Seabrook Farms, where relatively little loss occurred in 1958, followed a spraying program based upon results from research and development projected in 1948. (Table 1). The contract growers, on the other hand, who were not prepared with equipment to follow such a program, had heavy losses, with considerable abandoned acreage.

The Thaxter variety will be grown almost entirely in 1959. Unless Strain B of the causal organism, which was first discovered in 1958, appears, no control measures will be necessary. Our Fordhook type bean, however, is becoming a very important crop, and until a downy mildew-resistant Fordhook is available commercially, control measures will be necessary for it.

Dr. Heuberger reported downy mildew on Henderson bush lima beans in Delaware in 1945. Between 1945 and 1949 the disease twice threatened to wipe out the baby lima bean crop, which occupied the largest acreage of any vegetable grown in the State. Dr. Heuberger initiated experimental control measures with various fungicidal sprays and dusts, beginning in 1946.

In 1948, Seabrook Farms invited representatives from the United States Department of Agriculture, University of Delaware, Rutgers University, University of Maryland, and the New York State (Geneva) Experiment Station, to meet for the purpose of appraising the importance of controlling downy mildew on lima beans and to arrive at an agreement as to objectives and procedures for developing commercial control methods. The data submitted showed that downy mildew had become a major agricultural problem. For example, in 1946, Seabrook Farms

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Table 1. Estimated losses from lima bean downy mildew at Seabrook Farms, 1945 to 1952.

Year	Loss (\$)	Dusting costs (\$)
1945*	58,464.23	--
1946	120,841.33	16,000.75
1947	no mildew	--
1948	454,743.47	26,704.60
1949	89,839.34	441.20
1950	359,669.44	11,457.30
1951	132,972.24	29,961.20
1952	37,294.01	43,704.95

\*Seabrook Farms acreage only--other years included contract acreage of growers.

abandoned over 1200 acres of beans because of the disease; in 1948, infection again was quite severe. Similar experiences were reported from the neighboring States.

The conference was unanimous that research should be organized, with the following objectives: 1) to develop downy mildew-resistant lima beans through plant breeding; 2) to determine how the causal organism is carried over from year to year; 3) to determine the length of time between infection and appearance of symptoms; 4) to determine the climatic conditions necessary for the development and spread of the disease; 5) to investigate the feasibility of control by use of fungicidal sprays and dusts.

At the request of the representatives from the Universities of Delaware and New Jersey, Dr. W. J. Zaumeyer, Principal Pathologist, and his associates from the United States Department of Agriculture, agreed to conduct the necessary research on the breeding of a downy mildew-resistant lima bean. Dr. Heuberger agreed to conduct research on manner of carryover from one year to the next, and to set up research projects for the field testing of control measures, including various fungicides, proper timing and method of application, and the efficiency of both sprays and dusts.

Dr. R. A. Hyre, Regional Plant Pathologist of the Department of Agriculture, stationed at the University of Delaware, agreed to set up a forecasting service based upon climatic conditions, to warn the growers when initial infection would occur and when to begin spraying or dusting for proper control.

Seabrook Farms was already conducting research on the use of various fungicides, including the timing and method of application, and the thoroughness of coverage by different methods of application, and offered to cooperate with any of the institutions in the proposed control studies as well as in the development of a forecasting service. In addition, the Department of Agriculture's resistant hybrid beans were tested by Seabrook Farms. Testing was first for observation, then for yield in trial plots, and finally the hybrids were grown in pilot plantings. The crops were processed and rated for quality and appearance.

As a result of this cooperative project, in the spring of 1958 the Department of Agriculture released a downy mildew-resistant baby lima bean named Thaxter, which is now going into commercial production. We now have effective control measures and equipment for the proper application of the fungicides. We know how the fungus carries over from one year to the next. From correlation with climatic conditions, we can forecast with reasonable accuracy when downy mildew will occur. In addition, the Department of Agriculture, through Dr. Zaumeyer and Mr. Wester, have a downy mildew-resistant Fordhook nearly ready for commercial introduction.

The pooling of information, both farm and institutional, and the fixing of responsibilities for developing the objectives agreed upon, has resulted in a gratifying achievement. Usually, agriculture is at a disadvantage because of the segregation of its functions: for each person working on the farm, there are two others working off the farm. This situation makes it desirable for all groups to cooperate as a unit in undertakings, such as this one, in which there is a mutual interest.

SEABROOK FARMING CORPORATION

THE DEVELOPMENT OF A METHOD  
FOR FORECASTING DOWNY MILDEW OF LIMA BEAN

R. A. Hyre<sup>1</sup>

Abstract

A method has been developed for forecasting downy mildew of lima bean (due to Phytophthora phaseoli) from rainfall and temperature data. Initial appearance of downy mildew is forecast after about 8 consecutive downy mildew-favorable days, and continuing downy mildew-favorable weather. A day is considered favorable for downy mildew when the 5-day moving mean temperature, ending on the fifth day, is less than 79°F, with the minimum temperature 45° or above; and the 10-day total rainfall, ending on the tenth day, is about 1.2 inches, or more.

At a conference held at the Seabrook Farming Corporation, Seabrook, New Jersey, in September, 1948 (1) it was agreed that a reliable method of forecasting lima bean downy mildew, due to Phytophthora phaseoli, would be a valuable aid in its control. The responsibility for developing such a method was assigned to the writer. At the same time, the downy mildew records of the Seabrook Farming Corporation were made available for this purpose. These records were later used in the development of the forecast method, and appreciation for permission so to use them is hereby expressed.

The first task was to study the physiology and life history of the causal organism, in order to determine the effect, particularly, of temperature and moisture on the development of the organism and the disease. About this time Harold T. Cook published a method for forecasting epiphytotics of late blight of potato and tomato (2), in which he used "moving charts" of daily rainfall and temperature data for determining critical disease periods. His moving chart method was modified and adapted by the writer to form the basis of the method presently in use for forecasting not only downy mildew of lima bean but also late blight of potato and tomato in the northeastern United States. Other methods, involving relative humidity and dew, are under investigation to supplement the rainfall-temperature method.

The method, as used for downy mildew of lima bean, has been described in detail in a recent publication (3). Briefly, it is as follows: For downy mildew to occur, both rainfall and temperature must be favorable simultaneously. Rainfall is considered favorable when the 10-day total is about 1.2 inches or more. Temperature is considered favorable when the 5-day mean is less than 79°F. Any day is considered unfavorable, however, if the minimum temperature is less than 45°. Moving graphs, calculated from daily weather data (usually obtained from the United States Weather Bureau), are maintained and the disease is forecast after about 8 consecutive mildew-favorable days, if the weather at that time remains favorable for the disease. Downy mildew, then, is expected to appear 1 or 2 weeks later.

Figure 1 is an analysis of 13 years of weather and downy mildew data for southern New Jersey. On it are shown the periods of downy mildew-favorable weather, the dates when downy mildew was first observed, and the estimated severity of the disease for the season. There is a good correlation between the first weather periods of 8, or more, consecutive favorable days and the date of first observation of the disease. There were 2 years of no significant mildew. In 1947 there were no favorable weather periods, and no disease was observed. The year 1957 was very dry and all beans were harvested early -- "prior to September 30"; although no downy mildew was seen before harvest mildew-favorable weather occurred just prior to harvest and a little mildew was observed after harvest, on October 4. During 8 years when downy mildew was rated severe (62 percent of the years) both the time of first observation and the subsequent severity of the disease correlated very well with the mildew-favorable weather periods. Likewise, for the 3 years when mildew was light good correlation between disease incidence and mildew-favorable weather periods was evident. In 1953, a warm period followed the first 8-day favorable weather period and apparently stopped the development of mildew at that time.

<sup>1</sup> Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, University of Delaware, Newark, Delaware.



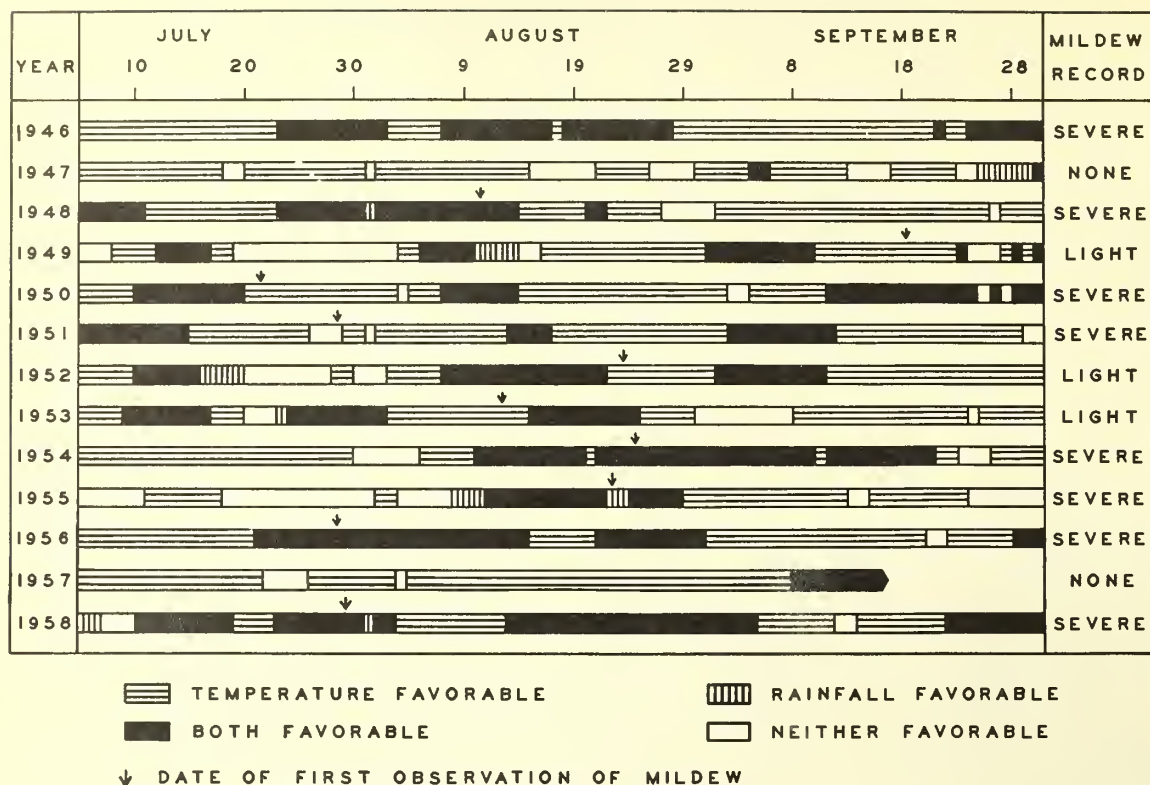


FIGURE 1. Summary of July-September temperature and rainfall data for Bridgeton, New Jersey, in relation to the importance of downy mildew of lima bean, 1946-1958 inclusive.

Downy mildew has been forecast for 6 years with good accuracy. The forecast area has been extended to the principal green lima bean areas in the northeastern United States, and includes the States of New York, New Jersey, Delaware, Maryland, and Pennsylvania.

The forecast method is defined in rather precise terms, but a degree of flexibility is desirable in applying the criteria in some situations; for instance, when a series of sub-minimal favorable periods occur closely together, or in isolated locations favorable for mildew. With experience such situations should cause little trouble.

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# BREEDING LIMA BEANS FOR RESISTANCE TO DOWNY MILDEW

R. E. Wester<sup>1</sup> and Robert C. Cetas<sup>2</sup>

A program of breeding lima beans resistant to the downy mildew fungus (*Phytophthora phaseoli* Thaxt.) was begun by the United States Department of Agriculture in 1948 in cooperation with the Long Island Vegetable Research Farm at Riverhead, New York. In tests of most domestic lima bean varieties and foreign plant introductions, resistance was located in four unnamed lines. These lines originated from India, Guatemala, southeastern United States, and California.

The first crosses between the downy mildew-resistant parents and Early Thorogreen and Fordhook 242 lima beans were made at the Plant Industry Station, Beltsville, Maryland, in the spring of 1949. It was discovered that the inheritance of resistance was controlled by a single dominant gene (2).

After three backcrosses to Early Thorogreen followed by seven generations of selection and testing for downy mildew resistance in the greenhouse (Fig. 1) and in the field, an outstanding resistant line was chosen. It was named Thaxter for the late Roland Thaxter, an eminent plant pathologist who first discovered the lima bean downy mildew fungus and described it (1) in 1889. The downy mildew-resistant parent of Thaxter was U. S. Department of Agriculture P.I. number 164155, a colored-seeded pole lima bean from Nagpur, India.



FIGURE 1. Early Thorogreen seedlings (center) killed by downy mildew strain A, while Thaxter seedlings (right and left) are highly resistant.

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In 1958 about 20,000 pounds of seed of Thaxter was produced by seedsmen from breeders' stock furnished by the United States Department of Agriculture for increase. It is possible that as much as 500,000 pounds may be available for planting in 1959.

In preliminary trials in 1954 and more extensive ones from 1954 to 1958 Thaxter was found to be well suited for processing. The tests showed that it was very productive and well adapted for vining. It was tested extensively in the lima bean-growing areas of Delaware, Maryland, New Jersey, and Pennsylvania, where downy mildew is frequently widespread, and until 1958 it always showed a very high degree of resistance to all collections of the downy mildew fungus. In the fall of 1958, however, a new race of the fungus known as race B (3) was discovered in New Jersey. Greenhouse tests have shown that Thaxter is susceptible to it. It cannot be predicted at this time, however, whether the new race will become widespread in future years.

Resistance has been incorporated into lines of the Fordhook type, in addition to Thaxter. Five or six backcrosses have been necessary to produce the desired type. Several promising lines, which have been resistant to downy mildew in both greenhouse and field tests since 1956, have been developed. Like Thaxter, however, these lines are susceptible to the new race B of the mildew organism.

As soon as race B was discovered, the U. S. Department of Agriculture started to test all the recent foreign plant introductions of lima beans, hoping to find resistance to it. Fortunately, P.I. No. 189403, named Piloy, from Guatemala was found to be highly resistant to this new race of downy mildew as well as to race A, which is very widespread. Piloy, a vigorous, highly productive, bush type with small, flat, red seed has been crossed with Thaxter, Fordhook 242, and USDA No. 551, a new Fordhook-type lima bean. It is hoped that Piloy, in addition to contributing resistance to downy mildew races A and B, may also contribute other genes for the improvement of Fordhook 242 and commercial baby lima beans.

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UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL  
RESEARCH SERVICE, AND CORNELL UNIVERSITY



# CONTROL OF LIMA BEAN DOWNY MILDEW BY FUNGICIDES<sup>1</sup>

J. W. Heuberger and D. F. Crossan<sup>2, 3</sup>

## Abstract

This paper is the fourth in the series in this Plant Disease Reporter Supplement, summarizing cooperative work in the Jersey-Delmarva area on various aspects of the downy mildew disease of the Henderson bush lima bean. It covers the aspect of control by the use of fungicides. Thirteen years of research on copper and organic fungicides are reviewed briefly. Maneb (2-100) was found to be the most effective of the fungicides tested when used as a spray. Two years of commercial custom spraying have substantiated the research results.

## INTRODUCTION

Downy mildew (*Phytophthora phaseoli*) of the Henderson bush lima bean<sup>4</sup> was first found in Delaware in 1945, even though the disease had been known to occur on the Fordhook bush lima in Delaware since 1905. Recognizing the potential seriousness of the disease to the Henderson lima bean industry (approximately 22,000 acres) in Delaware, particularly in view of what happened in New Jersey (2), the Experiment Station started a research program on the use of fungicides as sprays and dusts for control. Experiments have been conducted yearly since 1946 (4, 6, 7, 8).

Surveys of losses were made from time to time in Delaware, based on an estimate of percentage of the crop lost. Results were, at best, somewhat unsatisfactory. Therefore, in the fall of 1958, a questionnaire on losses from the downy mildew disease, prepared in such a way that fairly accurate information was needed to answer the questions, was sent to the lima bean processors. Replies received covered a total of 11,675 acres, more than half the total acreage in the State. Based on an average yield of 1600 pounds of shelled beans per acre, losses were as shown in Table 1.

Table 1. Estimated losses from lima bean downy mildew, 1958.

Acres included	Loss in shelled beans	
	Pounds/Acre	Total Pounds
280	200	56,000
275	250	68,750
95	600	57,000
231	714	164,934
1025	800	820,000
50	900	45,000
812	1600	1,299,200
		<u>2,510,884</u>

At a value of 7¢ per pound, the loss of 2,510,884 pounds amounted to \$175,762. This represented a loss on 11,675 acres of approximately 14 percent.

<sup>1</sup> Published with the approval of the Director of the Delaware Agricultural Experiment Station. Contribution No. 117 of the Department of Plant Pathology.

<sup>2</sup> Professor and Assistant Professor, respectively.

<sup>3</sup> The writers wish to acknowledge their indebtedness to the following lima bean processors whose unstinting cooperation made their work possible: H. P. Cannon and Son Co.; W. L. Wheatley Co.; Libby, McNeill, Libby Co.; Draper Canning Co.; and the Stokely Canning Co.

<sup>4</sup> Also commonly known as the "baby" lima bean.

## LITERATURE REVIEW

A review of the literature on control of downy mildew of lima beans on the Atlantic coastal plain soils showed only a few reports, mainly on the Fordhook variety. Sturgis (9), in 1897, recommended spraying with Bordeaux mixture. Clayton (3), in 1928, reported on his extensive experiments with Bordeaux mixture on Fordhook on Long Island. His data showed that good control was obtained with five applications, two before bloom and three after bloom, and that spraying did not noticeably discolor the pods. In 1947, Cunningham (5) reported his 6-year study on control by fungicides. He found that spraying or dusting, on a regular schedule, with copper fungicides gave control; that the copper fungicides did not noticeably discolor the pods, but copper injury in the form of rusty-brown spots did occur in transit if the beans were picked and packed when wet; that Bordeaux mixture caused some foliage injury; and, that of the organic fungicides tested (ferbam, Sperguson, Phygon, Dithane D-14 plus zinc sulfate and lime), only Dithane D-14 plus zinc sulfate and lime gave control equal to that obtained with the copper fungicides.

Prior to the work in Delaware, the only previous research on control of downy mildew on the Henderson bush lima was that conducted by the Department of Plant Pathology, New Jersey Agricultural Experiment Station, Rutgers University, during the period 1939-1943 inclusive (1). Various fungicides, including several copper materials, were tested as sprays and dusts. No information was obtained on downy mildew control as that disease was not present; however, striking data were obtained on copper injury. It was found that the Henderson bush lima was far more sensitive to copper than the Fordhook bush lima; in some cases, the yield of Henderson lima beans receiving copper fungicides was reduced 27 to 54 percent as compared with yield from untreated plants. The following conclusion was reached: "Under New Jersey conditions, where the bean diseases controllable by sprays or dusts are of minor importance, it would seem advisable to avoid the use of copper on these crops entirely and limit the applications to insecticides, except in specific cases where downy mildew threatens to become a serious problem on late lima beans"

## REVIEW OF RESEARCH IN DELAWARE

During the period 1946-1948, inclusive, experiments were conducted at Thompsonville on various copper and organic fungicides, used as dusts and sprays (6). Unfortunately, the disease did not become serious enough in the plots to obtain control data; however, data were obtained on plant injury and yield, as follows:

1. Bordeaux spray was injurious and markedly reduced yield.
2. Fixed coppers were injurious and reduced yields when used as sprays but not when used as dusts.
3. Zineb (Dithane Z-78; Parzate) was non-injurious and did not reduce yield, either as sprays or dusts.

In 1949, a total of 17 tests were conducted in the Bridgeville, Thompsonville, Milton, and Rehobeth areas on plantings of various ages (7). The mildew did not develop until October when it appeared in the last three tests on late-planted beans. Results were summarized as follows:

1. Copper sprays (Bordeaux; Tribasic) gave excellent disease control but were injurious. Tribasic Copper dust gave good disease control and did not reduce yield.
2. Zineb sprays (Dithane Z-78; Parzate) were not quite so effective in control as the copper sprays and did not reduce yield. As dusts, these materials were less effective in control than sprays.

During 1950, tests were conducted to determine: (a) if the mildew could be controlled when fungicide applications were begun after the disease appeared, and (b) the effect of the number of applications on control (7). The data obtained showed that the disease could be controlled after it first appeared in small amounts, provided that applications were begun immediately. Also, as the number of applications increased, control increased.

While this work was in progress, growers were not successful in controlling downy mildew by the use of dusts applied either by plane or helicopter; however, where ground equipment was used, some control was obtained provided the incidence of mildew was not too high when dusting began.

Thus, by the end of 1950, it was evident that a new chemical had to be found if growers were to obtain control by the use of fungicides. Accordingly, beginning in 1951, maneb was included in the test plots; and, in 1956, streptomycin (10) was included. In 1956, downy mildew developed in sufficient quantities so that excellent control and yield data were obtained in two plots (4). A brief comparison of the results from maneb, Tribasic Copper Sulphate, and streptomycin is given in Table 2.

Table. 2. Comparison of results from 1956 tests for control of lima bean downy mildew.

Material <sup>a</sup>	Concentration	Percent		Pounds	
		infected pods		shelled beans /acre	
		Test #1	Test #2	Test #1	Test #2
Untreated		38.0	34.0	2523	1842
Maneb	2-100 lb./gal.	0.4	1.0	3819	3991
Tribasic	4-100 lb./gal.	9.0	2.0	3248	3435
Streptomycin	100 ppm	25.0	14.0	2438	2282

<sup>a</sup> In Test #1, the first application was made when the disease was first beginning to develop (August 31); it was followed by a second application on September 12. In Test #2, the disease appeared about September 2. Applications were made on September 5, 13, and 20.

Subsequent tests in 1947 and 1958 confirmed the data above that maneb, used as a spray, is very effective in control of downy mildew and that its use results in high yields. Recent grower experience in New Jersey has indicated that maneb is not satisfactory for control when used as a dust.

#### COMMERCIAL CONTROL

During 1957 and 1958, one lima bean processor in Delaware sprayed hundreds of acres with maneb (2-100) on a contract basis, using hydraulic ground sprayers. Results obtained showed that excellent commercial control was obtained where the applications were timed properly according to weather conditions. This resulted in high yields of beans of high quality. This processor made a study of the labor costs in the plant for sorting beans on the belts from unsprayed and sprayed fields. His findings showed that much less labor was required to sort the beans from sprayed fields, in fact, the savings in labor were enough to pay for the cost of spraying in the field.

Thus, two years of commercial use has shown that maneb, as a spray, increases yield and improves quality of the beans to the grower, insures the processor of a crop of high quality beans, and decreases the labor cost for processing the beans in the plant.

#### CONCLUSIONS

Now that an effective fungicide is available and an accurate downy mildew forecasting system is functioning, and growers must obtain control of insects also, there is no reason why growers and processors alike should not be prepared to spray their beans when downy mildew threatens. The first fungicide application should be tied in with the first mildew warning; subsequent applications should be determined by seasonal conditions. As all the insecticides used on beans are compatible with maneb, joint application can be made for downy mildew and insect control.

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# THE PLANT DISEASE REPORTER

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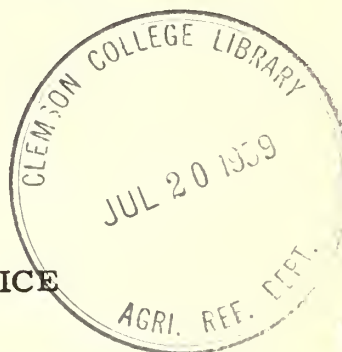
PHYSIOLOGIC RACES OF PUCCINIA GRAMINIS  
IN THE UNITED STATES IN 1958

Supplement 258

July 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.







# THE PLANT DISEASE REPORTER

## MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

### PHYSIOLOGIC RACES OF PUCCINIA GRAMINIS IN THE UNITED STATES IN 1958<sup>1, 2</sup>

D. M. Stewart<sup>3</sup>, R. U. Cotter<sup>3</sup>, B. J. Roberts<sup>4</sup>, and J. J. Christensen<sup>5</sup>

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#### Summary

From 566 uredial collections of wheat stem rust (Puccinia graminis var. tritici), 27 races and subraces<sup>6</sup> were identified among 775 isolates. Race 56 comprised 29 percent of the isolates, a slight decrease from the previous year; race 11 comprised 23 percent, an increase that was influenced by the unusually large number of isolates from the Pacific Northwest; race 15B, 18 percent, a slight decrease; the 17-29 race group<sup>7</sup> (with race 29) increased to 16 percent; and race 38 comprised 5 percent. These races totaled 91 percent of the isolates. In the spring-wheat area, including Minnesota, South Dakota, and North Dakota, race 15B was identified in 45 percent of the isolates, whereas the 17-29 group was found only on screening varieties in nurseries in this area.

Variants of several races or subraces were isolated that may prove important in breeding programs involving Frontana crosses and others. Race 34 also was isolated for the first time from the widely grown Selkirk wheat.

Among 138 uredial and aecial isolates of wheat stem rust from the Pacific Northwest, 15 races and subraces were identified, six of which were not found elsewhere in the United States. Race 11 was most prevalent among uredial isolates, comprising 91 percent in Oregon, 78 percent in Idaho, and 68 percent in Washington.

Seven races and one subrace of oat stem rust (P. graminis var. avenae) were identified among 286 uredial isolates from 234 collections. Race 7 (combined with 12) comprised 54 percent of the isolates; race 8 (with 10), 26 percent; race 2 (with 5), 14 percent;

<sup>1</sup> Paper No. 4107, Scientific Journal Series, Minnesota Agricultural Experiment Station. Cooperative investigations with the United States Department of Agriculture.

<sup>2</sup> For summaries for the years 1939 through 1942, see 522 and 522A to C in the Bureau of Entomology and Plant Quarantine E-series; for 1943, 1944, 1945-49, and subsequent reports through 1953, see unnumbered publications in the Physiologic Races series; for 1954, see ARS-81-3; for 1955, 1956, and 1957, see Plant Disease Reporter, Supplements 239 and 245 and Volume 42, No. 7.

<sup>3</sup> Plant Pathologists, Plant Pest Control Division, Agricultural Research Service, United States Department of Agriculture.

<sup>4</sup> Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

<sup>5</sup> Collaborator, Plant Pest Control Division, Agricultural Research Service, United States Department of Agriculture, and Head, Department of Plant Pathology and Botany, University of Minnesota.

E. C. Stakman continued leadership in the search for supplemental differential varieties and assisted in race identification at various times. Acknowledgment for collections is made to Donald G. Fletcher and E. B. Hayden, of the Rust Prevention Association, and to personnel of the two Agricultural Research Service Divisions and of the State Colleges and Departments of Agriculture.

<sup>6</sup> A race comprises many subraces that may be distinguished from each other by different infection types on the standard differentials and/or supplemental varieties. The term "biotype" is restricted to cultures derived from single urediospores or aeciospores which may or may not be the same genotype as a subrace.

<sup>7</sup> "Race group" is a term applied to closely related races that can be distinguished from each other only under certain environmental conditions.

subrace 7A, about 5 percent; and race 6, 1 percent. Race 8 was identified for the first time from California collections on the varieties Indio and Ventura.

From 29 barberry collections, 16 races and subraces of wheat stem rust were identified among 43 isolates. Race 11, the 17-29 group, and race 24 occurred most frequently. From four barberry collections made in New York, race 2 of oat stem rust was isolated once and race 7 three times.

#### WHEAT STEM RUST

From 566 collections of rusted wheat, barley, and grasses, 27 races and subraces, or biotypes<sup>6</sup>, of *P. graminis* var. *tritici* were identified among 775 isolates (Table 1). Races 56, 11, 15B, the 17-29 race group, and race 38 were more prevalent than other races and comprised 91 percent of the total isolates identified. Race 56 comprised 29 percent; 11, 23 percent; 15B, 18 percent; the 17-29 group (with race 29), 16 percent; and 38, 5 percent. The remaining 9 percent included 21 other races and subraces (Table 1).

Race 56 decreased slightly in prevalence in 1958 and occurred mainly on winter wheats, barleys, and wild grasses. Most of the late fall collections from Kansas, Oklahoma, and Texas also were race 56, an indication of its survivability. Percentage prevalence of this and other prevalent races in various areas of the United States is given in Table 2.

Race 11 was the most widely distributed race, as it was collected in 26 of 28 States sampled. Its high prevalence in 1958 compared with that in 1957, however, is not representative of regions east of the Rocky Mountains, as it was identified in about 79 percent of the unusually large number of isolates from the Inland Empire of the Pacific Northwest, where stem rust was epidemic. Outside of the Inland Empire it was much less prevalent. Race 11 was identified also from four counties in northern California, where there was rust damage in certain sections at elevations above 4000 feet, according to C. A. Suneson.

Race 15B, which has been decreasing in prevalence since the high of 63 percent in 1953, comprised only 18 percent of the isolates in 1958 compared with 32 percent the previous year (Fig. 1). However, it constituted 45 percent of the isolates from the spring-wheat States (Minnesota, South Dakota, and North Dakota) (Table 2). This race was not found in the Inland Empire or in other States west of Wyoming.

FIGURE 1. Relative prevalence of *Puccinia graminis* var. *tritici* race 15B in the United States, 1950-1958

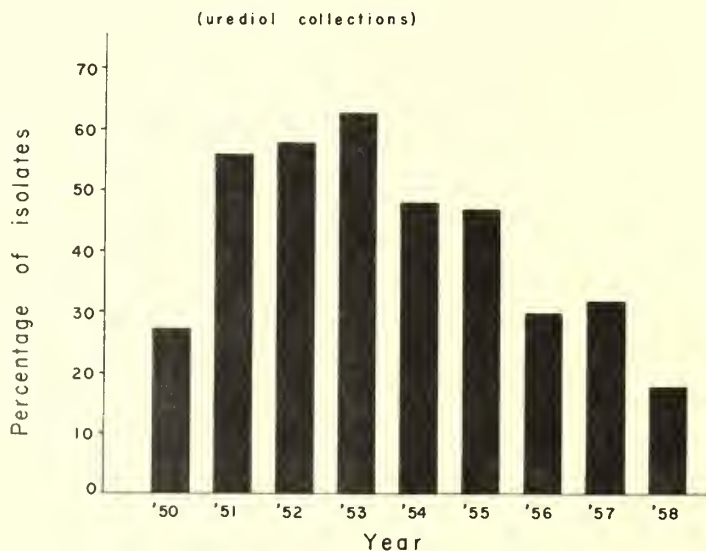


Table 1. Physiologic races of *Puccinia graminis* var. *tritici* isolated from uredial collections in the United States in 1958.

State	Race and number of times isolated																											Total number of--				
	1	10	11	14	15	15B	29	23	24	27	29	32	34	36	38	LFA	LFB	L9	54	56	59	69	111	133	139	147	186	late	Reese	Collec- tions		
Alabama	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2	
California	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4	4	
Colorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	3	1	3	3	
Florida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	1	1	
Georgia	-	-	1	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	6	5	5	5	
Idaho	-	-	35 <sup>a</sup>	-	-	1	-	-	-	-	-	1	-	1	-	3	-	-	4	-	-	-	-	-	-	-	-	45	6	39	6	39
Illinois	-	-	7	-	6	22	-	-	-	-	1	-	-	6	-	-	-	8	-	-	-	-	-	-	-	-	-	50	6	36	6	36
Indiana	-	-	8	-	4	8	-	-	-	-	3	-	-	1	-	-	-	9	-	-	-	-	-	-	-	-	-	33	6	19	6	19
Iowa	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	20	3	16	3	16
Kansas	-	-	4	-	15	2	-	-	-	-	-	-	1	-	1	-	-	41	-	-	-	-	-	-	-	-	-	64	6	43	6	43
Kentucky	-	-	4	-	2	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	4	11	4	11
Michigan	-	-	6	-	1	7	22	-	-	-	3	-	-	5	2	1	-	11	-	-	-	-	-	-	-	-	-	58	9	33	9	33
Minnesota	-	-	7	-	4	25	2	-	-	-	-	-	1	-	-	-	-	18	-	-	-	-	-	-	-	-	-	57	6	44	6	44
Missouri	-	-	5	-	-	3	3	-	-	-	1	-	-	3	-	-	-	19	-	-	-	-	-	-	-	1	-	35	7	25	7	25
Montana	-	-	2 <sup>a</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2	2
Nebraska	-	-	1	-	-	2	2	-	-	-	-	-	1	-	-	-	-	7	-	-	-	-	-	-	-	-	-	13	5	9	5	9
New York	-	1	1	1	-	-	3	1	-	1	-	-	-	-	1	-	-	-	1	10 <sup>b</sup>	1	-	-	-	1	-	1	43	14	17	14	17
North Dakota	-	-	4	-	2	27	1	-	-	-	-	-	1	-	1	-	-	10	-	-	-	-	-	-	-	-	-	46	7	36	7	36
Ohio	-	-	1	-	-	2	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	4	3	4	3
Oklahoma	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	10	3	8	3	8
Oregon	-	-	32	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	35	3	32	3	32
Pennsylvania	-	-	1	-	-	-	2	-	-	-	3	1	-	-	1 <sup>c</sup>	1	-	-	3	-	-	-	1	-	-	-	-	13	8	9	8	9
South Dakota	-	-	4	-	2	24	1	-	-	-	-	-	1	-	-	-	-	33	-	-	-	-	-	-	-	-	-	65	6	48	6	48
Texas	-	1	17	-	3	11	25	-	-	-	1	-	-	-	18	6	-	-	12	-	-	-	-	-	-	-	-	94	9	65	9	65
Virginia	-	-	2	-	-	1	2	-	-	-	-	-	-	-	1 <sup>c</sup>	-	-	-	1	2 <sup>d</sup>	-	-	-	-	-	-	-	9	7	8	7	8
Washington	1	-	27	-	-	-	1	-	1	-	-	1	-	-	-	1	1	1	4	-	-	-	-	1	-	-	-	40	11	32	11	32
Wisconsin	-	-	1	-	-	2	1	-	-	-	2	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	12	5	7	5	7
Wyoming	-	-	2	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	8	-	-	-	-	-	-	-	-	13	5	9	5	9
Totals	1	2	181	1	14	138	110	1	1	1	15	3	6	1	39	12	5	1	1	284	12	1	1	1	1	1	1	775	27	566	27	566
Percentage of isolates	0.1	0.3	24.4	0.1	1.2	14.2	0.1	0.1	0.1	0.1	1.9	0.4	0.6	0.1	5.1	0.7	0.1	0.1	0.1	1.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	100.0	0.1	100.0	0.1	100.0

<sup>a</sup> Included 1 isolate of the 11-12 group. <sup>b</sup> Includes 2 isolates each of 59A and 59B. <sup>c</sup> Identified in 20-1<sup>a</sup> group. <sup>d</sup> Includes 1 isolate of 59A.



Table 2. Regional distribution of the 9 most prevalent races and subraces of *Puccinia graminis* var. *tritici* in the United States in 1958.

Region <sup>a</sup>	Race and percentage of total isolates									
	11	15	15B	17-29 <sup>b</sup>	38	48A	48B	56	59	Other
Inland										
Empire	78.5	-	-	2.5	-	2.5	3.3	6.7	-	6.5
Spring										
wheat	8.9	4.8	45.2	2.4	0.6	-	-	36.3	-	1.8
Hard red										
winter wheat	13.1	1.1	14.2	14.6	8.4	2.3	-	44.4	-	1.9
Soft red										
winter wheat	15.0	0.7	12.9	42.1	8.2	1.4	0.7	19.0	-	0.0
East-										
central	8.9	-	2.2	22.3	6.7	2.2	-	11.1	26.8	19.8
Percentage of total isolates (U.S.)	23.4	1.8	17.8	16.1	5.1	1.7	0.7	28.9	1.6	2.9

<sup>a</sup> Inland Empire includes Idaho, Oregon, and Washington.

Spring wheat region includes Minnesota, South Dakota, and North Dakota.

Hard red winter wheat region includes Colorado, Iowa, Kansas, Missouri, Nebraska, Oklahoma, Texas, Wisconsin, and Wyoming.

Soft red winter wheat region includes Illinois, Indiana, Michigan, and Ohio.

East-central region includes New York, Pennsylvania, and Virginia.

<sup>b</sup> Includes 17-29 race group and race 29.

There also was a shift in prevalence of lines of 15B, which are identified on certain supplemental differential varieties. Golden Ball, for instance, was susceptible to 70 percent of 138 isolates of 15B studied in 1958, in contrast to 40 percent of the 342 isolates studied in 1957. The lines of 15B to which Golden Ball was susceptible in 1958 are especially virulent on the durum, Ramsey and Towner; and those to which Golden Ball was resistant are virulent on Langdon durum. The fluctuation in prevalence of lines within 15B during the last 3 years, as shown by the reaction of Golden Ball, is given in Table 3.

The 17-29 race group, which comprises races 17, 29, and 37, increased from 9 percent in 1957 to 16 percent in 1958 and was found in 21 of 28 States sampled. It was prevalent in Texas and constituted 42 percent of the isolates from the soft red winter-wheat area (Table 2). The prevalence of this race group in early-spring collections in Mexico and Texas indicates the possibility of this area as a source of rust for Illinois, Indiana, Michigan, and Ohio. The only isolates of this race from the spring-wheat area came from screening varieties in nurseries.

As supplemental differential varieties are becoming increasingly important in detecting new and virulent rust cultures, the following wheats, in addition to the 12 standard differentials, were inoculated with all collections of rust identified in 1958: Lee (C. I. 12488), Bowie (Texas Sel. 3708-22), Selkirk (C. I. 13100), Golden Ball (C. I. 5059), Kenya Farmer (C. I. 12880), Frontana x (Kenya 58-Newthatch) (Line II-50-17) (C. I. 13155). In addition, 22

Table 3. Percentage prevalence of lines of 15B differing in ability to attack Golden Ball.

Year	Total number of isolates	Susceptible	Resistant
1956	302	71	29
1957	342	40	60
1958	138	70	30

supplemental test varieties were inoculated with selected isolates of certain races. Some of these varieties appear to be useful in differentiating biotypes or subraces; other do not. Results will be published separately.

#### New Virulent Isolates

A culture of race 34 which can attack both seedlings and adult plants of Selkirk at moderate temperature (75° F) was isolated from adult Selkirk plants in the nursery at St. Paul. Although this race was identified only six times in 1958 -- once each from Minnesota, North Dakota, South Dakota, Nebraska, Kansas, and Wyoming -- it has potential virulence for Selkirk, which now occupies about 85 percent of the bread-wheat acreage in Minnesota, South Dakota, and North Dakota.

A culture of subrace 48A isolated from a field collection of rusted wheat near Manns Choice, Pennsylvania can attack seedling plants of certain lines of the variety Frontana x (K58-Newthatch), heretofore known as one of the most resistant wheats in the International Stem Rust Nurseries. Seven lines of this variety<sup>8</sup> were inoculated with the variant of 48A at 65°, 75°, and 85° F. Approximately half the plants of lines II-50-17 and II-50-25 -- the only widely grown lines -- were susceptible; and nearly all plants of line II-50-32 were susceptible. The other four lines, II-50-16, 21, 29, and 35, were immune or showed only necrotic flecks. No differences in rust reaction were evident at the three temperatures.

A culture of race 15 was isolated from durum St. 464 in the St. Paul nursery to which seedlings of line II-50-17 of the variety Frontana x (K58-Newthatch) are moderately susceptible (infection types 2 to 3). The six other lines of the variety were highly resistant. Several other cultures of race 15, which can be differentiated on Golden Ball, are able to attack the bread-wheat Willet and durums Ramsey, Langdon, and Yuma.

Cultures of race 15B also were obtained from nursery collections of the varieties CT 231 and ND 140, both of which are used as sources of stem-rust resistance in the spring bread-wheat-breeding program. These isolates will be studied further.

#### Races in the Inland Empire of the Pacific Northwest

From 10 aecial and 103 uredial collections of wheat stem rust on barberry, grains, and grasses in northeastern Oregon, eastern Washington, and contiguous sections of Idaho, 138 isolates of 15 races or subraces were identified. Race 11 comprised 91 percent of the uredial isolates in Oregon, 78 percent in Idaho, and 68 percent in Washington. This race also was destructive on certain varieties at Creston, British Columbia, according to the Canadian Department of Agriculture<sup>9</sup>. Prevalence of other races in the Inland Empire is shown in Table 2.

The following 6 of the 15 races were not found elsewhere in the United States in 1958: 1, 36, 44, 49, 54, and 133. In previous years, also, various races were identified from the In-

<sup>8</sup> Seed furnished by E. R. Ausemus.

<sup>9</sup> Peturson, B., G. J. Green, and D. J. Samborski. 1959. Cereal rusts in Canada in 1958. Canada Dept. Agr. Res. Lab., Winnipeg, Man., Plant Pathology Report 14.

land Empire and not elsewhere. Race 1, for example, was found only in the Inland Empire in 6 of the 20 years preceding 1958.

From 10 aecial collections, 18 isolates were identified, comprising 10 races: race 1, collected three times in Oregon; race 11, which was found in both Oregon and Washington; and races 24, the 17-29 group, 29, 32, 44, 48 and 48A, and 56.

#### OAT STEM RUST

From 234 collections, 7 races and 1 subrace of P. graminis var. avenae were identified among 286 isolates (Table 4). For the ninth consecutive year race 7 was predominant, although

Table 4. Physiologic races of Puccinia graminis var. avenae isolated from uredial collections in the United States in 1958.

State	Race and number of times isolated								Total number of --		
	2	5	6	7	7A	8	10	12	Iso- lates	Races	Collec- tions
California	-	-	-	-	-	3	-	-	3	1	3
Idaho	-	-	-	-	-	1	1	-	2	2	2
Illinois	3	-	-	10	-	1	-	-	14	3	10
Indiana	-	-	-	4	2	2	-	-	8	3	5
Iowa	5	-	1	40	2	4	1	-	53	6	48
Kansas	1	-	-	10	1	1	-	1	14	5	12
Michigan	3	-	-	11	-	8	-	-	22	3	18
Minnesota	7	1	-	28	3	24	-	-	63	5	50
Missouri	1	-	-	1	-	4	-	-	6	3	6
New York	4 <sup>a</sup>	-	1	11 <sup>b</sup>	-	2	-	1	19	5	14
North Dakota	4	-	-	5	1	1	-	-	11	4	8
Pennsylvania	-	-	-	2	-	-	-	-	2	1	2
South Dakota	6	-	-	17	3	15	-	-	41	4	34
Texas	1	-	-	4	1	-	-	-	6	3	5
Virginia	1	1	-	-	-	-	-	-	2	2	2
Washington	-	-	-	1	-	-	-	-	1	1	1
Wisconsin	2	-	1	9	-	7	-	-	19	4	14
Totals	38	2	3	153	13	73	2	2	286	8	234
Percentage of isolates	13.3		1.0		4.5		0.7				
		0.7		53.5		25.6		0.7	100.0		

<sup>a</sup> Isolated also from 1 aecial collection.

<sup>b</sup> Isolated also from 3 aecial collections.



Table 5. Physiologic races of *Puccinia graminis* var. *tritici* isolated from aecial collections in the United States in 1958.

State	Race and number of times isolated																	Total number of		
	:																	: Iso-		
	1	11	15	29	17-	23	24	29	32	38	44	48	48A	53	56	59	111	lates	Races	Collec- tions
Idaho	-	-	-	1	-	-	1	-	-	-	-	1	1	-	-	-	-	4	4	2
Illinois	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Iowa	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	3	3	2
Montana	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	2	2	1
New York	-	3	1	2	1	-	-	-	-	-	-	-	-	-	-	2	1	10	6	9
Oregon	3	1	-	2	-	-	2	1	1	-	2	-	-	-	1	-	-	13	8	7
Pennsylvania	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	2	3
Virginia	-	-	-	1	-	-	1	-	-	1	-	-	-	1	-	-	-	4	4	2
Washington	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Wisconsin	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1
Totals	3	8	3	7	1	4	2	2	2	2	2	3	1	1	1	2	1	43	16	29
Percentage of isolates	7.0	18.7	7.0	16.4	2.3	9.4	4.6	4.6	4.6	4.6	4.6	7.0	2.3	2.3	2.3	4.6	2.3	100.0		

it decreased slightly from the previous year. Race 7 (combined with 12) comprised 54 percent of the uredial isolates; race 8 (with 10), 26 percent; race 2 (with 5), 14 percent; subrace 7A, about 5 percent; and race 6, 1 percent. Race 13 and its virulent subrace 13A were not found in 1958, although they were reported in eastern Canada<sup>9</sup>. Compared with 1957 percentages, those for 1958 represent a decrease of 5 percent for race 7 (with 12), an increase of 5 percent for race 8 (with 10), and an increase of 2 percent for race 2 (with 5).

Subrace 7A, which can attack oat varieties, such as Rodney, with the so-called "Canadian type" of stem-rust resistance at both low and high temperatures, decreased in prevalence by about 2 percent in 1958. Distribution was less extensive also: it was found in 7 States, as compared with 11 in 1957.

Race 8 was identified for the first time in California collections in 1958. The oat varieties Indio and Ventura, which have the Richland type of resistance, were severely damaged in the northern part of the State, especially in Lassen, Modoc, Shasta, and Siskiyou Counties<sup>10</sup>. Heretofore these varieties were very resistant throughout California.

Race 6 was identified once each from Iowa, Wisconsin, and New York. This is the fourth consecutive year in which this race has been found outside the barberry-infested areas of northeastern United States. It was found once in Missouri in 1955 and again in 1956, twice in Texas and once in Wisconsin in 1957. It now appears that this race may have become established independently of barberry.

The following varieties of oats, in addition to the standard differentials, were inoculated with all collections of rust from which identifications were made in 1958: Rodney (R. L. 2123), Burnett (C.I. 6537), Landhafer x (Mindoo x H-J) x Andrew (C.I. 7144 and 7145), Minnesota '53 Ag. 354, Minnesota Selection II-47-11, Clinton<sup>2</sup> x Ark. 674 (C.I. 6643), and Saia (C.I. 4639).

#### RUST FROM BARBERRY

Sixteen races and subraces, or biotypes, of wheat stem rust were identified in 29 aecial collections on barberry, a ratio of 1 race to each 1.8 collections (Table 5). In the 43 isolates identified, race 11, the 17-29 group, and race 24 occurred most frequently. The following races were found only on barberry or in barberry-infested areas in 1958: 1, 23, 24, 44, 48, 53, and 111.

Two races of oat stem rust were identified in four aecial collections from New York: race 2, once; race 7, three times.

PLANT PEST CONTROL DIVISION AND CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, IN COOPERATION WITH THE MINNESOTA AGRICULTURAL EXPERIMENT STATION, ST. PAUL, MINNESOTA

<sup>10</sup> According to C. W. Schaller, Davis, California.







# THE PLANT DISEASE REPORTER

Issued By

CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

PAPERS PRESENTED AT THE COTTON DISEASE COUNCIL AT  
HOUSTON, TEXAS, DECEMBER 16, 1958

Supplement 259

August 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



THE PLANT DISEASE REPORTER

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

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## PROGRESS WITH PROBLEMS IN COTTON DISEASE CONTROL<sup>1</sup>

Albert L. Smith<sup>2</sup>

Cotton disease loss estimates show a year to year variation from 10 to 14 percent or 1 1/2 to 2 million bales during the 6-year period, 1952 to 1957. The money value of this loss in seed and lint in recent years averaged about 300 million dollars. The reduction of these over-all losses and elimination of serious losses to individual growers is a real challenge to plant pathologists and other scientists.

To define the problems in cotton disease control, surveys of disease losses have been made annually in 14 major cotton-producing States since 1952. P. J. Leyendecker, 1952 to 1956; and Harlan E. Smith, 1956 to the present time, as chairman of the Cotton Disease Losses Committee of the Cotton Disease Council, assembled and compiled the estimates that were the cooperative efforts of cotton State pathologists and agronomists. The loss estimates have been published annually in the Plant Disease Reporter and summaries were published for the 1952 to 1955 and 1952 to 1956 periods (1, 2). Loss data reported here cover the 1952 to 1957 period.

### DISEASE LOSS ESTIMATES

The relative importance of the seven major cotton diseases is illustrated in Figure 1, by the average annual loss in bales resulting from each disease.

Seedling diseases, boll rots, and bacterial blight, which are found from coast to coast, are of greatest importance. Verticillium wilt, root-knot, Fusarium wilt, and root rot are diseases of more limited distribution. Several diseases causing smaller losses are not reported here.

### REGIONAL DISTRIBUTION OF DISEASE LOSSES

Disease losses are grouped according to the three major cotton-producing regions, which are largely determined by climate and soil type. These regions are the Southwestern, composed of California, Arizona, New Mexico, Texas, and Oklahoma; the Mississippi Valley, with Louisiana, Mississippi, Arkansas, Missouri, and Tennessee; and the Southeastern, composed of Alabama, Georgia, South Carolina and North Carolina. The relative importance of losses caused by major diseases for the three regions is shown in Table 1. The data indicate that losses are slightly higher in the Southeastern region, 9.09 percent, as compared with the Southwestern region, 8.96 percent, and the Mississippi Valley, 8.63 percent. The greater losses in the Southeastern region may be partially attributed to effects of environment.

Seedling disease losses predominate in all three regions. The Southwest is characterized by high losses from root rot, Verticillium wilt, and bacterial blight, with nematodes and boll rots of secondary importance (Table 1). In the Mississippi Valley, Fusarium wilt and boll rots are of major importance, with Verticillium wilt and bacterial blight of secondary rank. The major causes of loss in the Southeast are boll rots and nematodes, followed by Fusarium wilt and bacterial blight.

Cotton disease losses have paralleled the westward shift in cotton production. The percentages of total production for the three regions are as follows: Southwestern 45.1, Mississippi Valley 33.5, and Southeastern 21.4. The corresponding percentages of total disease losses from eight diseases for the three regions are 45.5, 32.4, and 22.0, respectively.

In the Mississippi Valley region the overlapping distribution of eastern and western types of diseases sometimes creates a severe disease situation, best illustrated by the loss estimates for Missouri in 1957 (Table 2). Root rot was the only major disease not prevalent in Missouri. This 1957 disease loss report of 32.6 percent was the highest loss estimate in the 83 State reports made during the period from 1952 to 1957.

<sup>1</sup> Paper presented to the Cotton Disease Council, Houston, Texas, December 14 and 15, 1958.

<sup>2</sup> Plant Pathologist, United States Department of Agriculture, Agricultural Research Service, Crops Research Division, Cotton and Cordage Fibers Research Branch, Cooperative with Agronomy and Soils Department, Alabama Polytechnic Institute, Agricultural Experiment Station, Auburn, Alabama.

Table 1. Average annual loss, in bales, percentage reduction in yield, and dollar value, resulting from major cotton diseases in 14 States; regional and United States summary for the 6-year period 1952 to 1957.

Disease causing loss	: Southwestern :		: Mississippi :		: Southeastern :		: United States totals :	
	: 1000 :		: 1000 :		: 1000 :		: 1000 :	: Million :
	bales : Percent :	bales : Percent :	bales : Percent :	bales : Percent :	bales : Percent :	bales : Percent :	bales : Percent :	dollars <sup>a</sup>
1. Seedling diseases ( <u>Rhizoctonia</u> , <u>Pythium</u> , etc.)	175	2.12 <sup>b</sup>	131	2.15	96	2.44	402	2.20
2. <u>Boll-rots</u> ( <u>Glomerella</u> , <u>Diplodia</u> , etc.)	63	0.76	125	2.05	87	2.22	275	1.51
3. <u>Bacterial blight</u> ( <u>Xanthomonas malvacearum</u> )	139	1.69	51	0.84	33	0.84	223	1.22
4. <u>Verticillium wilt</u> ( <u>Verticillium albo-atrum</u> )	142	1.72	52	0.85	2	0.05	195	1.07
5. <u>Root-knot nematode</u> ( <u>Meloidogyne</u> spp.)	70	0.85	34	0.56	87	2.22	192	1.05
6. <u>Fusarium wilt</u> ( <u>Fusarium oxysporum f. vasinfectum</u> )	3	0.04	131	2.15	46	1.17	180	0.99
7. <u>Root rot</u> ( <u>Phymatotrichum omnivorum</u> )	144	1.75	tr	tr	0	0	144	0.79
8. <u>Ascochyta blight</u> ( <u>Ascochyta gossypii</u> )	3	0.04	2	0.03	7	0.18	12	0.07
Totals, lost	739	8.96	526	8.63	358	9.09	1,623	8.88
Totals, harvested	7,503		5,567		3,570		16,640	
Totals, harvested and lost	8,242		6,093		3,928		18,263	

<sup>a</sup> Lint calculated at \$160 per bale and seed at \$55 per ton.

<sup>b</sup> Percentages calculated from total bales harvested and lost, divided into bales lost.

Table 2. Cotton losses in Missouri for 1957, a year of maximum loss for any State during the survey period 1952 to 1957.

Disease causing loss	:Reduction in yield :		Value of seed and lint (1000 dollars)
	: Percent :	: Number of bales :	
		: of bales :	
1. Boll rots	11.0	35,090	6,246 <sup>a</sup>
2. Fusarium wilt	8.0	25,520	4,543
3. Bacterial blight	7.0	22,330	3,975
4. Verticillium wilt	2.5	7,975	1,420
5. Root-knot nematode	2.0	6,380	1,136
6. Seedling diseases	1.1	3,509	625
7. Ascochyta blight	1.0	3,190	568
Total losses	32.6	103,991	18,510
Harvested		215,000	38,270

<sup>a</sup> Lint calculated at \$160 per bale and seed at \$45 per ton.

Table 3. Average annual cotton disease losses, 1952 to 1957, from diseases for which (a) disease resistance, or (b) cultural practices, chemicals and other control measures, might be utilized or developed.

	: : Percentage : : reduction : : in yield :	: : Losses in : : bales : :(1000 bales) :	: : Losses in : : crop value: (million : : dollars) :	: : Percentage : of total : disease loss
(a) Control by disease resistance				
1. Bacterial blight	1.22	223	41	13.7
2. Verticillium wilt	1.07	195	35	12.0
3. Root-knot nematode	1.05	192	35	11.8
4. Fusarium wilt	0.99	180	33	11.1
Totals	4.33	790	144	48.7
(b) Control by cultural practices, chemicals, etc.				
1. Seedling diseases	2.20	402	73	24.8
2. Boll-rots	1.51	275	50	16.9
3. Root-rot	1.75	144	26	8.9
4. Ascochyta blight	0.07	12	2	0.7
Totals	5.53	833	151	51.3

### THE METHODS OF DISEASE CONTROL

Methods of disease control may be divided into two categories, (a) breeding for resistance, and (b) control by cultural practices, chemicals, and other methods (Table 3). Bacterial blight, Verticillium wilt, root-knot, and Fusarium wilt, which together account for 48.7 percent of the estimated losses, can be controlled most satisfactorily by developing resistant varieties. Seedling diseases, boll rots, root rot, and Ascochyta blight, which cause 51.3 percent of the losses, are controlled at present by methods other than breeding. These categories are not strictly defined, as root-knot nematode at present is partially controlled with soil fumigants. Seedling diseases may some day be partially controlled by developing cold-tolerant and disease-resistant varieties.



## PROGRESS IN DISEASE CONTROL

Seedling diseases, which account for approximately 25 percent of the total cotton disease losses, constitute a highly complex problem involving seed quality, soil texture, climate, soil- and seed-borne pathogens, fungicides, machines, and the vagaries of human nature, spread over a geographical expanse of 3000 miles. Progress in controlling seed-borne anthracnose has been the most spectacular development. Emergence of seedlings has been improved about 30 percent throughout the rainbelt. This phase of the work is essentially complete now, with the widespread adoption of fungicidal seed-treatment throughout the cotton belt. The major remaining seedling losses are attributed to soil-borne pathogens, such as Rhizoctonia, Pythium, Fusarium, and others. Excellent progress is being made in the development of satisfactory fungicides for in-furrow application. However, only about 200,000 acres are currently being planted with in-furrow fungicide treatments. The more basic problems, concerning the pathogens involved, seed deterioration, cold tolerance, and specificity of fungicides, are under investigation and further progress in seedling disease control is anticipated.

Serious boll-rot losses are largely dependent on weather conditions at the critical opening period. Boll rots account for 17 percent of the total disease loss. Probably this loss will not be measurably reduced in the near future. However, some decrease may be anticipated from the widespread development of bacterial blight-resistant varieties. Improvement of insecticides leading to reduction in number of insect wounds would also decrease boll-rot losses moderately.

Bacterial blight offers the best opportunity of any cotton disease for complete control in the immediate future. Although the blight breeding work has been under way for less than 20 years the varieties Acala 1517 BR, Austin, Blightmaster, and Rex, all resistant to Race 1, have been released. The appearance and rapid buildup of Race 2 of the blight pathogen has nullified a part of the value of these early releases. However, the importation of B<sub>2</sub>, B<sub>3</sub> from Knight's Sudan collection by Luther Bird of Texas A & M College, and their crossing into a number of commercial types, has provided a means for developing varieties resistant to both Race 1 and 2. Within the near future, new blight-resistant varieties will be widely available and blight losses thus markedly reduced, if not eliminated.

Verticillium wilt is a relatively new disease of cotton but it has spread rapidly. Losses fluctuate widely with temperature and rainfall. No major breakthrough in locating resistant genes has been accomplished. However, each year some improvement in Verticillium tolerance of varieties has been reported from several locations. Evidence indicates that resistance is controlled by minor genes, consequently progress will be slower than with diseases where fewer genes are involved.

Cotton root-knot nematode losses constitute a major problem in the Southeastern region. These losses have only recently been recognized because of the nature of the wilt-nematode complex. The widespread planting of Fusarium-resistant varieties has reduced wilt losses, whereas rootknot losses remain. Root-knot losses are of sufficient importance in the Southwestern and Mississippi Valley regions to indicate that all commercial varieties need improvement for resistance. Cleve wilt 6 and Auburn 56 are Upland commercial types with superior root-knot tolerance. Sources of high resistance are available in wild types of Gossypium barbadense and G. hirsutum. Root-knot resistance, being polygenic and recessive, will be difficult and time-consuming to transfer to commercial types.

Progress in the control of Fusarium wilt is illustrated by the percentage of total acreage planted (3) to resistant varieties (Fig. 2). The reduction in loss by use of resistant varieties in the Southeastern region is shown in the estimates (Table 1). At the present time, the greatest losses from Fusarium wilt are reported in the Mississippi Valley, where the disease became established relatively late and is still increasing in severity. Locally adapted resistant varieties are not yet available. Further progress in reducing wilt losses in the Southeastern region can be made only by improving the nematode resistance of varieties grown on wilt-infested soils. The importance of root-knot nematode tolerance in reducing wilt losses was amply demonstrated in the wide testing of the root-knot tolerant variety Auburn 56.

Cotton root-rot has caused some abandonment of cotton culture in certain areas, particularly the Blackland Prairies of Texas. Although biological control of root-rot through crop rotation was developed, difficulty was encountered in obtaining grower acceptance of the practice. At the present time, only limited progress can be reported in the control of root-rot.

# AVERAGE COTTON DISEASE LOSSES, 1952-1957

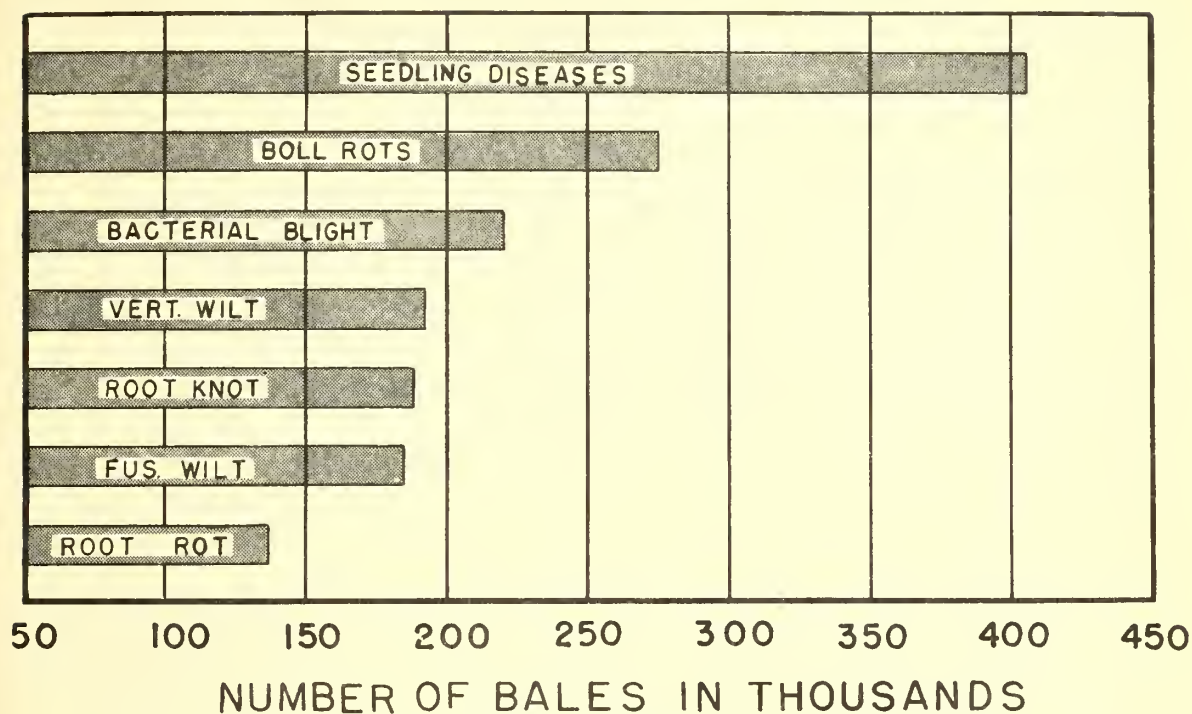


FIGURE 1. Reduction in bales from full yield caused by major cotton diseases, averages for the 6-year period 1952 to 1957, United States.

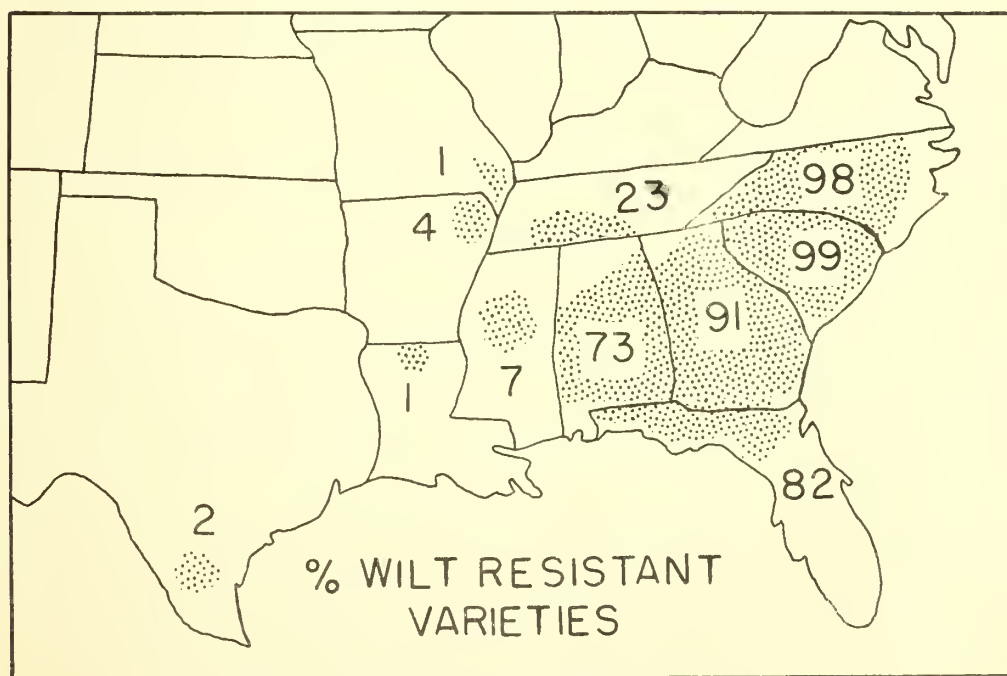


FIGURE 2. Percentages of total cotton acreage planted to Fusarium wilt-resistant varieties in States where wilt is established, 1958.

## CONCLUSION

In conclusion, the importance of the continued gathering and tabulation of disease survey information should be emphasized. Accurate estimates of disease losses over a period of years become invaluable to the worker in the field, the director of programs, and the administrator of funds as a yardstick for measuring progress. Pathologists working with cotton have the responsibility to make the most accurate disease loss estimates possible.

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## VALUE OF COTTON SEEDLING DISEASE CONTROL

Dow D. Porter, L. S. Bird and N. B. Smith<sup>1</sup>

### Abstract

In-furrow fungicides were applied at planting to control the seedling disease complex of cotton. Plots where the disease was controlled were compared with control plots to determine the loss caused by seedling disease. Under disease conditions severe enough to cause reduced stands a net return of \$27 per acre was measured where the disease was controlled. When disease conditions were not severe enough to cause reduced stands but did cause root injury a net return of \$4 per acre was measured. Also where the disease was controlled the crop was earlier than where the disease was present. For a 2-year period an average net return of \$15 per acre was obtained where replanting was not necessary and an average of \$20 per acre where replanting would have been necessary, by using in-furrow fungicide applications for cotton seedling disease control. The tests were conducted under dry-land conditions where the average yield is about two-thirds of a bale per acre.

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The seedling disease complex of cotton causes a yield loss of at least 2.5 bales for every 100 bales ginned in the United States. It is a major disease which is caused by several soil-borne fungi, among which the more important are Rhizoctonia solani Kuehn, Fusarium spp., and Pythium spp.

The seedling disease complex may be subdivided into four phases: seed rot, seedling root-rot, pre-emergence damping-off, and post-emergence damping-off. Seed rot may be controlled by proper seed treatment with any one of the approved materials. Seed treatment alone has very little, if any, effect on controlling seedling root-rot, pre-emergence or post-emergence damping-off. The zone of protection conferred by the seed protectant is too limited to prevent infection after rupture of the seed coat. Efforts have been made to protect the seedling from the seed zone to the soil surface by mixing fungicides into the covering soil at planting. This method, which proved effective, is recommended for use in controlling the seedling disease complex (1).

In-furrow fungicide application has provided a tool for evaluating losses caused by the disease. Under field conditions the disease is controlled by fungicides and these plots are compared with plots where the disease is not controlled.

In-furrow tests have been conducted at the U. S. Cotton Field Station, Greenville, Texas since 1956. The stand results and methods of application have been reported elsewhere (1, 2). Yield data were taken from the 1957 and 1958 tests.

### RESULTS OF IN-FURROW FUNGICIDE APPLICATION TESTS

The results of the 1957 test are given in Table 1. The fungicide mixtures of 1.5 pounds captan plus 2 pounds zineb plus 1.5 pounds PCNB, 3 quarts nabam plus 0.5 quarts Ceresan 100, and 2 pounds Omadine 1563 plus 3 pounds PCNB gave an average yield 32 percent higher than the yield for the control. Allowing \$6 per acre for the cost of applying the chemicals, the net return for controlling cotton seedling disease was \$27 per acre. Increased yields tended to be associated with increased stands due to disease control. The one exception was nabam, which maintained a stand of 26,000 plants per acre but resulted in a yield that was lower although not significantly so.

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Table 1. Yield data for 1957 Greenville test-1 for evaluating fungicides mixed with the covering soil for cotton seedling disease control.

Fungicides	Rates per acre	Final stand per acre <sup>a</sup>	Yield, seedcotton per acre (pounds)	Yield value <sup>b</sup> per acre (dollars)	Percent gain over control <sup>c</sup>
Captan+Zineb+PCNB	1.5#+2#+1.5#	27	1258	138	35
Nabam+Ceresan 200	3 qts.+0.5 qts.	19	1219	134	31
Omadine 1563+PCNB	2#+3#	18	1205	133	30
Vancide 51	4 qts.	14	1126	124	22
PCNB+Captan+Omadine 1563	2#+2#+1#	14	1120	123	21
Nabam	4 qts.	26	1115	123	21
Captan+PCNB+Ceresan 200	2#+2#+0.25 qt.	14	1070	118	16
Control	--	6	927	102	--
L.S.D. .01		9	256		
.05		6	191		

<sup>a</sup> In thousands of plants.<sup>b</sup> Based on 11 cents per pound for seedcotton.<sup>c</sup> The top three treatments have an average gain over the control of 32%. For a cost of \$6 per acre a net return of \$27 per acre in yield was obtained. These and other factors such as not having to replant and the fact that replanted areas around the test area yielded less than the test control point out the importance of seedling disease control.

Table 2. Stand, yield and root data for the in-furrow fungicide test conducted at the U. S. Cotton Field Station, Greenville, Texas. 1958.

Fungicides	Rates per acre	Stand <sup>a</sup>	Total <sup>b</sup> yield	Yield <sup>b</sup> first harvest	Yield <sup>b</sup> second harvest	First harvest, percent of total	Percent healthy roots	Return per acre <sup>c</sup> (dollars)
Captan+Phaltan	2#+2#	46.2	839	305	534	36.4	80	62.88
Maneb+Ceresan 100	3#+0.5 qt.	39.8	821	259	561	31.5	82	61.14
Captan+PCNB	2#+2#	43.0	809	287	523	35.4	77	60.36
Nabam	4 qts.	41.5	799	255	546	31.8	74	59.30
Maneb	5#	50.7	795	272	523	34.2	74	59.18
Captan+PCNB+Zineb+Ca Cl <sub>2</sub>	1.5#+1.5#+2#+10#	45.0	788	238	550	30.2	69	58.37
Captan+PCNB+Thiram	1.5#+1.5#+1.5#	38.5	787	216	571	27.4	72	58.12
Captan+PCNB+Zineb	1.5#+1.5#+2#	53.7	777	261	516	33.6	77	57.70
Acti-dione+PCNB+FeSO <sub>4</sub>	3+11.43+3.75 ozs.	29.0	767	206	561	26.9	81	56.48
Nabam+Ca Cl <sub>2</sub>	4 qts.+10#	37.8	761	223	539	29.2	70	56.11
Captan+PCNB+Zineb+G.A.	1.5#+1.5#+2#+0.2 gm.	34.3	739	257	481	34.8	77	54.73
Control	--	39.7	698	154	546	21.9	67	55.61
Control, replant	--	54.8	660	23	637	3.5	97	46.67
L.S.D. .01		13.3	91	73	70	--	--	--
.05		10.0	69	55	52	--	--	--

<sup>a</sup> Average number of seedlings per 26.2 row feet.<sup>b</sup> Pounds seed cotton per acre.<sup>c</sup> Where the gross return is adjusted for harvesting, replant and treatment cost. Initial planting, cultivating and insect control costs were not considered. Return value is based on 11 cents per pound for seed cotton.



FIGURE 1. Root systems of plants from treated plots on right and from the control plots on left. Branching from the main stem occurred closer to the soil line on plants from the treated plots.

The results of the 1958 experiment are given in Table 2. In this test a replant control was obtained by making a planting 3 weeks after the main test planting. The test was planted April 25 and the replant control was planted May 14. The disease was not severe enough to cause real differences in stand. There was a definite trend for the better treatments to give higher total yields than the controls. All treatments gave a significantly higher yield than the controls in the first harvest. The replant control gave the higher yield in the second harvest. The second harvest yields for the treatments and the regular control were about the same. The treatment plots tended to be about 10 percent earlier than the regular control and about 28 percent earlier than the replant control.

The root systems of the plants were examined. There was a trend, although not a significant one, for the plants in the treated plots to have healthier root systems than the regular control. Plants from the replant control definitely had healthier roots. A comparison of the root systems is shown in Figure 1.

The chemical treatments gave about a \$4 per acre net return over the regular control and a \$13 per acre net return over the replant control.

#### DISCUSSION

In-furrow fungicide application at planting for cotton seedling disease control not only helps to maintain adequate uniform stands but produces a final stand composed of seedlings with healthier root systems. Seedlings with healthy root systems grow off faster than seedlings with damaged root systems. As shown by the 1958 test results this gives an earlier crop. Where the necessity for replanting is avoided through disease control the crop is considerably earlier, as shown by comparing the regular and replant controls.

For the 2-year period at the Greenville station, an average increase in income per acre by controlling seedling disease amounted to about \$15 per acre where replanting was not necessary and about \$20 per acre where replanting would have been necessary. The average yield for the 2-year period was about two-thirds of a bale per acre. Therefore, this amounts to a 15 to 20 percent increase in income by controlling seedling disease.

The seedling disease situation on the Greenville station during 1957 and 1958 was typical of the Greenville, Corsicana, Dallas, and McKinney areas. If seedling disease had been controlled



by in-furrow fungicide application the cotton farmers in the area would have had an additional \$ 15 to \$20 per acre income. Therefore, the growers and the general agricultural business of the area would have been much better off financially. This is an area where cotton seedling disease is a problem 4 out of every 5 years.

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TEXAS AGRICULTURAL EXPERIMENT STATION, AND UNITED STATES  
DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

POTASSIUM GIBBERELLATE AND OTHER SEED TREATMENTS FOR  
CONTROLLING COTTON SEEDLING DAMPING-OFF<sup>1</sup>

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Abstract

Potassium gibberellate, Panogen (methyl-mercury dicyandiamide), Dow 9-B (zinc 2, 4, 5-trichlorophenoxide), and five Dow experimental seed treating chemicals of unknown composition were tested for ability to control cotton seedling damping-off. In four field tests no advantages were noted from treating cotton seed of three varieties with potassium gibberellate. There was a general tendency toward decrease in stand from seed treatment with potassium gibberellate, and in one case this treatment gave a stand significantly below that of the nontreated check. Panogen gave significantly higher stands when compared with the nontreated check. No significant differences were found between the stands from seed treated with Dow 9-B and nontreated seed. No significant differences were found between any of the Dow chemicals of unknown composition and the nontreated check, except chemical number 2 in a single test. In a greenhouse test potassium gibberellate used as an in-the-furrow treatment reduced pre-emergence damping-off significantly but showed no post-emergence disease control.

INTRODUCTION

Gibberellic acid and its derivatives, though known for over 20 years, have been intensively studied in the United States only within the last few years (4). This plant hormone induces early seed emergence and accelerates the growth of many vegetable and ornamental plants. It was thought that cotton seed treated with the potassium salt of gibberellic acid might increase emergence of cotton seed under cool, wet conditions, as well as stimulate the growth of cotton seedlings. The rapid growth might prevent or decrease the incidence of cotton seedling damping-off under field conditions. Four field trials and a greenhouse test were carried out in the spring of 1958 to test the effects of potassium gibberellate and other seed treating materials on cotton seedling damping-off.

The chemicals tested were: the potassium salt of gibberellic acid (P. G.), Panogen (methyl-mercury dicyandiamide), Dow 9-B (zinc 2, 4, 5-trichlorophenoxide), and five Dow experimental seed treating chemicals of unknown composition.

FIELD TRIALS

The field trials were located at the Northeast Louisiana Experiment Station, St. Joseph, and the Red River Valley Experiment Station, Curtis. The plots were completely randomized in replicated blocks. The first test at St. Joseph used reginned Deltapine Smoothleaf seed treated with P. G.; Dow 9-B; Dow seed treatments 2, 6, 7 and 9; and a nontreated check. The second test consisted of four treatments: P. G.; Panogen, P.G. plus Panogen; and a nontreated check. Reginned Stardel cotton seed was used. The first test at Curtis used reginned Deltapine Smoothleaf seed treated with P. G.; Dow 9-B; Dow seed treatments 2, 6, 7, 8, and 9; and

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a nontreated check. The second test at Curtis used reginned Deltapine 15 cotton seed treated with P. G., Panogen, P. G. plus Panogen, and a nontreated check. P. G. was applied as a dust at the time of planting at the rate of 1 gram active ingredient to 100 pounds of seed; Dow 9-B at 3 ounces per 100 pounds of seed; and Panogen at 3 ounces per 100 pounds of seed. The tests at both locations consisted of two-row plots. Stand counts were taken on 100 feet of row for each treatment 2 weeks after planting at St. Joseph and 3 weeks after planting at Curtis.

### FIELD RESULTS

Stands of cotton were generally poor because of relatively low seed viability and cool, wet weather conditions. In both locations seedling damping-off was marked throughout all plots. At St. Joseph, cotton seed treated with Panogen alone gave a significantly higher stand than seed treated with a combination of P. G. plus Panogen, but no significant difference was noted between the same treatments at Curtis. However, the latter combination at Curtis tended to give a lower stand count (Table 1). There was no significant difference between seed treated with P. G. and the nontreated plot, although the Curtis test showed that P. G. -treated seed

Table 1. Stand count means, based on 100 feet of row, from cotton seed treated with Panogen and potassium gibberellate (P. G.) alone or in combination, at location indicated, 1958.

Treatment	Means	
	St. Joseph	Curtis
P. G.	82	43
Panogen	176	140
P. G. plus Panogen	121	134
Nontreated	80	63
LSD .05	34	31
.01	48	42

Table 2. Stand count means, based on 100 feet of row, from reginned Deltapine Smoothleaf cotton seed treated with potassium gibberellate (P. G), Dow 9-B, and five Dow experimental seed-treating chemicals at Curtis and St. Joseph, 1958.

Treatment	Means	
	Curtis	St. Joseph
Dow 9-B	191	111
P. G.	153	86
Experimental Chemical No. 2	181	133
No. 6	102	122
No. 7	137	125
No. 8	138	
No. 9	141	
Nontreated check	161	119
LSD .05	ns	9
LSD .01	ns	12

tended to have a lower stand count. Differences in these tests may be due to different soil types and varieties. Reginned Stardel was used at St. Joseph and reginned Deltapine 15 at Curtis.

Deltapine Smoothleaf variety was used throughout the second series of tests at both locations. There was no statistically significant difference between seed treatments at the Curtis plot, but the stand resulting from seed treated with P. G. was considerably lower than that in the nontreated plot or plots treated with Dow 9-B or experimental treatment number 2. At St. Joseph the stand resulting from seed treated with P. G. alone was significantly lower than the stand in either of the other seed treatment plots or the nontreated plot (Table 2).



## GREENHOUSE TESTS

A program of screening various chemicals for controlling *Rhizoctonia* damping-off of cotton seedlings under field and greenhouse conditions has been started (2, 3). P. G. was included in this screening program, along with various fungicides and antibiotics, as a liquid in-the-furrow treatment (3). Reginned Deltapine 15 cotton seed previously treated with Dow 9-B was used.

The greenhouse test was run in flats, using sterilized field soil inoculated with an isolate of *Rhizoctonia solani* Kuehn. Fungicides were applied at the time of sowing, at the rates of 5 pounds per acre for wettable powders and 4 quarts per acre for the liquids. Combined fungicides were applied at equivalent rates. P. G. was applied at a concentration of 50 ppm. Inoculated-nontreated and noninoculated-nontreated plots served as controls. All treatments were replicated seven times with 50 Deltapine 15 cotton seeds per replicate. Emergence counts and the number of seedlings showing damping-off symptoms were taken approximately 2 weeks after the sowing and treatment date. These figures were used to determine the percentage of healthy plants surviving from 50 seed sowed.

## GREENHOUSE RESULTS

The emergence mean from seed treated with P. G. was significantly lower than from seed treated with PCNB plus captan, PCNB plus nabam, and the nontreated-noninoculated check. No statistically significant difference in emergence was found between P. G. treated seed and the PCNB plus dichlone treatment (Table 3). However, emergence from the P. G. treated seed was significantly above that from the nontreated-inoculated check. P. G. gave no disease con-

Table 3. Means of indicated treatments for emergence (E) and disease (D), and percentage of surviving healthy cotton seedlings from 50 seed (MH) when grown in sterilized field soil inoculated with an isolate of *Rhizoctonia solani* under greenhouse conditions, 1958.

Treatment	Means		
	E	D	MH
PCNB plus captan	37	5.7	63
PCNB plus nabam	40	2.4	76
PCNB plus dichlone	33	18.0	29
Potassium gibberellate (P.G.)	26	25.7	0
Nontreated-inoculated check	4	4.0	0
Nontreated-noninoculated check	39	0.0	77
LSD .05	12	1.7	3
LSD .01	16	2.2	4

trol, as indicated by the highest mean for the disease index and by absence of surviving healthy plants.

## SUMMARY AND CONCLUSIONS

Field tests showed that there were no advantages gained by treating cotton seed of three varieties with potassium gibberellate for controlling cotton seedling damping-off. There was a general tendency for a decrease in stand from seed treated with potassium gibberellate and in one case potassium gibberellate gave a stand significantly below that of the nontreated check.

In a single greenhouse test, using potassium gibberellate and other chemicals as an in-the-furrow treatment, potassium gibberellate tended to reduce pre-emergence damping-off significantly, but showed no post-emergence disease control. These latter results are in general agreement with the findings of Bradford and Ewing (1).

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LOUISIANA AGRICULTURAL EXPERIMENT STATION

COTTON SEED TREATMENT TRIALS IN CALIFORNIA, 1954-1958  
WITH SPECIAL REFERENCE TO SPECIFIC FUNGICIDES

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Abstract

Uniform seed treatment trials conducted in the cotton-producing areas of California during 1953, 1954 and 1955 showed that several commercial fungicides gave fairly good protection when the disease was moderate but failed when infection was severe. Additional fungicides were tested separately against Pythium ultimum and Rhizoctonia solani. Several fungicides were effective against Pythium but best results among seed treatments were obtained with 2 or 4 ounces of 85 percent Bayer 22555 (P-dimethylaminobenzene diazosodium sulfonate) per 100 pounds of seed. Against Rhizoctonia PCNB proved to be the most effective fungicide tested. With soils infested by both Pythium and Rhizoctonia, either PCNB or Bayer 22555, used alone, was ineffective, but when the two fungicides were used together the seedlings were protected. In uniform field trials of seed treatments during 1958, captan, Ceresan 100, Panogen, Bayer 15080, and Bayer 22555 were compared alone and in combination with PCNB. The addition of PCNB to any of the other fungicides significantly improved the protective value of the treatment.

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During the past 5 years greenhouse and field trials have been conducted to evaluate the cotton seedling disease problem in California and to identify materials and practices that would be most effective in reducing losses of cotton seedlings from this cause.

Seed treatment of cotton for protection against seed decay and damping-off has been a common practice in California for a number of years. The fungicides in commercial use provide fairly satisfactory protection when seedling diseases are light or moderate but under conditions of severe infestation do not provide the degree of protection desired.

Several years ago it was shown (4) that the addition of an insecticide such as lindane (99.5 percent gamma isomer of benzene hexachloride) to the fungicidal seed treatment would provide protection against wireworms and the seed-corn maggot. Dosage trials in pasteurized soil in greenhouse flats and in enclosed chambers indicated that 75 percent lindane used at the rate of 2 2/3 ounces per 100 pounds of seed was noninjurious to germinating cotton seed but effective as a protectant against wireworms and seed maggots. Under field conditions, however, some observers reported that emergence from cotton seed treated with 2 ounces of lindane per 100 pounds of seed was not as good as from seed treated with lighter dosages of lindane or with the fungicide alone. To measure the value of fungicidal and insecticidal treatments on cotton seed in different cotton-producing areas of California a series of uniform trials was established in 1954 and again in 1955, with the cooperation of farm advisors and experiment station staff. Because seedling insect attacks were almost totally absent from the 20 field trials in 1954 and 1955, no information was collected on the protective value of these insecticides. During 1956, insecticides were tested in a separate program and the fungicide seed treatment trials were expanded to include several additional materials.

In general the results from 28 field trials over a period of 3 years indicated that captan, Ceresan M, or Panogen, the three fungicides in commercial use as cotton seed treatments in California, were about equally effective and that any one of the three provided satisfactory protection with moderate infestations. In a certain number of fields, however, seedling pathogens occurred at a high inoculum level and conditions were favorable for severe seedling infection. Under these conditions none of the seed treatments provided adequate protection.

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Two fungus organisms, *Pythium ultimum* and *Rhizoctonia solani*, are recognized as the main pathogens involved in the cotton seedling disease complex in California and both are known to be present in the soils of most cotton-growing areas. However, these organisms vary in their relative abundance and pathogenic activity according to soil type, climatic conditions, and previous cultural practices.

As new fungicides have become available they have been tested in the laboratory and greenhouse at Davis against each of the seedling pathogens. Some of these fungicides show a high degree of effectiveness against one of these organisms but are so specific in their activity that they are relatively ineffective against the other. By combining certain of these specific fungicides promising results have been obtained where both *Rhizoctonia* and *Pythium* were active in the soil.

The relative protective effects of specific fungicides used alone, in combination with each other, or in combination with commercial seed treatment fungicides, were tested in uniform field trials during 1957 and 1958.

## PROCEDURE

During each of the 5 years a quantity of clean acid-delinted Acala 4-42 cotton seed secured from the U. S. Cotton Field Station, Shafter, California, was divided by means of a Boerner Sampler into 12 equal lots (8 in 1956 and 1957) which received the treatments indicated. Each treated lot was divided by weight into lots of approximately 200 seeds each. Identical field trials were planted at several locations in typical cotton-producing areas of California under the supervision of the local farm advisors<sup>4</sup>. The treatments were replicated six times in a randomized block design. A single replicate of a treatment consisted of 200 seeds planted in a row approximately 50 feet long. The seed was hand-dropped through the planter tube with the seed hopper removed. Counts were made during emergence and a final count when all post-emergence deaths were thought to have occurred.

## EXPERIMENTAL RESULTS

### 1954 Trials

Complete data concerning emergence and survivors were collected from nine field trials by cooperating farm advisors. To secure a more complete picture of the results throughout the cotton-producing area results of six trials having similar (homogeneous) error mean squares have been pooled according to the method of Roessler and Leach (6). This procedure made possible a more critical evaluation of treatment effects. The pooled data for emergence from six locations and for survivors from five locations are presented in Table 1. For a comparison of lindane and fungicide effects from the pooled data the averages for all plots receiving the same material alone or in combination with others are also presented in Table 1.

These results show that although damping-off was not a serious factor in these trials seed treatment with captan, Ceresan M-2X, or Panogen significantly improved emergence and survival over that from nontreated seed. At the dosage rates used captan did not appear to be quite as effective as the other two fungicides. In subsequent trials the dosage of captan was increased to 2 ounces per 100 pounds of seed.

Lindane alone reduced emergence by a significant amount but when used with a fungicide this adverse effect almost disappeared. When all treatments without lindane are compared with the same treatments with each dosage of lindane the effect on emergence appears to be nonsignificant although the survivor data suggest that the higher dosage is injurious.

The fact that these adverse effects do not occur with the higher rate of lindane in pasteur-

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The field trials were conducted under the supervision of Marvin Hoover, Extension Cotton Specialist, University of California, Shafter, by the following University of California farm advisors: Fresno County, L. K. Stromberg; Imperial County, R. A. Kortsen; Kern County, G. V. Ferry; Kings County, W. L. Hopkins and O. D. McCutcheon; Madera County, C. E. Johnson; Merced County, C. C. Conley; Riverside County, W. M. Lawson; San Bernardino County, R. C. Harkins; Tulare County, A. G. George. The writers would also like to acknowledge the valuable assistance of Dr. Donald C. Erwin, Assistant Plant Pathologist, University of California, Riverside and of Robert C. Lambe, J. C. Harvey and Alex Lange, Senior Laboratory Technicians, University of California, Davis, during portions of these trials.

Table 1. Effect of three fungicides and two dosages of lindane on emergence and survival of cotton -- 1954.

Treatment :	Fungicide :		Insecticide :		Emergence <sup>a</sup> :	Survivors <sup>b</sup>
	: Oz/100 :		: Oz/100 :			
	Material	lb.	Material	lb.	percent	percent
A	None	-	None	--	77.1	66.1
B	None	-	Lindane <sup>f</sup>	1.33	73.2	61.6
C	None	-	Lindane	2.67	73.4	63.1
D	Captan <sup>c</sup>	1	None	--	82.5	70.9
E	Captan	1	Lindane	1.33	82.7	70.2
F	Captan	1	Lindane	2.67	82.4	68.8
G	Ceresan M-2X <sup>d</sup>	1	None	--	84.7	74.1
H	Ceresan M-2X	1	Lindane	1.33	85.2	73.3
I	Ceresan M-2X	1	Lindane	2.67	85.2	71.1
J	Panogen <sup>e</sup>	1.5	None	--	85.2	75.3
K	Panogen	1.5	Lindane	1.33	84.8	72.2
L	Panogen	1.5	Lindane	2.67	85.5	72.5
L. S. D.	19:1				2.54	4.12
	99:1				3.35	5.43

## Effect of Lindane

Without Lindane	82.4	71.6
With 1 1/3 oz. of 75% Lindane	81.5	69.3
With 2 2/3 oz. of 75% Lindane	81.4	68.8
L.S.D. 19:1	n.s.	2.06

## Effect of fungicides

No fungicide	74.5	63.6
Captan -- 1 oz.	82.5	70.0
Ceresan M-2X -- 1 oz.	85.0	72.8
Panogen -- 1.5 oz.	84.8	73.3
L.S.D. 19:1	1.47	2.38
99:1	2.00	3.00

<sup>a</sup>Average of 6 homogeneous field trials.<sup>b</sup>Average of 5 homogeneous field trials.<sup>c</sup>75 percent N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide.<sup>d</sup>15.4 percent N-(ethylmercuri)-p-toluenesulfonanilide.<sup>e</sup>2.2 percent cyano (methylmercuri) guanidine.<sup>f</sup>75 percent lindane (99.5 percent gamma isomer of benzene hexachloride).

ized soil in the greenhouse indicates that injury could be associated with the presence of damping-off organisms in naturally infested soils. Such "predisposing" effects have been observed for certain seeds by Lange and co-workers (5).

## 1955 Trials

Unlike the 1954 cotton planting season when conditions were quite favorable for germination and emergence, the 1955 season was extremely unfavorable. At the time of the earliest plantings in late March the temperature was favorable for germination; however, soil moisture losses from the surface soil prevented some plantings from completing germination and emergence. Later in the planting season, during much of April and May, rains and cool temperatures slowed germination and severe crusting of the soil reduced emergence thus masking in some cases the possible advantages from seed treatment.

Seed treatment trials were conducted by farm advisors in eight counties. Owing to the

generally unfavorable growing conditions some tests were abandoned. Among the eight trials from which final stand data were obtained only trial 6 (Tulare County) and trial 10 (Madera County) showed a significant improvement in emergence and survival as a result of fungicidal seed treatments. Because of the great variability experienced it was not possible to combine the 1955 trials into a single homogeneous series for purposes of analysis as was done with the 1954 data. The most reliable conclusions can therefore be drawn from an examination of the results from trials 6 and 10, presented in Table 2.

Whereas in the 1954 trials 75 percent captan at 1 ounce per 100 pounds of seed showed less protection than Ceresan M-2X at the same dosage, in the 1955 trials 75 percent captan at 2 ounces per 100 pounds (treatments C and D) gave protection essentially equal to that from Ceresan M-2X (treatments E, F, G, and H).

Mema Special (treatments I and J) appeared to give somewhat less protection than captan or Ceresan in trials 6 and 10. Panogen, which in the 1954 trials appeared to give protection equal to that from Ceresan M-2X, did not provide as good stands in the 1955 trials 6 and 10. It should be pointed out, however, that the combination treatment of Panogen and aldrin did provide protection equal to that from captan or Ceresan M despite the fact that no insect injury was noted in these plantings.

Owing to the low incidence of insects it was impossible in the 1955 trials to compare the value of different insecticides adequately. In trial 10, however, lindane alone improved emergence and survival as compared with nontreated seed, and the Panogen-aldrin combination appeared significantly better than Panogen alone. These results suggest protection against seedling insect attack although the addition of insecticides to captan or Ceresan M-2X did not result in similar increases.

### 1956 Trials

Because few of the trials in 1954 and 1955 showed enough insect damage to measure the value of insecticidal seed treatments adequately, the 1956 tests were limited to a comparison of fungicides except that one treatment (Ceresan M) was combined with lindane. Separate tests with insecticides in fields known to be infested by seedling insects were conducted by Dr. W. H. Lange.

Whereas the trials in 1954 and 1955 were limited to three and four fungicides, respectively, six fungicides were tested in 1956. The treatments were planted in identical field trials in eight locations ranging from Imperial County in the south to Merced County in central California. Seven of the plantings were carried to completion and the results are presented in Table 3.

Trials 1 and 2, located in Imperial County, showed no improvement in stand as the result of seed treatment. When Erwin and co-workers (3) artificially infested soil in this area with inoculum of both Pythium ultimum and Rhizoctonia solani they observed infection of cotton seedlings by Rhizoctonia but not by Pythium. They therefore concluded that conditions were unsuitable for Pythium ultimum.

Three of the five trials in the San Joaquin Valley showed significant improvement from seed treatment. Because their error variances do not represent a homogeneous series it is not possible to pool the data for a combined analysis and no statistical conclusions can be drawn from comparison of the average stands. In most of the cases, however, the highest emergence was obtained with captan or Ceresan M-2X with only slightly lower stands from Dow 9B, Gallotox, or Panogen.

The addition of lindane to Ceresan M-2X neither increased nor decreased the emergence by a significant amount in any trial and since the average results of these two treatments were nearly identical it can be assumed that insects attacking germinating seedlings were not an important factor in these particular trials. This is in conformity with the observations of the cooperators.

### Greenhouse Evaluation of Specific Fungicides

Trials conducted from 1955 through 1957 showed that pentachloronitrobenzene (PCNB) used as a seed treatment gave good protection against Rhizoctonia solani but little or no protection against Pythium ultimum (Tables 4 and 5). Protection of cotton seedlings by PCNB seed treatment has been reported by Arndt (1) and Brinkerhoff (2).

In addition to observations on emergence and survival of seedlings a disease index was calculated for each treatment using the scale 0 = disease-free, 1 = slight hypocotyl infection,



Table 2. Results of cotton seed treatment with fungicides and insecticides -- 1955.

Treatment	Fungicide		Insecticide		Trial number 6		Trial number 10	
					Emer-	Survi-	Emer-	Survi-
	Oz. per		Oz. per		gence	vors	gence	vors
	Material	100 lb.	Material	100 lb.	percent	percent	percent	percent
A	None	--	None	--	60	56	28	26
B	None	--	Lindane <sup>g</sup>	2.67	59	55	43	40
C	Captan <sup>a</sup>	2	None	--	72	67	85	79
D	Captan <sup>b</sup>	2	Lindane	0.63	70	66	82	79
E	Ceresan M-2X <sup>c</sup>	1	None	--	68	65	86	82
F	Ceresan M-2X	1	Lindane	2.67	77	72	82	78
G	Ceresan M-2X	1	Dieldrin <sup>h</sup>	1.33	77	72	87	83
H	Ceresan M-2X	1	Heptachlor <sup>i</sup>	2.00	73	70	87	83
I	Mema Special <sup>d</sup>	4 fl.	None	--	65	62	72	68
J	Mema Special	4 fl.	Lindane	2.67	67	62	69	67
K	Panogen <sup>e</sup>	2 fl.	None	--	67	64	72	67
L	Panogen <sup>f</sup>	2 fl.	Aldrin	3.20	75	71	82	80
Sign Diff. (19:1)					9.9	8.6	8.3	7.8
(99:1)					13.2	11.4	11.0	10.4
Without insecticide					66.6	62.6	68.6	64.4
With insecticide					71.2	66.7	76.0	72.8

<sup>a</sup>Captan -- 75 percent N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide.<sup>b</sup>Ortho Seed Guard containing 50 percent captan and 16.5 percent lindane.<sup>c</sup>Ceresan M-2X -- 15.4 percent N-(ethylmercuri)-p-toluenesulfonanilide.<sup>d</sup>Mema Special -- a mixture of methoxyethylmercury acetate and ethylmercury acetate containing 3.2 ounces of mercury per gallon.<sup>e</sup>Panogen -- 2.2 percent cyano (methylmercuri) guanidine.<sup>f</sup>Panogen (PA-2N) containing 0.4 percent cyano (methylmercuri) guanidine and 24.4 percent (aldrin) hexachloro hexahydro-endo-exo-dimethanonaphthalene.<sup>g</sup>Lindane -- 75 percent (99.5 percent gamma isomer of benzene hexachloride).<sup>h</sup>Dieldrin -- 75 percent hexachloro-epoxy-octahydro-endo-exo-dimethanonaphthalene.<sup>i</sup>Heptachlor -- 25 percent heptachloro tetrahydro methanoindene.

Table 3. Effect of seed treatment upon emergence of cotton in seven field trials during 1956.

Treatment	Dosage	Percent emergence							
		Trial no.							
		1	2	3	4	5	7	8	Average
None	--	52.1	47.8	49.0	60.3	4.3	18.0	31.9	37.6
Captan <sup>a</sup>	2	57.6	51.8	74.2	85.2	39.6	36.2	45.5	55.7
Ceresan M-2X <sup>a</sup>	1	57.9	48.8	69.3	81.8	31.5	27.2	41.4	51.1
Ceresan M-2X + Lindane <sup>a</sup>	2 2/3	53.3	46.0	76.3	88.2	32.1	29.0	34.9	51.4
Dow 9B <sup>b</sup>	2	56.5	47.5	69.1	76.9	20.7	29.1	37.5	48.2
Gallotox <sup>c</sup>	2 fl.	53.2	44.6	67.2	79.7	43.4	20.8	34.2	49.0
Mema <sup>d</sup>	1 1/4 fl.	54.1	45.7	55.6	58.6	5.4	22.2	28.3	38.6
Panogen <sup>a</sup>	2 fl.	57.1	48.1	62.9	78.2	25.4	30.4	30.6	47.5
Sign. Diff. (19:1)		n.s.	n.s.	13.3	8.2	18.1	n.s.	n.s.	
(99:1)		n.s.	n.s.	17.9	11.0	24.2	n.s.	n.s.	

<sup>a</sup>See Table 2.<sup>b</sup>32 percent zinc 2,4,5-trichlorophenoxide.<sup>c</sup>7 percent phenylmercury acetate.<sup>d</sup>11.4 percent 2-methoxyethylmercury acetate.

Table 4. Comparison of Bayer 15080 and PCNB as cotton seed treatments in greenhouse soil pasteurized and then infested by Pythium or Rhizoctonia.

Material	Dosage : oz/100 lb.	Pythium		Rhizoctonia	
		Emergence	Survivors	Emergence	Survivors
		: percent	: percent	: percent	: percent
Nontreated	--	38	30	7	6
Bayer 15080 <sup>a</sup>	2	51	42	60	41
Bayer 15080	4	82	81	60	36
PCNB <sup>b</sup>	4	40	28	83	79
PCNB	8	21	18	90	89
PCNB	12	14	12	83	82
PCNB	16	29	19	83	81
LSD .05		36	34	16	23
LSD .01		ns	ns	23	32

<sup>a</sup>20 percent quinoneoxime benzoyl hydrazone.<sup>b</sup>75 percent pentachloronitrobenzene.Table 5. Results of trials with cotton seed treatments in greenhouse soils for protection against Rhizoctonia solani.

Material	Dosage : oz/100 lb.	Per 100 seeds		
		Emergence	Survivors	Disease index <sup>d</sup>
Nontreated	-	57	40	2.41
Ceresan 100 <sup>a</sup>	2	71	26	2.61
Bayer 22555 <sup>b</sup>	4	65	42	2.30
PCNB <sup>c</sup>	2	76	65	1.37
PCNB	4	77	71	1.17
PCNB	8	70	67	1.23
LSD .05		ns	20	--
LSD .01		ns	27	--

<sup>a</sup>3.1 percent ethylmercury 2,3-dihydroxypropyl mercaptide and 0.67 percent ethylmercury acetate (2.3 percent Hg).<sup>b</sup>85 percent P-dimethylaminobenzene diazosodium sulfonate.<sup>c</sup>See Table 4 (footnote b).<sup>d</sup>See text for scale.Table 6. Results of trials with cotton seed treatments in greenhouse soils for protection against Pythium ultimum.

Material	Dosage : oz/100 lb.	Trial number 1			Trial number 2		
		Emergence	Survivors	Disease	Emergence	Survivors	Disease
		: percent	: percent	index <sup>d</sup>	: percent	: percent	index <sup>d</sup>
Nontreated	-	13	12	3.6	0	0	4.0
Captan 75 <sup>a</sup>	2	--	--	-	63	45	2.6
Ceresan 100 <sup>b</sup>	2	34	32	2.9	33	23	3.3
Bayer 15080 <sup>c</sup>	2	38	36	2.7	--	--	-
Bayer 15080	4	39	39	2.5	--	--	-
Bayer 22555 <sup>b</sup>	1	57	56	1.9	52	38	2.7
Bayer 22555	2	81	80	0.7	66	57	2.0
Bayer 22555	4	94	94	0.3	93	90	0.9
LSD .05		14	15	-	21	23	-
LSD .01		19	20	-	28	31	-

<sup>a</sup>See Table 1. <sup>b</sup>See Table 5. <sup>c</sup>See Table 4. <sup>d</sup>See text.

Table 7. Comparison of effectiveness of Ceresan 100 and Bayer 22555, each at three dosages, in *Pythium*-infested greenhouse soil.

Material	Dosage oz/100 lb.	Emergence percent	Survivors percent	Disease index <sup>b</sup>
Nontreated	-	31	25	3.4
Ceresan 100 <sup>a</sup>	1	40	39	2.9
Ceresan 100	2	55	52	2.4
Ceresan 100	4	70	64	1.9
Bayer 22555 <sup>a</sup>	1	84	79	1.5
Bayer 22555	2	90	87	0.8
Bayer 22555	4	86	86	0.7
LSD .05		22	20	-
LSD .01		30	28	-

<sup>a</sup>See Table 5. <sup>b</sup>See text.

2 = moderate to severe hypocotyl infection, 3 = post-emergence damping-off, and 4 = seed decay or pre-emergence damping-off, as determined by examination and comparison with emergence in pasteurized soil.

In our trials, increasing the dosage of PCNB did not result in appreciable improvement of protection against *Rhizoctonia*. Bayer 15080 (quinoneoxime benzoyl hydrazone) on the other hand gave good protection against *Pythium* but was relatively ineffective against *Rhizoctonia*. Captan and Ceresan M or Ceresan 100 usually improved emergence but did not reduce post-emergence infection appreciably (Tables 5, 6, 7).

#### 1957 Trials

During the 1957 planting season captan, ceresan M, and Bayer 15080 were evaluated as seed treatments alone and in combination with PCNB in three field plantings. Although these three trials did not show striking differences between the treatments there were indications that combining PCNB with captan, Ceresan, or Bayer 15080 increased emergence and survival over that obtained from the same fungicides used alone.

In March 1957, another fungicide, Bayer 22555 (P-dimethylaminobenzene diazosodium sulfonate) was offered for testing as a soil fungicide. Greenhouse trials with this material used as a seed treatment on cotton showed that it was extremely effective against *Pythium ultimum*, especially when the dosage was increased to 2 or 4 ounces per 100 pounds of seed (Tables 6, 7), but was ineffective against *Rhizoctonia solani* (Table 5). Combination seed treatments with Bayer 22555 and PCNB were outstanding in soils infested with both organisms.

On the basis of these encouraging results uniform trials including several combination seed treatments were conducted in four counties in the San Joaquin Valley of California during 1958. The emergence counts from trials 1 through 5 are presented in Table 8.

Because trial 1 showed a relatively high error variance and trial 3 an exceptionally low error variance it was not possible to combine the five trials for statistical analysis. However, trials 2, 4, and 5 do represent a homogeneous series and were analyzed as a combined group. The average results show that all the fungicides tested, except Bayer 15080 used alone, improved the emergence of cotton seedlings. When PCNB was combined with the other fungicides it produced an additional improvement in each case.

To test the effect of PCNB the average of all plots receiving this fungicide was compared with the average of all plots in the same trial not receiving PCNB. It is clear that PCNB significantly improved emergence in trials 1, 3, and 5 but not in trials 2 or 4. The combined figures for the three homogeneous trials show that without PCNB the average emergence for all treatments was 50 percent while the same treatments with PCNB averaged 60 percent, a highly significant increase.

Among the other fungicides Bayer 15080 appeared to be the least effective while captan, Ceresan 100, Panogen, or Bayer 22555 were all significantly better than no treatment but with little or no differences among them.



Table 8. The effect of seed treatments on emergence of cotton seedlings; results of 1958 seed treatment trials.

Seed treatment <sup>a</sup>	Percent Emergence						
	Trial number					Average of 3	
	1	2	3	4	5	Average of 5 trials	homogeneous trials <sup>b</sup>
None	45	54	79	54	26	52	44
PCNB	63	59	83	51	51	61	54
Captan	61	62	89	63	36	62	53
Captan + PCNB	67	66	89	58	58	68	60
Ceresan 100	75	59	85	65	40	65	54
Ceresan 100 + PCNB	77	61	89	65	62	71	63
Panogen	63	51	84	63	42	61	52
Panogen + PCNB	74	58	88	65	57	68	60
Bayer 15080	57	46	79	57	23	52	42
Bayer 15080 + PCNB	76	57	90	64	59	69	60
Bayer 22555	61	61	84	57	40	61	52
Bayer 22555 + PCNB	70	61	90	63	61	70	63
Sign. Diff. (19:1)	24.4	n.s.	7.0	16.0	13.6	--	9.0
(99:1)	n.s.	n.s.	9.3	n.s.	n.s.	--	11.9
Effect of PCNB							
Without PCNB	60.4	55.6	83.1	59.8	34.6	58.83	49.7
With PCNB	71.0	61.0	88.2	60.8	58.1	67.83	59.9
Sign. Diff. (19:1)	10.0	7.4	2.9	n.s.	5.5	--	3.7
(99:1)	n.s.	n.s.	3.8	n.s.	7.3	--	4.9
Effect of other fungicides							
None	53.9	56.8	80.9	52.4	38.6	56.5	48.8
Captan	64.1	63.9	88.7	60.4	47.1	65.0	56.7
Ceresan 100	76.2	59.9	86.9	64.5	51.4	68.0	58.5
Panogen	68.3	54.4	85.9	63.8	49.3	64.5	55.9
Bayer 15080	66.5	51.7	84.7	60.5	41.1	60.5	51.1
Bayer 22555	65.2	63.5	86.8	60.2	50.5	65.5	57.8
Sign. Diff. (19:1)	17.3	n.s.	5.0	11.3	9.5	--	6.4
(99:1)	n.s.	n.s.	6.6	n.s.	n.s.	--	8.4
C of V	32.2	29.6	6.8	23.0	25.4		24.3

<sup>a</sup>Pentachloronitrobenzene (75 percent PCNB) was applied at 4 ounces per 100 pounds of seed; all other fungicides were applied at 2 ounces per 100 pounds of seed. For composition of the formulated fungicides see footnotes Tables 1, 4, and 5.

<sup>b</sup>Average of trials 2, 4, and 5 were combined on the basis of similar error variances.

#### SUMMARY AND DISCUSSION

Most of the fields used for cotton planting in the San Joaquin Valley of California are infested with either *Pythium ultimum* or *Rhizoctonia solani* and usually both organisms are present but at varying inoculum levels. The seed treatments currently used in commercial practice provide considerable protection but are considered inadequate under conditions of severe infestation. This has stimulated interest in localized placement of fungicides in the seed furrow and in the development of more effective seed treatments.

In most instances insecticides combined with fungicides did not result in improved stands owing to the low incidence of insect attack, but in one case an increase in emergence was obtained with a Panogen-aldrin combination. Lindane used in the absence of a fungicide in certain tests resulted in a slight stand decrease.

In greenhouse experiments and in limited field trials it has been found that seed treatment with pentachloronitrobenzene (PCNB) provided improved control of Rhizoctonia infection and that its addition to the seed treatments now in commercial use improved emergence and survival of cotton seedlings in soils infested by both Pythium and Rhizoctonia.

Similar trials in soils infested by Pythium ultimum showed that an experimental fungicide, Bayer 22555, used as a seed treatment was extremely effective in protecting cotton seedlings against this organism.

The specificity of these two fungicides is indicated by the fact that PCNB offered little or no protection against Pythium whereas Bayer 22555 was ineffective against Rhizoctonia. It followed that neither material used alone offered protection in soils with mixed infestation.

When PCNB was combined with Bayer 22555, each at its optimum dosage, a higher level of protection was observed in soils infested with both Pythium and Rhizoctonia than with other fungicides tested.

In field trials with moderate infestations the PCNB-Bayer 22555 was equal to but no better than PCNB combined with captan, Ceresan 100, or Panogen. These results suggest the possibility of using suitable combinations of specific fungicides to secure higher levels of protection than is usually obtained from our present commercial seed treatments.

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DISEASE SUSCEPTIBILITY OF COTTON SEEDLINGS  
FROM ARTIFICIALLY DETERIORATED SEEDS<sup>1</sup>

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Abstract

Pathogenicity tests were carried out at 21° and 27° C with cotton seeds which had been deteriorated to different degrees by heating at 50° in a moist atmosphere for various periods. Although emergence of deteriorated seeds was reduced in proportion to the degree of deterioration even in the absence of fungus inoculum, such fungi as *Alternaria* sp., *Aspergillus flavus* Link., *Aspergillus niger* van Tieghem, *Colletotrichum gossypii* South., *Fusarium moniliforme* Sheld., *F. oxysporum* Schlecht., *F. oxysporum* f. *vasinfectum* (Atk.) Snyder & Hansen, *Helminthosporium* sp., *Rhizopus* sp., *Sclerotium bataticola* Taub., *Thielaviopsis basicola* (Berk. & Br.) Ferr., and *Trichoderma* sp. caused additional suppression in emergence of deteriorated seeds. The degree of susceptibility of the seeds to injury by these fungi usually increased as the deterioration period was lengthened. Most of the microorganisms caused a greater reduction in emergence of deteriorated seeds at 21° than at 27° C. *Pythium ultimum* Trow and a virulent isolate of *Rhizoctonia solani* Kuehn completely inhibited emergence of all seeds, including undeteriorated ones. Increased susceptibility to fungus attack as a result of seed deterioration was observed less frequently in the post-emergence stage of seedling growth than in the pre-emergence phase. However, test results with some of the moderately pathogenic microorganisms indicated that these fungi were more damaging to emerged plants from deteriorated seeds than to those from good-quality seeds. Very few seedlings survived in the tests with *C. gossypii* or with *T. basicola* regardless of whether or not the seeds had been deteriorated. Isolates of *Cladosporium* sp., *Penicillium* sp., and *Verticillium albo-atrum* Reinke & Berth. caused little or no damage to any seeds or seedlings.

INTRODUCTION

Previous investigators have shown that damage to seeds caused by unfavorable field or storage conditions may result in reduced viability (8, 9, 10) and in the production of plants of reduced size and low vigor (11). It has been assumed that such plants are predisposed to disease, although there appears to be little experimental evidence to support such an assumption. In the past it was difficult to obtain information on this subject because no quick laboratory method which would duplicate natural deterioration was available. Presley (5, 6) recently devised a rapid method for artificially deteriorating cotton seeds to various degrees in the laboratory. It was decided that tests with such artificially deteriorated seeds would be useful as a guide in determining whether or not cotton seedlings from naturally deteriorated seeds are predisposed to disease. Consequently, an experiment was set up in which cotton seeds deteriorated to various degrees by Presley's method were tested against a number of fungi isolated from diseased cotton seedlings. Included in the series were fungi known to be pathogenic to cotton seedlings and also several fungi commonly considered relatively nonpathogenic despite the fact that they are recovered from almost all field collections of diseased cotton seedlings (2, 3, 4, 7, 12).

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## METHODS AND MATERIALS

A single lot of Hale 33 cotton seed, 1956 crop, was used for the entire series of tests. The seeds were acid-delinted and gravity-graded. All cracked and otherwise obviously damaged seeds were discarded. The seeds were allowed to dry at room temperature and then aliquots were held at 50° C and 100 percent relative humidity for 24, 48, 72, and 96 hours. Presley (5) demonstrated that the length of time the seeds could be subjected to these conditions before becoming deteriorated was greatly influenced by their moisture content. Therefore, the moisture contents of the seeds, both initially and at the end of each 24-hour period of conditioning, were determined by calculating the loss in weight of the seeds after drying at 100° C for 24 hours. The initial moisture content of the seed lot used in the present tests varied from 7 to 10 percent during the course of the work. After conditioning, the average moisture contents of the seeds were as follows: 24 hours, 10 percent; 48 hours, 12 percent; 72 hours, 13 percent; 96 hours, 14 percent. The percentage germination of the seeds was determined by placing samples of each aliquot between moist filter paper in Petri dishes and incubating them at constant temperatures of 16°, 20°, and 28°.

Pathogenicity tests with the conditioned seeds were carried out in sand cultures in the greenhouse at constant temperatures of 21° and 27° C. The fungus inoculum for the tests was produced in a liquid medium consisting of a modified Richard's solution in which dextrose was substituted for sucrose and V-8 juice was added. When the fungus cultures were ready for use the medium was decanted and replaced with an equal volume of distilled water. The fungus growth was comminuted in the Waring Blendor and a standard volume of the suspension was thoroughly mixed with sterilized sand in 1-gallon crocks. In all tests 20 seeds were planted in each crock of sand at a uniform depth of 1/2 inch immediately after conditioning. A standard volume of distilled water was added to each crock daily. Beginning shortly after emergence the plants were given a balanced nutrient solution each day. Uninoculated control crocks containing the complete series of conditioned and unconditioned seeds were included in each test. Each experiment contained three replicates of each microorganism and of the uninoculated controls with each type of seed. Emergence counts were taken 12 days after planting. Three weeks after planting the seedlings were pulled up and rated for post-emergence disease. For the uninoculated checks the emergence data were calculated as percent of the total number of seeds planted. For the inoculated series emergence data were computed as percentages of plants emerging in each inoculated unit compared with the emergence in the uninoculated check with the same degree of seed deterioration. Post-emergence disease was rated by means of an index calculated by multiplying the number of plants with slight disease symptoms by 20, moderately injured plants by 40, severely injured plants by 60, and dead plants by 100, and dividing the sum by the total number of plants emerged in the particular treatment being rated. Therefore, the indices give disease ratings only for the seedlings which actually emerged and ignore pre-emergence damping-off and seed decay.

## RESULTS

In the uninoculated controls the conditioned seeds showed an inverse correlation between emergence and degree of deterioration. The longer the period of deterioration the fewer the plants that emerged. This was evident at both temperatures, although the emergence percentages were slightly higher at 27° C (Table 1). In the controls there was also a progressive reduction in size of the seedlings proportionate to the length of time the seeds had been deteriorated. The emergence data indicate that deterioration of the seeds usually did not begin until they had been conditioned about 48 hours. The number of plants emerging from the 24-hour seeds was approximately the same as from unconditioned seeds and in the 48-hour seeds emergence was only slightly reduced. In all the experiments there was a considerable decrease in emergence of plants from seeds conditioned 72 hours. With 96-hour seeds the emergence in sterile sand was drastically reduced (Table 1). The results of the laboratory germination tests with the conditioned seeds were in agreement with the data for emergence of seedlings in sterile sand except that the laboratory germination percentages were usually slightly higher.

The results of the pathogenicity tests with the various fungi indicate that they fall into two groups: 1) those which caused injury only in the pre-emergence phase of seedling development, and 2) those which caused injury in both the pre-emergence and post-emergence phases. The damage caused by the first group of fungi is measured by any reduction in emergence of the seedlings in addition to that which occurs in the deteriorated seeds even in the absence of fungus growth. The emergence data obtained with these fungi are recorded in Table 1. When the seeds were tested against Pythium ultimum and against Rhizoctonia solani 118-O no plants emerged

Table 1. Seedling emergence from artificially deteriorated cotton seeds inoculated with fungi pathogenic only in the pre-emergence phase at 21° and 27° C.

Fungus and isolate number	Percentage emergence at designated temperatures (°C) from seeds artificially deteriorated for : <sup>a</sup>									
	0 hours		24 hours		48 hours		72 hours		96 hours	
	21°	27°	21°	27°	21°	27°	21°	27°	21°	27°
Check	93	94	95	93	80	83	51	69	18	31
<i>Pythium ultimum</i> (1501-O)	0	0	0	0	0	0	0	0	0	0
<i>Rhizoctonia solani</i> (118-O)	0	0	0	0	0	0	0	0	0	0
<i>Rhizopus</i> sp. (1002-F)	76	74	69	83	51	70	40	52	38	18
<i>Trichoderma</i> sp. (1202-F)	79	98	77	100	73	93	59	53	12	100
<i>Alternaria</i> sp. (304-WR)	95	100	90	100	83	100	76	89	10	100
<i>Helminthosporium</i> sp. (803-N)	93	89	93	100	97	100	99	100	44	100

a Emergence counts were taken 12 days after planting. Check emergence is the percentage of seedlings emerging compared with the number of seeds planted. The emergence of each inoculated series is the percentage of seedlings emerging compared with the emergence in its respective check.

Table 2. Seedling emergence from artificially deteriorated cotton seeds inoculated with fungi pathogenic both in the pre-emergence and post-emergence phases at 21° and 27° C.

Fungus and isolate number	Percentage emergence at designated temperatures (°C) from seeds artificially deteriorated for : <sup>a</sup>									
	0 hours		24 hours		48 hours		72 hours		96 hours	
	21°	27°	21°	27°	21°	27°	21°	27°	21°	27°
Check	93	94	95	93	80	83	51	69	18	31
<i>Colletotrichum gossypii</i> (611-O)	49	89	58	87	47	67	20	40	12	17
<i>Thielaviopsis basicola</i> (1313-O)	76	96	67	99	50	89	25	81	0	50
<i>Rhizoctonia solani</i> (1123-F)	7	58	0	45	0	37	0	27	0	0
<i>Aspergillus flavus</i> (411-O)	100	94	88	100	92	93	68	82	51	75
<i>A. niger</i> (422-G)	96	87	94	97	82	99	72	64	100	34
<i>Fusarium oxysporum</i> (2028-G)	100	98	97	95	78	97	69	93	14	72
<i>F. oxysporum</i> f. <i>vasinfectum</i> (2018-F)	96	95	83	100	80	96	71	35	0	0
<i>F. moniliforme</i> (217-F)	82	99	82	100	69	97	88	92	0	50
<i>Sclerotium bataticola</i> (1114-M)	97	96	95	91	86	90	81	68	71	50

a Emergence counts were taken 12 days after planting. Check emergence is the percentage of seedlings emerging compared with the number of seeds planted. The emergence of each inoculated series is the percentage of seedlings emerging compared with the emergence in its respective check.

Table 3. Pathogenicity of various fungi to emerged seedlings from artificially deteriorated cotton seeds at 21° and 27° C.

Fungus and isolate number	: Post-emergence disease at designated temperatures (°C) <sup>a</sup>									
	: Seeds artificially deteriorated for:									
	: 0 hours		: 24 hours		: 48 hours		: 72 hours		: 96 hours	
	: 21°	27°	: 21°	27°	: 21°	27°	: 21°	27°	: 21°	27°
Check	0	0	0	0	0	0	0	0	0	0
<i>Colletotrichum gossypii</i> (611-O)	100	100	100	100	100	100	100	100	100	100
<i>Thielaviopsis basicola</i> (1313-O)	100	68	100	69	100	64	100	70	-- <sup>b</sup>	82
<i>Rhizoctonia solani</i> (1123-F)	13	40	--	45	--	49	--	33	--	--
<i>Aspergillus flavus</i> (411-O)	30	26	32	30	40	32	32	35	29	44
<i>A. niger</i> (422-G)	22	6	21	8	27	9	22	16	22	14
<i>Fusarium oxysporum</i> (2028-G)	13	18	14	22	16	22	24	31	19	36
<i>F. oxysporum</i> f. <i>vasinfectum</i> (2018-F)	17	2	23	5	12	9	23	54	--	--
<i>F. moniliforme</i> (217-F)	0	9	0	12	0	16	19	21	--	38
<i>Sclerotium bataticola</i> (1114-M)	16	13	17	15	17	17	18	31	38	29

a Post-emergence disease index: slight injury 20; moderate injury 40; severe injury 60; death 100.

b No emergence.

regardless of whether they had been deteriorated or not. *Rhizopus* sp. caused some reduction in emergence with all types of seeds at both temperatures but the reduction was greater in the deteriorated ones. The longer the seeds were subjected to the deterioration process the more susceptible they were to attack by *Rhizopus* sp. The effect of *Trichoderma* sp. on emergence was similar to that of *Rhizopus* sp. at 21°C, but the former was much less destructive than the latter at 27°. *Alternaria* sp. and *Helminthosporium* sp. both depressed emergence of seeds with prolonged deterioration in the 21°C tests, but had little or no effect on seedling emergence at 27°.

Emergence data obtained with fungi belonging to the second group are recorded in Table 2. *Colletotrichum gossypii* and *Thielaviopsis basicola* both caused severe post-emergence disease in the seedlings, but with seeds of high vigor they did not appreciably depress emergence at 27° C. However, in deteriorated seeds these two fungi caused a drastic reduction in emergence, particularly if the deterioration was prolonged. *R. solani* 1123-F, a less virulent strain of this fungus than the isolate described previously, permitted considerable emergence of seedlings at 27° but almost none at 21°. In the 27° test with this fungus seedling emergence was depressed in proportion to the degree of seed deterioration. *Aspergillus flavus* and *A. niger* both caused reduction in emergence of deteriorated seeds and the degree of suppression usually increased with the length of time the seeds had been deteriorated. *Fusarium oxysporum* depressed emergence of deteriorated seeds to a greater extent at 21° than at 27°. *F. oxysporum* f. *vasinfectum* and *F. moniliforme* both caused reduction in emergence of deteriorated seeds at each test temperature. Deteriorated seeds were likewise more susceptible than undeteriorated seeds to attack by *Sclerotium bataticola*, as is shown by the reduction in emergence of 72- and 96-hour seeds.

Table 3 gives post-emergence disease indices for fungi which damaged the emerged seedlings. *C. gossypii*, one of the most virulent cotton seedling pathogens (1, 2), killed all plants regardless of whether the seeds had been deteriorated. *T. basicola* was almost as severe in its attack, but some plants did survive in the 27°C experiment. In this test disease indices for plants from the 72- and 96-hour deteriorated seeds were only slightly higher than those for plants from undeteriorated seeds. In the 27° test with *R. solani* 1123-F the number of surviving plants



and the severity of disease symptoms did not appear to be related to the degree of seed deterioration. Cotton seedlings grown in sand inoculated with *A. flavus* usually are stunted, have very short, stubby tap roots and few or no secondary roots (2). In these studies with deteriorated seeds nearly all seedlings infected with *A. flavus* showed these symptoms to some degree. However, in the test carried out at 27° it was apparent that plants from the 0- and 24-hour conditioned seeds were not so severely affected by the fungus as those from deteriorated seeds. The differences were not great, but seedlings from the 72- and 96-hour seeds were more stunted and had fewer secondary roots than the 0- and 24-hour plants. Many of the plants grown in the presence of *A. niger* were stunted and had discolored, poorly developed root systems. These symptoms were rather mild, as shown by the disease indices in Table 3. Seedlings from deteriorated seeds were often more severely affected by *A. niger* than plants from undeteriorated seeds, but the results were not entirely consistent. *Fusarium* spp. often caused more disease in seedlings from deteriorated seeds than in those from undeteriorated seeds, but usually the symptoms were not severe. On many plants *S. bataticola* produced dark-brown lesions at the soil line and occasionally the lesions penetrated deeply enough to cause death of the seedlings. Injury was more severe at 72- and 96-hour deterioration than at 0, 24, or 48 hours, but the increase in severity of symptoms with increasing degree of seed deterioration was not very great.

*Cladosporium* sp., *Penicillium* sp., and *Verticillium albo-atrum* caused little or no pre- or post-emergence disease in seedlings from either deteriorated or undeteriorated seeds.

#### DISCUSSION AND CONCLUSIONS

The purpose of the experiments just described was to determine whether deteriorated cotton seeds and the seedlings they produce are more susceptible to disease than undeteriorated seeds and the seedlings resulting from them. The data provide substantial evidence that the deteriorated seeds were vulnerable to seed decay and pre-emergence damping-off than were undeteriorated ones and that the longer the seeds were subjected to the deterioration process the greater was the degree of susceptibility. Most of the so-called nonpathogenic fungi caused sizable reductions in emergence of deteriorated seeds without appreciably affecting undeteriorated ones. These reductions in emergence of deteriorated seeds in the inoculated series represent a suppression in addition to that which occurred even in the absence of disease organisms. The data for *Colletotrichum gossypii* and *Thielaviopsis basicola* indicate that these fungi depress the emergence of deteriorated seeds more than that of good-quality seeds. However, other highly pathogenic fungi, such as *Pythium ultimum* and *Rhizoctonia solani*, were very destructive even to carefully selected, undeteriorated seeds. With the majority of the fungi the reduction in emergence with deteriorated seeds was greater at 21° than at 27° C, which is in agreement with Presley's report (5) that unfavorable temperatures place deteriorated seeds at an even greater disadvantage in comparison with those of good quality.

The fungi which were more pathogenic to seedlings from deteriorated seeds than to those from undeteriorated seeds did their principal damage to the plants in the pre-emergence stage. However, in tests with some of the moderately pathogenic fungi plants from deteriorated seeds had slightly higher post-emergence disease indices than those from good-quality seeds. With the methods used in this study it is difficult to determine whether emerged seedlings from deteriorated seeds are predisposed to attack by the extremely virulent pathogens since these fungi killed nearly all plants regardless of the degree of seed deterioration.

Fulton and Bollenbacher (2) found in pathogenicity tests with cotton seedlings involving both pathogenic and nonpathogenic fungi that a slight depression in emergence was produced even by fungi which otherwise caused no disease symptoms in the seedlings. The seed lots used in those tests were not selected and probably contained some naturally deteriorated seeds. The reduction in emergence with fungi which are not otherwise pathogenic may have been due solely to their action on naturally deteriorated seeds in unselected seed lots.

The experimental results reported here also suggest a partial explanation for the increased stands derived from cotton seeds treated with fungicides. The seed treatment may increase emergence by giving naturally deteriorated seeds some degree of protection against emergence-depressing fungi.

The findings reported emphasize the importance of using good-quality cotton seeds for planting, particularly if unfavorable growing conditions are likely to occur.

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RESPONSE OF COTTON VARIETIES TO SEED DETERIORATION  
AND THE INFLUENCE OF SEED TREATMENT ON DETERIORATION

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Abstract

Presley's method of artificially deteriorating cottonseed was used to compare 12 varieties and for comparing the influence of seed protectant fungicides on deterioration. Of the varieties studied, seed of Acala 1517c deteriorated faster than the other varieties while seed of Floyd 8G, Delfos 9169 and Northern Star No. 11 had the slowest rate of deterioration. The results suggested that progress in selecting for resistance to seed deterioration could be made.

The seed treatment results indicated that seed treated with protectant fungicides, especially at the higher rates, tend to deteriorate faster than untreated seed.

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Recent research has emphasized that the failure to obtain a good stand of cotton due to seedling disease is closely associated with the condition of planting seed (2, 3, 4). Seedlings from poor seed, that is, deteriorated seed or seed exposed to excessive moisture while in the field or in storage, are slow in emerging and they are more apt to be attacked by seedling disease fungi (2, 3). Seedlings from deteriorated seed also are susceptible to a wider range of soil-borne fungi (1, 3). A laboratory method (3, 4) for deteriorating seed has been developed. Complete deterioration is obtained in about 6 days. The actual time depends on the initial moisture content and previous amount of deterioration of the seed. Thus, the method is readily adaptable to studies of all phases of seed deterioration and how it influences seedling disease.

### MATERIALS AND METHODS

Seeds of the 12 standard varieties of the Texas Statewide cotton variety testing program were used for variety comparison. The seeds<sup>2</sup> were from the 1957 A. and M. College Plantation irrigated variety test. The seedcotton for all varieties was stored together and all were ginned the same day on a saw gin. The seeds were acid-delinted before initiating the experiment.

Seeds of the Deltapine 15 variety were used for the seed treatment test. Seedcotton from 1-day-open bolls was harvested and ginned on a roller gin. The seeds were acid-delinted and the floaters were discarded. The delinted seeds were treated with the seed protectant fungicides before initiating deterioration.

The seed deterioration method given by Presley (4) was used for the experiments. Half-pint laboratory jars were used to hold 50-gram seed lots and a container with 50 cc of water. Small narrow neck cream jars were used for the water containers. Filter paper wicks were inserted into each water jar to insure free evaporation. The half-pint jars containing the seeds and water jars were sealed and placed in a constant-temperature oven at 50° C. Samples were taken daily for determining seed moisture and seed germination. The seeds were placed in moisture chambers in a 76° F constant-temperature room for determining the amount of germination. Counts were made the second, fourth and fifth days after beginning the germination tests. Values for the second and fourth days indicate the germination rate while the fifth day counts indicate the maximum germination. The average of the 3 day counts was used to repre-

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Table 1. Cotton varietal differences in seed deterioration.

Varieties	Germination for days of seed deterioration <sup>a</sup>				
	2	4	5	6	7
Floyd 8G	24.0	18.4	19.2	2.9	2.4
Delfos 9169	24.0	17.5	18.0	1.8	1.8
Northern Star #11	23.0	21.3	18.9	2.3	1.5
Stoneville 7	24.2	16.4	10.1	0.5	0.5
Malones Rowden	22.9	20.8	10.4	2.3	0.4
Empire WR	23.6	22.3	11.1	5.4	0.0
Lankart Sel. 57-5	22.2	20.1	12.1	3.9	0.0
Deltapine TPSA	24.7	20.6	12.0	3.4	0.0
Brazos	23.5	15.9	14.3	0.3	0.0
Deltapine 15	22.6	18.4	12.2	0.0	0.0
Deltapine Fox	24.7	20.8	11.3	0.0	0.0
Acala 1517c	23.9	13.9	8.7	0.0	0.0
L.S.D. .01		6.6	5.1	5.3	2.2
.05	n.s.d.	4.9	3.8	4.0	1.7

<sup>a</sup> An average of 25 equals 100% germination.

Table 2. Cotton varietal differences in germination rate of seed deteriorated five and six days.

Varieties	Germination for days of seed deterioration and germination <sup>a</sup>					
	5			6		
	2	4	5	2	4	5
Floyd 8G	12.5	22.5	22.5	0.3	3.8	4.5
Delfos 9169	14.3	19.8	19.8	0.0	2.7	2.8
Northern Star #11	11.5	22.2	23.0	0.2	2.8	3.8
Stoneville 7	4.3	12.8	13.2	0.0	6.7	8.3
Malones Rowden	8.0	11.0	12.0	0.0	3.5	3.5
Empire WR	6.8	13.2	13.3	1.7	7.3	7.3
Lankart Sel. 57-5	5.8	15.2	15.3	0.2	5.8	5.8
Deltapine TPSA	9.7	13.0	13.3	1.0	4.8	5.5
Brazos	11.2	15.5	16.2	0.0	0.3	0.7
Deltapine 15	3.0	16.5	17.0	0.0	0.0	0.0
Deltapine Fox	10.5	11.8	11.8	0.0	0.0	0.0
Acala 1517c	1.0	12.3	12.7	0.0	0.0	0.0
Average	8.2	15.5	15.8	0.3	2.7	2.9

<sup>a</sup> An average of 25 equals 100% germination.

sent the germination value for varieties. Therefore, the size of the value reflects both germination rate and total germination.

Three replications were used for the variety comparison test and two were used for the seed treatment test.

## RESULTS

Seed germination data for the 12 varieties after 2, 4, 5, 6, and 7 days' deterioration are given in Table 1. In general, germination decreased with length of deterioration. There were no significant differences in germination among the varieties after 2 or 3 (not given in Table 1) days' deterioration. Acala 1517c showed significant deterioration as reflected in decreased germination after 4 days. Floyd 8G, Delfos 9169, and Northern Star No. 11 deteriorated less than the other varieties, as shown by better germination after 5 days. There were no real differences among varieties after 6 days, although Deltapine 15, Deltapine Fox, and Acala 1517c had ceased to germinate by then, nor after 7 days, when only Floyd 8G, Delfos 9169, Northern Star No. 11, Stoneville 7, and Malones Rowden still maintained some ability to germinate.

The second, fourth and fifth days' germination counts for the fifth and sixth days of deterioration are given in Table 2. Floyd 8G, Delfos 9169, Northern Star No. 11, Brazos, and Deltapine Fox tended to have faster germination rates after 5 days' deterioration. Empire WR and Deltapine TPSA tended to have higher germination rates after 6 days.

From the standpoint of selecting for resistance to seed deterioration, selections for some varieties would have to be made the second day of germination after 6 days' deterioration, while for other varieties selections would have to be made the fourth day of germination. Selections for some varieties would have to be made after 5 days' deterioration.

Percent seed moisture data for the varieties by days of deterioration are given in Table 3. The biggest change in moisture occurred from the first to the second day and from the sixth to the seventh day. Seeds of some varieties gained moisture from the fifth to the sixth day while those of others lost moisture. The deterioration rank number for the varieties in Table 1 is given in Table 3 along with the moisture change from the fifth to the sixth day. Positive changes in moisture content tended to be higher for the more slowly deteriorating varieties and lower for the more rapidly deteriorating ones. The higher negative moisture changes were associated with varieties which were intermediate in deterioration rank.

The results of the seed treatment-seed deterioration experiment for days of deterioration are given in Table 4. Seed treated with 2 ounces of Ceresan 100 did not deteriorate more rapidly than the control. Germination at the 3-ounce rate was higher than in the control after 1 and 4 days, but dropped after the fifth day. Seed treated with 3 ounces of Dow 9B showed reduced germination after 5 days' deterioration. Germination at the 4-ounce rate was lower after 4 days' deterioration, and after 5 days was significantly lower, than in the control. Seed treated with Captan 75 gave germination values similar to those for Dow 9B.

The rate of germination for the treated seed after 5 days' deterioration is given in Table 5. Germination was reduced at the higher treatment rates. Ceresan 100 used at 2 ounces was the only treatment that tended to increase the germination rate. The influence of deterioration on the germination rate is better shown with the seed treatment data in Table 6. The germination rate was reduced slightly from zero day to the first day. There was no change from the first through the fourth day of deterioration. The big reduction was from the fourth to the fifth day.

The moisture content of the treated seeds by days of deterioration is given in Table 7. Beginning on the fourth day the treated seeds tended to have a higher moisture content than the control. This trend continued through the fifth day. On the sixth day only seeds treated at the 2-ounce rate of Ceresan 100, the 3-ounce rate of Dow 9B, and both rates of Captan 75, had higher moisture contents than the controls.

## DISCUSSION

These seed deterioration results, although preliminary, emphasize the importance of the artificial deterioration method as a tool in seedling disease investigations. The indications of varietal differences in seed deterioration rates suggest that this character may be heritable. If this should prove to be so, progress in selecting for resistance to seed deterioration could be made. With this type of resistance added to commercial varieties the problem of producing high quality planting seed would be reduced. Seedlings of such varieties would be less apt to be damaged or killed by seedling disease fungi.

Table 3. Percent moisture by days of deterioration for cottonseed of twelve varieties.

Varieties	Percent seed moisture for days of deterioration					Deterioration rank	Moisture change from 5th to 6th day
	1	2	5	6	7		
Northern Star #11	8.0	10.9	14.3	16.9	15.6	3	+2.6
Floyd 8G	7.9	10.9	14.9	16.4	15.7	1	+1.5
Brazos	8.3	12.6	14.8	15.7	17.1	9	+0.9
Delfos 9169	8.6	11.6	14.9	15.6	17.2	2	+0.7
Deltapine Fox	8.8	11.4	15.4	15.9	18.2	11	+0.5
Deltapine 15	9.0	11.3	15.6	15.9	16.8	10	+0.3
Stoneville 7	8.6	11.2	15.9	16.1	16.8	4	+0.2
Deltapine TPSA	8.1	10.3	16.0	15.5	17.9	8	-0.5
Malones Rowden	8.1	10.0	15.6	15.0	17.5	5	-0.6
Lankart Sel. 57-5	9.1	11.2	16.0	15.4	19.1	7	-0.6
Acala 1517c	9.0	11.4	15.7	14.9	16.2	12	-0.8
Empire WR	9.0	11.2	16.0	15.0	18.5	6	-1.0

Table 4. The influence of seed treatment on seed deterioration.

Days of deterioration	Average germination <sup>a</sup>						Average <sup>b</sup> for days
	Control	Ceresan 100		Dow 9B		Captan 75	
		2 ozs.	3 ozs.	3 ozs.	4 ozs.	2 ozs. 4 ozs.	
0	24.7	25.0	23.0	24.0	23.8	24.7 24.3	24.2
1	20.7	23.8	24.3	18.8	20.5	24.8 18.7	21.7
4	21.8	21.5	24.0	23.3	16.0	19.2 18.7	20.6
5 <sup>c</sup>	17.0	18.8	14.5	12.5	7.5	11.3 4.0	12.2
6	1.3	0.0	1.3	0.0	0.0	0.0 0.0	0.3

<sup>a</sup> An average of 25 equals 100% germination.

<sup>b</sup> The first and 4th days are significantly lower than 0 day, the 5th day is significantly lower than the 1st and 4th days and the 6th day is significantly lower than the 5th day.

<sup>c</sup> L.S.D. for treatments for the 5th day, 1% level 9.3, 5% level 6.1.

Table 5. The influence of seed treatment on the fifth day of seed deterioration.

Days of Germination	Average germination <sup>a</sup>						Average
	Control	Ceresan 100		Dow 9B		Captan 75	
		2 ozs.	3 ozs.	3 ozs.	4 ozs.	2 ozs. 4 ozs.	
2	6.0	8.5	6.5	3.5	2.5	4.0 0.0	4.4
4	22.5	24.0	18.5	17.0	10.0	15.0 6.0	16.1
5	22.5	24.0	18.5	17.0	10.0	15.0 6.0	16.1

<sup>a</sup> An average of 25 equals 100% germination.

The results point out that the deterioration time for effective selection would vary with different varieties. The specific number of days of deterioration and days of germination used for selection would have to be established for the particular variety under consideration.

The results also indicate that seeds of Acala 1517c deteriorate faster than seeds of the other varieties studied. This variety was developed in the Southwestern area, and probably has undergone less natural selection for resistance to seed deterioration than the other varieties. This circumstance further suggests that progress in selection could be made.

The fact that Acala 1517c possesses the highest degree of seedling vigor among the varieties studied suggests that seedling vigor and resistance to seed deterioration may be negatively associated. For this reason selections for resistance to seed deterioration should be evaluated for seedling vigor also.



Table 6. The influence of seed deterioration on the germination rate.

Days of Germination	Germination for days of deterioration <sup>a</sup>				
	0	1	4	5	6
2	22.6	15.5	15.6	4.4	0.0
4	25.0	24.7	23.1	16.1	0.6
5	25.0	24.7	23.1	16.1	0.6
.01		9.5	8.2	11.0	
L.S.D. .05	n.s.d.	4.1	3.6	4.8	n.s.d.

<sup>a</sup> An average of 25 equals 100% germination.

Table 7. Percent moisture by days of deterioration for cottonseed treated with protectant fungicides.

Treatments	Percent seed moisture for days of deterioration				
	0	1	4	5	6
Control	7.7	9.7	11.7	12.9	13.6
Ceresan 100 2 ozs.	7.9	9.5	13.3	13.5	14.1
3 ozs.	7.9	8.9	12.5	12.9	13.9
Dow 9B 3 ozs.	7.5	9.0	13.7	15.6	15.7
4 ozs.	7.6	10.6	13.5	14.2	13.6
Captan 75 2 ozs.	7.5	10.4	12.8	14.5	14.7
4 ozs.	7.8	9.3	14.1	15.4	16.3

Results with seed treated with protectant fungicides indicate that possibly the factor of seed deterioration should be considered in evaluating seed protectants as well. The results indicate that high quality seed treated with certain fungicides would deteriorate faster after planting, especially if conditions unfavorable for germination, such as cool, wet soil, last for several days. The fungicide, although protecting the seed from soil-borne fungi, could cause the seed to become less viable sooner than it normally would. Moreover, the results indicate that perhaps seed treated with certain materials deteriorates faster in storage than untreated seed, especially if conditions are unfavorable.

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# A LINT-ROT OF COTTON IN CALIFORNIA CAUSED BY NIGROSPORA ORYZAE<sup>1</sup>

Byron R. Houston and Richard H. Garber<sup>2</sup>

## Summary

During the past several years *Nigrospora* has been found responsible for a cotton lint-rot ranging in severity from a trace to as high as 15 percent of the bolls affected on individual plants. The rot has been most important in the central-east side of the San Joaquin Valley cotton-growing area. Infection occurs at or just before initiation of boll opening and results in a gray rot of the lint and a failure to fluff. The affected lock often falls from the bolls before picking unless it is only partially invaded by the fungus. Typical rot has been induced by inoculations in the field and the greenhouse.

## INTRODUCTION

The fungus *Nigrospora oryzae* (Berk. & Br.) Petch (*Basisporium gallarum* Moll.) has been reported as the causal agent of diseases of a number of monocotyledonous species (2, 3, 7, 8, 9, 11). The most commonly reported host was maize on which the fungus was active as an ear and stalk rot. *Nigrospora* has also been reported as being associated with a rot of potato tuber (4), tomato fruit (10), and apple fruit (1). In 1929, Jaczewski (6) reported *Nigrospora* as one genus among over 70 species of fungi isolated from cotton fibers from bolls from central Asia. Hansford (5) reported *N. oryzae* as one of many fungi isolated from the interior of cotton seed.

During the past 10 years *N. oryzae* has been sporadically found associated with a gray lint-rot of cotton in the San Joaquin Valley of California. A survey of cotton fields scattered throughout the northeastern San Joaquin Valley in early November, 1955, showed that *Nigrospora* rot was present in 12 of the 35 fields examined. Infected bolls ranged from a trace to as high as 10 percent of the open bolls present on the plants.

## SYMPTOMS AND SIGNS

The lint in the affected locks (carpel contents) fails to fluff and is light-gray to almost black (Figure 1-A). At times only the base or the tip of the lint mass is affected and the remainder of the fibers fluff normally at maturity. Affected fibers are extremely weak and tend to break into small fragments under slight tension. By harvest time the diseased locks commonly have fallen from the boll or are easily dislodged when plants are jarred. For these reasons few of the severely damaged locks are harvested; however, partially invaded masses of lint were often present in cotton picked either by hand or by machine.

The dark color imparted to invaded lint is the result of heavy conidial production by the fungus. Individual conidia can be distinguished under low-power magnification by their extreme dark color as contrasted with the light colored mycelium and cotton fibers (Figure 1-B). Mycelium and conidia are produced throughout the invaded portion of the locks so that the internal color is also gray.

## RELATION OF THE FUNGUS TO THE FIBERS

Microscopic examination showed that the mycelium of *Nigrospora* was present both in the lumen (Figure 1-C), and on the surface of the fibers. Conidia were produced abundantly from the surface mycelium, but also were found occasionally in the fiber lumen (Figure 1-D). The mycelium appeared to penetrate the cellulose fiber walls at random but often was concentrated in elongated strands in the lumen. The fiber walls were greatly weakened and tended to shred

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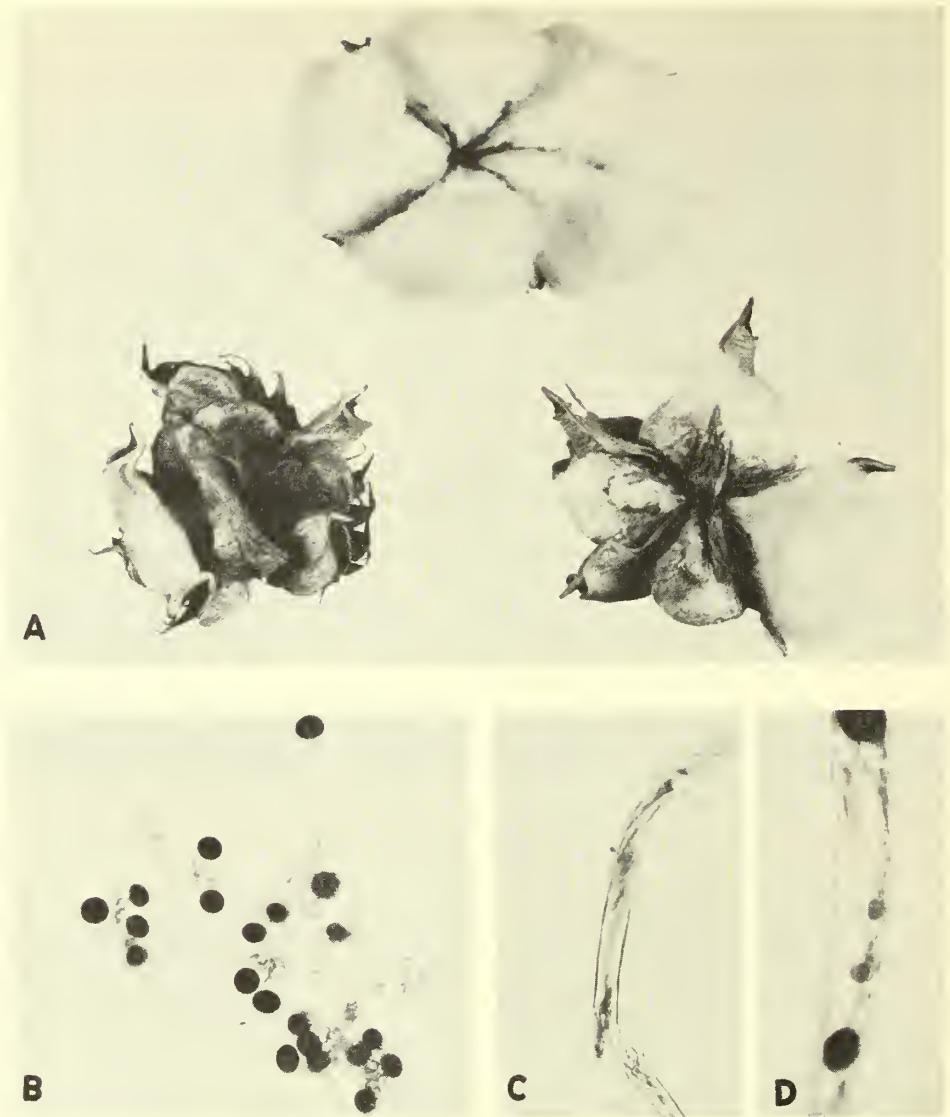


FIGURE 1. A -- Open bolls of Acala 4-42 cotton. Top: normal boll with fluffed fibers. Bottom: diseased locks showing complete and partial invasion by Nigrospora oryzae. B -- Typical conidia, conidiophores and mycelium of Nigrospora oryzae isolated from diseased cotton. Conidia average  $15\ \mu$  in largest diameter. C -- Breaking and shredding of fiber wall at point of mycelial concentration. D -- Mycelium and conidia of N. oryzae in fiber lumen.

and break at such points of mycelial concentration. Typical N. oryzae was isolated from all parts of the invaded lint.

For study of the growth of the fungus on cotton fibers in culture, media were prepared by adding distilled water or inorganic salts of a basal medium to raw or processed and bleached lint. The media were sterilized by autoclaving and inoculated with N. oryzae. The fungus grew more abundantly on raw than on processed lint. The mycelium penetrated the fiber walls, but there was much less evidence of damage to the fiber strength and structure as compared with the damage shown by fibers from naturally infected bolls.



## INOCULATION PROCEDURES AND RESULTS

Bolls of the variety Acala 4-42 were inoculated in the field by spraying a spore suspension of *N. oryzae* into the natural cracks along the carpel sutures as the boll approached the opening stage or by hypodermic injection of a spore suspension into the natural opening between the carpels at the "blossom end" of the boll about 5 days before such bolls would have opened naturally. Only 2 of 55 bolls sprayed with spore suspension developed lint-rot, whereas 78 of 110 bolls inoculated with a hypodermic needle showed typical lint-rot 3 weeks after inoculation. The number of locks affected in each boll varied from 1 to 5, with an average of 2.5.

Hypodermic inoculations of bolls of Acala 4-42 in the greenhouse at Davis, California, gave results similar to those in the field on bolls unopened at the time of inoculation. When cracked or partially opened bolls were inoculated in the greenhouse, lint-rot was very limited unless the bolls were subsequently either shaded or partially enclosed by a plastic covering. In either of the latter cases complete invasion of all locks usually resulted. Hypodermic inoculations into green bolls which had developed to half size or larger resulted in complete invasion of each lock inoculated. The fungus did not appear to penetrate the carpel walls and thus spread from one lock to another. Reisolations all yielded typical *N. oryzae*.

All evidence from inoculations indicates that the fungus must be introduced into the lint at a very early stage of boll opening, and during periods or in areas of high relative humidity in order to develop and produce the lint-rot.

This appears to be the first report of *N. oryzae* as a causal agent of lint-rot of cotton under field conditions in the United States of America.

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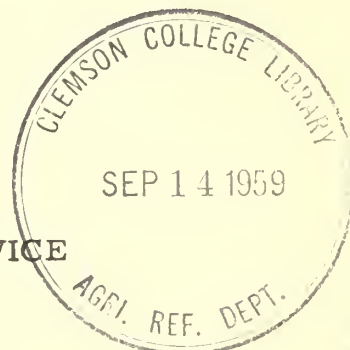
# THE PLANT DISEASE REPORTER

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CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE



STUDIES ON THE SOYBEAN CYST NEMATODE, HETERODERA  
GLYCINES AND ITS INJURY TO SOYBEAN PLANTS IN JAPAN

Supplement 260

September 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



THE PLANT DISEASE REPORTER

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

STUDIES ON THE SOYBEAN CYST NEMATODE HETERODERA  
GLYCINES AND ITS INJURY TO SOYBEAN PLANTS IN JAPAN

Minoru Ichinohe

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STUDIES ON THE SOYBEAN CYST NEMATODE HETERODERA  
GLYCINES AND ITS INJURY TO SOYBEAN PLANTS IN JAPAN

Minoru Ichinohe<sup>1</sup>

## 1. HISTORICAL REVIEW

The occurrence of the soybean-cyst nematode in Japan was first recorded by S. Hori in 1915. According to his report, Hori discovered the nematode on the roots of a soybean plant which was sent from Shirakawa, Fukushima Prefecture, where the same disease had been observed for many years. He noticed that this nematode was different from the root-knot nematode which had been well known in Japan at that time, and asked S. Uchida to identify it. In accordance with S. Uchida's identification, Hori referred the nematode to a species closely related to Heterodera schachtii which had been known as the causal nematode of "sugar-beetsickness" in Europe. Hori added in his paper that it is necessary to compare this nematode with Heterodera göttingiana which attacks pea in Germany.

In the next year, T. Ishikawa (1916) reported that in Niigata Prefecture there had occurred for many years the soybean disease which was called "Tsukiyobyō" (literally translated into "moon night disease") probably after the characteristic appearance of the diseased part of the fields which was likened to full moon, and reported that at Omote-ga-hara, Uonuma-gun, Niigata Prefecture the land became incapable of cropping soybeans due to this disease. He mentioned in his paper that the causal organism was thought to be the same which Hori (1915) reported.

K. Katsufuji (1919) and S. Ito (1921) reported the occurrence of this nematode in Hokkaido, the northernmost island of Japan. According to Ito (1921), this disease had been observed on soybean in Iburi and Oshima Provinces, southern part of Hokkaido, for more than 10 years, and the nematode was thought to be the same species as the sugar-beet nematode, Heterodera schachtii, judging from the morphology of females and larvae. In his paper, Ito named this disease "Daizu-iwo-byō" (literally translated into "soybean yellow dwarf disease") after the characteristic symptom of yellowish discoloration of the diseased plant.

T. Tanaka (1921) reported the occurrence of soybean "moon night disease" in Ibaragi Prefecture and thought that the causal nematode was different from both root-knot nematode (Heterodera marioni) and sugar-beet nematode (Heterodera schachtii).

K. Fujita and O. Miura (1934) studied the host range of this nematode and revealed that it can infect the soybean, azuki bean, kidney bean, and multiflora bean, but did not attack the other legumes tested. These are: Pea, Pisum sativum; lima bean, Phaseolus limensis; broad bean, Vicia faba; common vetch, V. sativa; peanut, Arachis hypogaea; cowpea, Vigna sinensis; red clover, Trifolium pratense; Lupinus albus; Lathyrus tingitanus. The following plants were also tested without infection: Chenopodiaceae (sugar beet, Beta vulgaris; spinach, Spinacia oleracea), Solanaceae (potato, Solanum tuberosum), Cruciferae (cabbage, Brassica oleracea var. capitata; pe-tsai, B. pekinensis; kohlrabi, B. oleracea var. caulorapa; rape, B. napus), and Gramineae (oats, Avena sativa; barley, Hordeum vulgare; wheat, Triticum aestivum; corn, Zea mays). These results indicated that the soybean-cyst nematode was a biological race of H. schachtii occurring in Japan, similar to those which were called the pea-, oat-, and potato-races of Heterodera schachtii in Europe.

Franklin (1940) raised some so-called biological strains (or races) of H. schachtii to the rank of a species after morphological studies of those nematodes. Since then, the specific status of soybean-cyst nematode has been so indistinct that although most of the workers have referred to it as H. schachtii, some workers (Filipjev and Schuurmans Stekhoven-1941, Goffart-1951, Yokoo-1951) have considered it to be H. göttingiana.

Ichinohe (1952) compared the soybean-cyst nematode with specimens of other species of Heterodera, and described it under the name Heterodera glycines. The main differences be-

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tween *H. glycines* and *H. schachtii* are in punctation of cyst wall, presence of the "yellow phase" of the living female, ratio of length to breadth of cyst, and length of stylet in the male. *H. glycines* differs from *H. göttingiana* in that the spicules of the former species have bifid tips while *H. göttingiana* has spicules with trifid tips. In addition, the mature cyst of *H. glycines* has "brown knobs" at the posterior end which are lacking in *H. göttingiana*.

## 2. DISTRIBUTION IN ASIA

The soybean-cyst nematode has been found in many places in Japan (Hokkaido-, Honshu-, Shikoku-, Kyushu Islands), but there are few reports on distribution from these islands except Hokkaido. In Hokkaido, the soybean-cyst nematode was discovered in four localities (Date-, Sobetsu-, Abuta-, Horobetsu-mura) in or about 1920. The survey made in 1932 to 1935 by the Hokkaido Agricultural Experiment Station revealed 49 localities infested by this nematode. As of 1958 more than 64 localities were found to be infested. It can be said that all of these infested localities are restricted to the southern part of Hokkaido, particularly to such types of soil as sandy, less-organic, and volcanic ash soil.

It is reported by T. Yokoo (1936) that this nematode has been observed in Korea.

K. Nakata and H. Asuyama (1938) reported that the soybean-cyst nematode was found in Manchuria (present Red China's territory). (The details of this report from Manchuria are noted in section 10, page 247.

No report on the occurrence of this nematode has been made from any other place in Asia.

## 3. THE MORPHOLOGY OF THE SOYBEAN-CYST NEMATODE

Morphology of the adult male is as follows: Body is 1.2 - 1.4 mm ( $M = 1.33$  mm) in length and 27 - 31  $\mu$  ( $M = 28.6$   $\mu$ ) in width. Cuticle is 3.0 - 3.5  $\mu$  in thickness and consists of three layers. The transverse striations on the cuticle are 1.5 - 2.4  $\mu$  apart, although this varies dependent upon the portion of body. The lateral field is marked by four longitudinal incisures, beginning as three incisures anteriorly and increasing to four just posterior to the base of spear, extending the length of the body and around the blunt tail posteriorly. The head region is hemispherical, 6.2 x 11.3  $\mu$  in size, and bears four or five annules. In face view the head region has six radially arranged lips, of which the lateral lips, possessing slit-like openings of amphid aperture, are smaller in size than the submedian lips. The cephalic framework is heavily sclerotized. The spear is 26.1  $\mu$  in mean length with laterally to anteriorly protruded knobs. The oesophagus, 160 - 180  $\mu$  ( $M = 173$   $\mu$ ) long, is divided into three parts. The median bulb is 19.4  $\mu$  x 12.8  $\mu$  in size, and from the anterior end of the body to the posterior side of the median bulb is 90 - 100  $\mu$  ( $M = 94.6$   $\mu$ ). The orifice of the dorsal oesophageal gland is located about 4  $\mu$  posterior to the spear. The testis starts at the middle of the body or slightly anterior. The spicules are slightly arcuate and 34  $\mu$  long with bifid tips. The gubernaculum is 11.5 - 12.0  $\mu$  ( $M = 11.7$   $\mu$ ) in length. The excretory pore is located ventrally 144 + 11.0  $\mu$  from the anterior. The phasmid is 2 to 8  $\mu$  (usually 4 to 6  $\mu$ ) from the posterior. Tail is 1.7 - 5.5  $\mu$  ( $M = 3.5$   $\mu$ ) in length. Table 1 compares males of this and three other species.

Morphology of the adult female is as follows: The body is lemon-shaped with a short neck, 0.07 - 0.10 mm long, anteriorly and with a prominent vulva posteriorly. It varies from 0.47 to 0.79 mm in length and 0.21 to 0.58 mm in width. The color is white at first and then turns yellow as eggs develop, -- the "yellow phase" as described by Jones (1950) for *H. rostochien-sis* and *H. galeopsidis*. The newly developed female is coated with a so-called subcrystalline layer which persists on the brown cyst. The cuticle is thickened, being from 7 - 9  $\mu$  at the middle part of the body to 9 - 11  $\mu$  at the neck and at the posterior region. The cuticle consists of three layers. The outer layer is marked by a rugose pattern except for several annulations on the anterior end. In face view the head region bears no six-radial lips, but a hexagonal circum-oral cuticular plate. The spear is somewhat slender with posteriorly protruded knobs and is 27.5  $\mu$  in mean length. The oesophagus and median bulb are much larger than those of the male and larvae, being 39.0 x 32.5  $\mu$  in size. The anus is located ventrally 75 to 90  $\mu$  from the middle of the vulva. The paired ovaries fill almost the entire body cavity and open to the posteriorly located vulva. A gelatinous egg sac roughly one-third of body in size is attached to the vulva and may contain as many as 200 eggs. Various sclerotized structures surround the vulva.

The cyst is brown and lemon-shaped. It is 0.56 - 0.85 mm ( $M = 699 \pm 60$   $\mu$ ) in length, 0.35 - 0.59 mm ( $M = 490 \pm 54$   $\mu$ ) in width, and 1.43 in ratio of length to breadth (Table 2). The cyst wall consists of two layers, of which the outer layer is marked by a rugose pattern. The inner layer has minute punctations which are usually arranged with a tendency to run in parallel rows particularly on part of the posterior region.



Table 1. Comparisons of males of *Heterodera*<sup>a</sup>.

Species	Body length ( $\mu$ )	Spear length ( $\mu$ )	Tip of spicules
<i>H. schachtii</i> (mangold)	1.468-0.0095	29.71-0.4104	Bifid
<i>H. gottingiana</i> (pea)	1.295-0.0188	27.54-0.4047	Trifid
<i>H. rostochiensis</i> (potato)	1.113-0.0089	27.39-0.4773	Monofid
<i>H. glycines</i> (soybean)	1.313-0.0980	26.80-0.26	Bifid

<sup>a</sup> From Franklin (1940) in part.

Table 2. Variations in the size of cyst of the soybean-cyst nematode.

No. of group of :	Length :			Width :			Ratio av. length to av. width
	Max.	Min.	Av.	Max.	Min.	Av.	
10 cysts :							
1	808	640	726	589	438	523	1.39
2	850	614	698	547	387	475	1.47
3	791	614	695	564	370	494	1.41
4	800	623	705	555	429	503	1.40
5	757	606	687	572	387	473	1.45
6	774	589	683	547	404	460	1.48
7	808	572	709	547	370	478	1.48
8	808	555	711	581	354	513	1.39
9	741	600	675	572	421	482	1.40
10	808	564	708	581	404	492	1.44

The first-stage larvae complete their development within the egg, and cast off the first-stage larval cuticle when they hatch. The hatched larva (the second-stage larva) is 450 - 490  $\mu$  ( $M = 470.6 \pm 17 \mu$ ) in length, which falls into the "medium" group when measured by the standard technique of Fenwick and Franklin (1951). The body width is 18.0 - 18.5  $\mu$  ( $M = 18.3 \mu$ ). The head region is 4.5 x 8.9  $\mu$  in size and bears three or four annules. In face view the head region bears six radially arranged lips. The cephalic framework is heavily sclerotized. The spear is 23.1  $\pm$  0.2  $\mu$  long with anteriorly protruded knobs. The median bulb is 16.5 x 10  $\mu$  in size; the distance between the anterior and the end of the median bulb is 69  $\mu$ . The orifice of the dorsal oesophageal gland is about 4  $\mu$  posterior to the spear. The anus is located 42.0 to 47.0  $\mu$  ( $M = 45.0 \mu$ ) from the tail tip. The genital primordium is 15 x 8.5  $\mu$  in size. The body cavity extends to 20  $\mu$  posterior to the anus. The excretory pore is located ventrally 92  $\mu$  from the anterior. The phasmid is 10  $\mu$ , five or six annules, posterior to anus.

The eggs are 98 - 118  $\mu$  ( $M = 107.5 \pm 4.8 \mu$ ) long and 40 - 47  $\mu$  ( $M = 42.7 \pm 2.1 \mu$ ) wide.

#### 4. SYMPTOMS CAUSED BY THE SOYBEAN-CYST NEMATODE

The "yellow dwarf" disease caused by the soybean-cyst nematode appears in fields toward the middle of July, about 2 months after sowing. It is characterized by severe retardation of growth, stunting, and yellowish appearance on the aerial parts of the plants.

The foliage of the diseased plant falls off early. The plant bears only a few flowers, and a few seeds which are smaller in size and inferior in quality to the normal ones.

The roots of affected plants bear many developed lateral rootlets and in most cases many fewer bacterial nodules than those of healthy plants.

In the field the disease occurs in more or less circular patches at first, and these patches spread as the season proceeds. If soybeans are successively planted on the infested land, these patches will cover the whole field within 2 or 3 years. Actually, due to these yellowish and sunken patches in the field, we can easily recognize the occurrence of disease from outside of the field, in many cases even from a distance.

It is not rare that a smaller yield than the seed sown has been harvested.

## 5. HOST PLANTS AND THE PARASITISM OF THE SOYBEAN-CYST NEMATODE

The hosts of the soybean-cyst nematode hitherto recorded by several authors show that the host plants are rather restricted in number. Fujita and Miura (1934) revealed that this nematode attacks the soybean with the most severity, the azuki bean always slightly, and only a trace of infection was found on the kidney bean and the Spanish runner bean (multiflora bean).

Ichinohe (1953) reported the nematode-infection indices of these four plants, based on the number of the white females attacking the tap roots of plants which were grown for 6 weeks in infested soil. These indices are:

Soybean ( <i>Glycine max</i> )	28.3
Azuki bean ( <i>Phaseolus angularis</i> )	26.7
Kidney bean ( <i>Phaseolus vulgaris</i> )	3.2
Spanish runner bean ( <i>Ph. multiflorus</i> )	0

It was noticed that these differences in the degree of nematode infection among the four susceptible plants were not related to the number of larvae that invaded the roots. The author also proved that the rates of larval development inside the different hosts were almost identical and that the exceedingly small number of the females on the kidney bean was probably due to the following circumstances: On the soybean and the azuki bean, the young adult females break the cortical tissue of the roots of the host plant as they develop, and finally they protrude from the roots. On the kidney bean, however, the young females in the root tissue were not fully grown and of small size, and very few females could break to the surface of the root. Egg production was also decreased. Though Fujita and Miura (1934) had reported the multiflora bean to be a host plant of this nematode, the author observed that the larvae which invaded the root could not complete their development and that none had reached the adult female stage. This fact convinced the author that this plant is not a host plant.

*Glycine ussuriensis* was proved to be a host of the soybean-cyst nematode by Ichinohe (1955). This plant shows typical symptoms in above-ground parts and seems similar to the soybean in susceptibility to this nematode. *Glycine ussuriensis* is said to be a wild-type of soybean, and grows naturally in Honshu.

We have never tested whether or not *Vicia sativa* and *Lespedeza stipulacea*, which were reported to be hosts of the soybean-cyst nematode in the United States of America, are host plants in Japan. These plants are not common in Hokkaido. The author found very recently that one species of *Lespedeza* which is a common annual weed in certain places in Honshu seems to be an undescribed host plant of this nematode.

The parasitism of the soybean-cyst nematode to 28 species of plants generally not regarded as host plants was tested. The plants were grown in 5-inch pots inoculated with many cysts of this nematode and examined every 7 days for the presence of invading larvae and, if larvae were found, on the amount of development undergone. The results of this test indicated that this nematode always invaded the roots of many species of leguminous plants other than the hitherto known host plants, but that plants not belonging to Leguminosae showed almost no evidence of an invasion. Moreover, in certain species such as peas, broad beans etc., many larvae invaded but failed to develop after invasion, and in other species such as alsike clover, lima bean, etc., occasionally the partly-grown parasite, not reaching to the adult stage, could be found. The fact that the soybean-cyst nematode invades the roots of plants hitherto not regarded as host plants is of considerable importance, because those plants may be applied as a "trap crop" to control this pest.

The hatching responses of larvae when they were exposed to the root diffusates of host plants or non-host plants were investigated during winter months of 1949-1950, with negative results.

The root of the soybean responds to invasion by the nematode by the production of giant cells.

## 6. DEVELOPMENT OF THE SOYBEAN-CYST NEMATODE AND ITS POSSIBLE GENERATIONS IN ONE YEAR IN HOKKAIDO, JAPAN

The number of days necessary for the invading larva to mature in root tissue varies with environmental soil temperature. The adult male appears earlier than the adult female. It is usually observed that a male lives in the gelatinous egg-sac of the female.

The number of eggs in a single cyst varied from 95 to 478, with an average of 262, when 66 cysts that had matured on soybean root were tested. The number of eggs found in the egg sac

varied from a few to 218. Single females produced from 228 to 564 eggs. Tokachi Province, Hokkaido, where this pest is most severe, is said to be extremely cold in winter. According to the meteorological report from Obihiro-shi, Tokachi, the land is frozen from November to April, with the maximum frozen depth of 27.4 cm on February 25<sup>2</sup>. This means that the cyst of the soybean-cyst nematode is highly resistant to cold. It was ascertained that cysts exposed to such a low temperature as -40° C for 7 months still contained viable eggs.

In 1952 and 1953, observations on the length of one generation of *H. glycines* were repeated eight times. One generation, from the time of larval entry at the time of germination of soybean seed to the time of appearance of embryonated eggs within the egg sac, takes 24 days at an average soil temperature of 23.3° and 41 days at 17.8° C. The rate of nematode development, which was expressed by a reciprocal of the number of days for one generation, was roughly proportional to the average soil temperature of each period. The author calculated the accumulated effective temperature needed for one generation of this nematode, to compute the possible number of generations per year in the Sapporo district, Hokkaido. The threshold temperature of nematode development was 10° C, thus the accumulated effective temperature necessary to complete one generation varied from 304 to 320, with an average of 313, day-degrees. In the Sapporo District, the time during which this nematode can develop was estimated as from June 1 to October 10, which coincides with the vegetative period of the host crop. Information about soil temperatures in the field was obtained from the Hokkaido National Agricultural Experiment Station. The total effective temperature of this period, calculated by summing up the temperatures in excess of the threshold temperature of development, was calculated as 1209 day-degrees at a depth of 5 cm in soil and 1069 day-degrees at a depth of 30 cm. The possible number of generations, dividing the total effective temperature by the accumulated effective temperature of 313 day-degrees was 3.8 at a depth of 5 cm and 3.4 at 30 cm. Thus, it is thought that a maximum of three generations would be completed on the soybean roots each year if conditions in addition to the soil temperatures were favorable.

## 7. DAMAGE OF SOYBEAN DUE TO THE SOYBEAN-CYST NEMATODE

Affected plants are decreased in height and yield; heavily infected plants may be only one-third as tall as normal plants. Seed production may be reduced to 10 to 30 percent of normal.

Table 3 shows the reduction of affected soybean plants studied in 1954 at Ebetsu, Hokkaido. In this field of about 2.5 acres, there occurred three patches of the diseased plants.

In August 1952, a survey of soybean-cyst nematode-injury was made in Memuro-machi, Tokachi Province, Hokkaido. Tokachi Province is supposed to be the biggest soybean-producing area in Japan, and is supposed to be the biggest soybean-producing area in Japan, and Memuro-machi is the town which has the widest soybean field in Tokachi Province. In this survey, every soybean field was inspected and damage due to nematode was graded into four classes: severe, moderate, slight, and none. We derived an average yield-reduction index D (41.3 percent) from the result of the survey by using the following formula:

$$D = \frac{\text{Total "severe" area} \times 3 + \text{Total "moderate" area} \times 2 + \text{Total "slight" area} \times 1}{\text{Total "injured" area} \times 3}$$

This index was applied to estimate the damage in the whole Tokachi Province as shown in Table 4.

The following study was made on October 4 to 6, 1949 in a soybean field belonging to the Tokachi Branch Station of the Hokkaido Prefectural Agricultural Experiment Station, Obihiro, Hokkaido. The affected "Tokachi-nagaha" variety of soybean totalling 127 plants taken from seven rows in this field were examined in respect to height, yield, and the number of new females attached on the root system. The plants varied 306 to 639 mm in height, 6 to 76 in number of pods, 0.7 to 28.3 grams in weight of seed, and 28 to 226 in number of new females per plant. The tested plants were divided into 12 gradations of damage according to the pod number per plant, and in each gradation an average and the standard deviation of the number of new females were calculated. These are shown in Table 5.

The data in Table 5 happened to show that fewer females were counted on the roots of heavily affected plants as well as on those of healthy plants than on roots of moderately affected plants.

<sup>2</sup> Average 1922-1932.



Table 3. Growth of soybean plants taken from inside of three patches of diseased and healthy plants from outside of patches (average of 15 plants, September 20, 1954)

Patch of disease	Height of plant (cm)	Weight of plant (grams)	Number of pods per plant
" A "	22.9	4.0	2.4
" B "	34.2	15.6	6.2
" C "	41.5	20.0	10.7
Healthy	61.2	84.0	38.0

Table 4. Estimated loss due to soybean cyst nematodes in Tokachi Province.

Locality :	Total : cropping: land : (acres) :	Total : bean- cropping : land : (acres) :	Percentage : of bean- cropping :	Total bean- cropping : land where nema-disease was observed : (acres) :	Percentage : of nema- diseased : land to total bean cropping : land :	Average : yield- reduc- tion : index : (percent) :	Amount : of injury in million yen
:	:	:	$\frac{A}{B}$	:	$\frac{C}{B}$	:	:
:	A	B	$\frac{A}{B}$	C	$\frac{C}{B}$	D	$C \times D \times E^a$
Memuro- machi	41639	17336	41.6	8707	50.2	41.3	115
Tokachi Province	326623	134102	41.1	37611	28.0	41.3	497

<sup>a</sup>E = Market price of soybean per Tan (or 1/4 acre) = 3520 (yen) x 2.46 (bales)

Table 5. Comparison between soybean plant growth and extent of infection by the soybean cyst nematode.

Number of group	Number of pods	Weight of seeds (grams)	Height of plant (mm)	Number of females	Number of plants
1	(8.1 + 1.5)	1.2 + 0.5	429.6 + 34.7	52.8 + 19.6	9
2	(13.4 + 1.5)	3.3 + 1.3	407.6 + 57.4	66.1 + 27.7	7
3	(18.4 + 1.3)	3.8 + 1.5	458.4 + 52.8	79.5 + 32.0	24
4	(22.7 + 1.2)	4.5 + 1.9	459.1 + 44.4	93.8 + 34.7	19
5	(28.2 + 1.6)	6.5 + 0.2	484.4 + 72.9	86.8 + 26.0	14
6	(33.6 + 0.9)	7.3 + 2.5	495.4 + 35.5	140.3 + 39.9	9
7	(38.6 + 1.2)	10.4 + 2.5	504.1 + 48.3	135.0 + 36.8	8
8	(41.9 + 0.8)	11.1 + 1.4	527.5 + 60.5	142.0 + 40.9	8
9	(47.2 + 1.0)	12.8 + 3.3	517.8 + 39.3	166.0 + 48.8	5
10	(52.6 + 1.6)	13.5 + 2.6	535.6 + 42.2	165.2 + 28.3	5
11	(56.5 + 0.7)	16.5 + 3.1	523.5 + 30.0	101.8 + 43.2	8
12	(66.9 + 2.4)	20.1 + 3.9	545.9 + 32.3	118.1 + 53.5	11

## 8. STUDIES ON CONTROL MEASURES

### a. Control by the Cropping Method

It should be emphasized that rotation is still the only measure which is practicable and effective for control of the soybean-cyst nematode. According to our studies, it was shown that a 5- or 6-year rotation system (every fifth or sixth year cropping of soybean) seems to be almost perfect both for obtaining good yields of soybeans and for starving the nematodes, if we are careful to prevent introducing contaminated soil from other fields. In most cases, 3- or 4-year rotations were found unsatisfactory to control this nematode well, although comparatively high yields of soybean were obtained as compared with successive cropping. On the other hand, there are several cases in which even after more than 5 years of growing non-host plants, the yellowish dwarf patches appeared during the first year of soybeans. In such cases it is possible that the dispersal of the nematode cysts was made with agricultural implements, particularly when the plough was used carelessly. We think that in most cases the disease is spread in this way.

The most hopeful means of controlling this nematode is a rotation system which involves as many kinds of trap crops as possible. This work is now under way. According to the author's studies so far, several leguminous plants such as red clover, alfalfa, and peas seem to be useful for this purpose. The preliminary experiment showed a larger reduction of the nematode population by planting these crops than by fallowing or by planting host plants.

Also, we are testing the effectiveness of kidney bean, which is supposed to be a host of this nematode, as a trap crop. Our experiment showed that the plots where the kidney beans were planted had less population at the end of the growing season than the initial levels, though large increases of nematode populations occurred in adjacent plots where soybeans and azuki beans were grown. The reductions of population from the initial levels by one cropping of these crops were as follows:

<u>Crop</u>	<u>Grown in</u>	<u>Percent reduction in population</u>
Garden pea	Pot	86
Kidney bean	Frame	64
Kidney bean	Field	80
Fallow	Pot	62
Fallow	Frame	37
Fallow	Field	42

It must be true that control of this nematode by using these kinds of trap crops has actually been practiced to some extent by the farmer without his knowing it, since crops such as clover, alfalfa, and peas are fairly common in Hokkaido. Other crops which are common in Hokkaido are wheat, oats, barley, corn, potato, sugar beet, flax, and vegetables.

### b. Chemical Control

The soybean cyst nematode is comparatively easy to control with moderate applications of standard nematocides such as D-D or EDB, but the complete eradication of this nematode is quite difficult or impossible. Also, it is true that the increase of the cyst population is so rapid that even if the chemicals reduced the population to a low level, a high population will again be built up by one or two croppings of soybean. Our experiments proved 75 pounds per Tan of D-D (which is equivalent to 300 pounds per acre) very effective for control. Seventy-five pounds per Tan of EDB (Nemafume W-20) was also effective, but this chemical seemed slightly less effective as compared with the same dosage of D-D. Several other chemicals such as N-869, 1,3-dichloropropene (Telon), DBCP (Fumazone), were also found to be effective.

Several factors make it difficult to use these chemicals for practical control. The most important is that every chemical costs more than 6,000 yen per Tan<sup>3</sup>, which is uneconomical, and indeed impracticable. In Japan, soybeans are one of the cheapest crops. The reason that the farmers have been growing soybeans in Hokkaido so widely is that the soybean can be raised even in the comparatively sterile soil so long as it is free from nematodes. Also, soybeans are easy to raise, and the market price of soybean seeds seems rather stable. According to the agricultural statistics in Hokkaido in 1953, the average yield of soybean per Tan is 2.46

<sup>3</sup> 360 yen = 1 dollar; 4 Tan = 1 acre

bales (1 bale contains about 1.9 bushel) and the market price of 1 bale was 3,520 yen.

The other difficulty in the use of chemicals is that we have thus far no injecting instrument which can be used on a large scale in soybean fields.

### c. Resistant Varieties

The highly resistant varieties of soybeans seem to be very few. Out of hundreds of varieties, we found so far four resistant varieties which had been used in a certain district of the northern part of Honshu where this nematode is also found. These varieties are: Daiichi-hienuki, Nangun-takedate, Geden-shirazu, and Tan-ryoku. All of these resistant varieties show healthy appearance and good yield in spite of having fairly large numbers of females on their roots. These varieties are so resistant that yields as high as about 80 percent of the uninfected plants of those varieties can be obtained, compared with 80 to 100 percent reduction of yield in susceptible varieties in the same field. The trouble is that all of these resistant varieties happen to be extremely late-ripening even in Honshu, and in most cases they fail to yield in Hokkaido. Also, it is true that the quality of seed of some resistant varieties is inferior. Of these 4 varieties, "Geden-shirazu" seems most hopeful both in its high resistance to soybean-cyst nematodes and the good quality of its seeds. Attempts are being made to shorten the growth period of this variety by M. Ishikawa in the Soybean Breeding Laboratory, Tohoku National Agricultural Experiment Station, Kariwano, Akita, Japan, and others.

## 9. STUDY ON THE NATURE OF VARIETAL RESISTANCE TO THE SOYBEAN-CYST NEMATODE

A study was made in 1955 to clarify the nature of varietal resistance, using the four varieties "Daiichi-hienuki" (resistant), "Nangun-takedate" (resistant), "Tokachi-nagaha" (susceptible), and "Kokuso" (susceptible).

When plants completed their growth in pots where the same levels of cysts were inoculated, infected plants of both resistant varieties showed 95 to 105 percent of the yield of healthy plants from non-infested pots, whereas noticeable disease symptoms and only 42 to 56 percent of the yield of healthy plants were recorded for both susceptible varieties.

The nature of the resistance seemed to be retained even when the resistant variety was grown under conditions that reduced the growth period by the short-day treatment. Under this treatment infected plants of both resistant varieties yielded 92 to 106 percent as much as non-infected healthy plants given the same treatment, whereas infected plants of the susceptible variety "Tokachi-nagaha" yielded only 68 percent as much as healthy plants.

A study on larval invasion of both resistant and susceptible varieties indicated that no general relationship exists between the number of the invading larvae and the degree of varietal resistance. Many larvae that invaded roots of the resistant plants, however, showed some signs of early death in all of those varieties. Both susceptible varieties had fewer dead larvae in their root tissue than the resistant varieties. The number of the dead larvae after invasion seems to increase with the degree of the varietal resistance.

The numbers of females per plant showed no differences between resistant and susceptible varieties, and the resistant varieties had more females than the susceptible varieties late in the season. But if the number females per unit weight of root is taken into consideration, it can be said that there were fewer females per gram of root on the resistant varieties than on the susceptible ones, because the resistant varieties had much bigger root systems.

The resistant varieties had very vigorous root systems with unusually large laterals.

The root nodules per unit weight of root were fewer on susceptible than on resistant varieties. Almost all plants grown in infested soil had fewer root nodules in comparison with those grown in sterilized soil. It was a variety with a comparatively large number of root nodules that had the smallest number of white females per unit weight of root.

Table 6 summarizes the results of these studies.

In all respects mentioned above, the resistant varieties tested are placed not in the "resistant" but in the "tolerant" classification, following Dropkin (1955), and it is thought that some ecological features of the resistant varieties are associated with their resistance. These are: 1) failure of any large number of larvae to survive after entering, 2) increase in the activity of root-nodule bacteria, 3) great growth of the root system and consequently of above-ground parts.



Table 6. A comparison of nematode infection, growth and nodulation of susceptible and resistant soybean varieties examined on August 7-8, 1955 (upper figure) and on September 6-9, 1955 (lower figure).

Variety	Number of females		Weight of root (grams)	Number of lateral roots	Number of bacterial nodules	
	Per plant	Per gram of root			Per plant	Per gram of root
Daichi- hienuki	108	4.3	27.0	13.5	351	13.9
	1,560	14.1	118.3	12.6	1,186	10.7
Nangun- takedate	363	7.0	46.6	22.1	362	7.0
	6,607	40.5	146.0	19.5	880	5.4
Kokuso <sup>a</sup>	638	24.5	24.2	19.0	94	3.6
	366	17.3	19.2	17.1	17	0.8
Tokachi- nagaha	591	13.4	42.0	20.3	215	4.9
	2,922	56.3	49.1	16.1	167	3.2

<sup>a</sup>Kokuso is an extremely early ripening variety.

#### 10. STUDY ON THE SOYBEAN-CYST NEMATODE IN MANCHURIA

A paper by K. Nakata and H. Asuyama (1938) discusses the soybean-cyst nematode in Manchuria. Drs. Nakata and Asuyama were requested by the Government of Manchukuo to make a general survey of the diseases of crops in Manchuria, and their report was made in "Survey of the principal diseases of crops in Manchuria", Report No. 32 from Bur. of Industry, 166 pp., 1938, (in Japanese). A part of this article (pages 62-63) was translated as follows:

a. Distribution and Injury: The soybean-cyst nematode was found at Khu-lan (Pin-kiang hsiu), Tsi-tsi-har (Helung-kiang hsiu), Tao-nan, Khi-shu-lien (Kih-rin-hsiu), where the damage of some varieties of the soybean were so serious that they entirely failed to grow and died early. This disease does not seem to be spread widely at this time except in the above-mentioned district.

b. Environment for the Outbreak of the Disease: It is said that nematode invasion to living plants is more severe in soil deficient in organic matter, and the damage of plants is particularly severe in infertile soil. It seems that this disease is severe in areas where there is much rainfall and slight in dry land, and this is thought to be a reason why the disease is widely spread in the Tsi-tsi-har and Tao-nan districts. It is very likely that this disease is most common in the south-western part of Manchuria just as it is most common in the southern part of Hokkaido, Japan.

c. Varieties: The damage of the soybean plant by this nematode is, to a great extent, connected with the resistance of the variety concerned. In Tsi-tsi-har district, variety "Kung No. 557" is resistant to this nematode, varieties "Kung No. 555" and "Kung No. 556" are most susceptible and "Huang-pao-chu" is intermediate in susceptibility. In Tao-nan, variety "Huang-pao-chu" is highly susceptible, and every variety which was bred with the variety "Huang-pao-chu" was found susceptible.

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NATIONAL INSTITUTE OF AGRICULTURAL SCIENCES, TOKYO, JAPAN

# THE PLANT DISEASE REPORTER

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UNITED STATES DEPARTMENT OF AGRICULTURE

A GUIDE TO THE LITERATURE  
ON CERTAIN EFFECTS OF LIGHT ON FUNGI: REPRODUCTION,  
MORPHOLOGY, PIGMENTATION, AND PHOTOTROPIC PHENOMENA

Supplement 261

November 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



MYCOLOGY AND PLANT DISEASE REPORTING SECTION

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A GUIDE TO THE LITERATURE ON CERTAIN EFFECTS OF LIGHT ON FUNGI:  
REPRODUCTION, MORPHOLOGY, PIGMENTATION,  
AND PHOTOTROPIC PHENOMENA

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A GUIDE TO THE LITERATURE ON CERTAIN EFFECTS OF LIGHT ON FUNGI:  
REPRODUCTION, MORPHOLOGY, PIGMENTATION,  
AND PHOTOTROPIC PHENOMENA

Paul B. Marsh, Eldon E. Taylor, and Loretta M. Bassler<sup>1</sup>

### BACKGROUND

In the course of investigating the problem of pre-harvest microbial deterioration of cotton fiber, the writers noticed from accounts in the literature that isolates from three of the fungus genera which are most frequently involved in this problem -- Alternaria, Fusarium, and Diplodia -- are influenced in their sporulation in culture by light. Among the numerous fungi which grow upon the fiber in humid storage -- Aspergilli, Penicillia, Mucorales, and so forth -- some species also were reported to exhibit effects of light in respect to sporulation, or phototropic effects. Trichoderma, a fungus used in fundamental studies of fiber deterioration and in testing mildew resistance of textiles, also had been shown to be induced to sporulate by light.

While searching the literature for information on light effects on fungi important in microbial fiber deterioration, the writers observed that no general source of information on the effects of light on fungi was available. Consequently, over a period of time they built up a set of reference cards on this subject; the present literature guide is derived from these reference cards.

### NATURE AND PURPOSE OF THE GUIDE

The literature references listed here are concerned principally with effects of light on reproductive, morphological, and phototropic phenomena among the fungi and with light effects on pigmentation. Lethal and mutagenic effects and effects observed with fungi growing on or in a living plant have been excluded. The information presented is arranged according to the fungus involved, the listings being alphabetical by genus under each of four main taxonomic categories -- Phycomycetes, Ascomycetes, Basidiomycetes, and Fungi Imperfecti.

In preparing the guide there has been no intention of trying to develop a critical review of experimental evidence nor of dealing in great detail with the physiological mechanism of light effects. Rather, the guide is intended principally for use by the individual who is working with a particular fungus or group of fungi and wishes to locate such information as may be available in the literature on formative and pigmentation effects of light on this organism or organisms. When an original author of a paper has claimed to have observed some influence of light on a fungus which he has investigated, such information has generally been included here independent of any possible thought of the reviewers in respect to the validity of the claim made. Not infrequently there apparently has been some question about whether or not effects of light had been clearly separated from possible effects of temperature differences.

In many instances the summary statement used here follows quite closely the wording of statements made in the original paper. The conclusions presented in the original papers are, of course, more extensive in many cases; the statement used here is intended only to indicate the general nature of the experiments as a help to the reader in deciding whether or not he should consult the original reference. The original authors' terminology in respect to fungal morphology and nomenclature is followed here. In some cases information cited here was obtained from the Review of Applied Mycology, books, or other secondary sources and the original papers were not examined by the present writers. In such cases this fact is indicated in the literature citation.

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## LITERATURE SUMMARIES

## PHYCOMYCETES

Achlya recurva. Cultures were placed in darkness and in diffuse daylight on top of a laboratory table at approximately the same temperature. They were examined after 72 hours. Dark cultures were then left in daylight for an additional 72 hours. Light was necessary for the germination of zygotes. (Ziegler, A. W., 1948).

Albugo occidentalis. Hanging-drop slides of conidia were arranged in a chamber at 12° C so that light from a 3-cell flashlight fell on them, while others were placed in the dark. Results after 48 hours showed that spores germinated equally well in light or darkness. (Raabe, R. D., and G. S. Pound, 1952).

Allomyces arbuscula. Cultures exposed to darkness for 7 days and to diurnal illumination for the same period formed zones under both conditions. (Hatch, W. R., 1936).

Blakeslea trispora. Sporangia formed profusely in bright light, subdued light, and total darkness. The shortest sporangiophores were produced in bright light. During their development the sporangiophores were distinctly phototropic. (Weber, G. F., and F. A. Wolf, 1927).

Blastocladiella emersonii. A normal strain and a carotenoid-bearing mutant grew more rapidly in light than in darkness. Illumination induced an increase in CO<sub>2</sub> fixation and concomitantly a large increase in the labeled succinate and a decrease in the labeled ketoglutarate pools in the organism. Both labeled and unlabeled glucose were consumed more rapidly in the light than in the dark. Cell-free preparations mediated an enzymatic TPN-dependent oxidation of isocitrate which was inhibited by bicarbonate and light. These same preparations mediated an enzymatic oxidation of reduced TPN which was accelerated by ketoglutarate and bicarbonate; simultaneously, ketoglutarate was carboxylated. These reactions were further accelerated by light. The mechanism of the effect of illumination was tentatively interpreted in terms of a light-stimulated cyclic process, the S.K.I. cycle. This involved carboxylation of ketoglutarate, via isocitric dehydrogenase and perhaps citritase, to succinate and oxalate, and the further carboxylation of some of the succinate to yield ketoglutarate once again. (Cantino, E. C., and E. A. Horeinstein, 1956).

Blastocladiella emersonii. Submerged, liquid cultures proliferated more rapidly and produced greater yields of plant material in white light than in darkness. Illuminated, growing cultures of orange plants grew more rapidly in bicarbonate media and fixed more CO<sub>2</sub> per unit weight of organism produced, than those incubated in darkness. The quantity of light necessary to induce the effect was not high. The degree of stimulation rose linearly with increasing intensity to about 100 f.c., which yielded maximum results; further increase in intensity up to 300 f.c. neither stimulated nor inhibited. The effective spectrum was in the range of 400-500 mμ. (Cantino, E. C., and E. A. Horeinstein, 1957).

Blepharospora cambivora. Zoosporangia actively formed only at night, differentiation and release from the sporangium occurring in the morning. Positive phototropism of the zoospores was easily demonstrated in preparations illuminated unilaterally. (Petri, L., 1925).

Choanephora conjuncta. The influence of light is very marked in this species. When subjected to the ordinary illumination of alternating daylight and darkness, the fungus forms conidia at night which mature during the early hours of daylight. If, however, the fungus is kept in constant darkness, the formation of conidia is totally inhibited. (Couch, J. N., 1925).

Choanephora cucurbitarum. Cultures were illuminated at 60 f.c. with a daylight fluorescent light at 25° C. For total darkness, cultures were put into a cardboard box in a darkened room at the same temperature. Conidia failed to form in continuous bright light or in continuous total darkness. When cultures were exposed to alternate light and dark periods, (approximately 12 hours each), numerous conidial heads were produced. (Barnett, H. L., and V. G. Lilly, 1950).



Choanephora cucurbitarum. Cultures were incubated in a constant temperature room at 25° C in continuous light, in continuous total darkness, and in 12-hour light-dark cycles using white, blue, green, yellow, and red light of known wave length. No conidia were produced in continuous bright light, continuous total darkness, or in red light under the 12-hour light-dark cycle. Conidial heads were formed only in darkness after a minimum of 2 hours' exposure to bright light and in continuous light of low intensity. The following approximate numbers of conidial heads were produced under the different colors of light used in the 12-hour cycle: white (2000), blue (50-100), green (25-50), yellow (0-10). (Barnett, H. L., and V. G. Lilly, 1953).

Choanephora cucurbitarum. The fungus could fruit in complete darkness but equal periods of light and darkness were most stimulative to fruiting. Red light was slightly inhibiting to fruiting. Yellow light promoted a fluffy aerial mycelium, while exposure to blue or violet light led to a much more compact mycelium and red or yellow-red light resulted in an intermediate condition. (Christenberry, G. A., 1938).

Cokeromyces recurvatus. Continuous illumination at high intensities, exposure to alternating day and night illumination, and growth in total darkness were found to favor zygosporangium production. Only under continuous illumination at low intensity was zygosporangium production suppressed. The effect of total darkness upon growth and sporulation was slight. Cultures so exposed produced both zygosporangia and sporangia. The only noticeable variation in these cultures was that some lacked zonation and others developed distinct rings. The effects of specific wave lengths of the visible spectrum upon growth and sporulation were negligible. Zonation occurred in cultures kept in complete darkness as well as in alternating light and darkness. (Poitras, A. W., 1954).

Conidiobolus paulus. Phototropic conidiophores were produced. (Drechsler, C., 1957).

Conidiobolus physosporus. Conidia were produced much more freely in light than in darkness. Discharged conidia, caught on a 2 percent malt agar plate and left in the light, germinate directly to give secondary conidia which are discharged on to the lid of the dish (when illuminated from above). When, however, the spores caught on the agar are allowed to germinate in the dark, mycelium production is promoted. In cultures grown for a few days in darkness and then transferred to light, it can be seen that the irregular hyphae give off straight branches which grow vertically or nearly so. When these hyphae break through the agar surface they are clearly destined to be conidiophores and are positively phototropic. (Dring, V. J., 1958).

Conidiobolus villosus. Conidiophores are strongly positively phototropic. (Martin, G. W., 1925).

Cystopus candidus (= albigo). No difference was observed in the time or percentage of conidial germination in light as compared with darkness. (Melhus, I. E., 1911).

Dicranophora fulva. It was found that sporangia are formed only when there has been some illumination, whereas the early stages of zygosporangium formation occur only in the dark. A very slight exposure to light is sufficient to induce sporangial formation, and to inhibit the development of the larger zygosporangial branches, which lose their contents into the surrounding mycelium and are left as empty sacs. (Dobbs, C. G., 1938).

Haliphthoros milfordensis. Light had no apparent effect on sporulation. (Vishniac, H. S., 1958).

Karlingia rosea. Cultures were grown in daylight and in complete darkness. Pigmentation was more intense in the light. (Haskins, R. H., and W. H. Weston, Jr., 1950).

Mucor dispersus. Cultures all produced significantly larger spores when grown in the dark than when grown in light of approximately 120 f.c. (The light source was daylight fluorescent lamps.) (Williams, C. N., 1959).

Mucor flavus. Cultures on Raulin's liquid medium were placed near a north window from which they received daylight through various colored filters (discontinuous light). In white light and violet light mycelium, sporangia, and chlamydospores developed. In blue light myce-

lium but no sporangia developed. In yellow light mycelial development was sparse and neither sporangia nor chlamydospores formed. In red light mycelium developed with droplets of oil but no sporangia or chlamydospores formed. In darkness mycelium appeared and also what looked like sporangia, but no spores developed. (Lendner, A., 1897).

Mucor jansseni. Three different culture series were set up: 1) in the light of the room; 2) in the dark but interrupted with 1 minute of light from the room after 3 days; and 3) in the dark continuously. The continuous-dark cultures showed much branching of the sporangiophores, the interrupted dark cultures less branching, and light cultures even less branching. These observations were made after 8 days. There were no clear cut differences when observations were made after 3 weeks. (Zobl, K. H., 1943).

Mucor mucedo. Cultures on a medium composed of Van Tieghem solution, 2 percent agar, and 2 percent beer wort were placed near a north window from which they received daylight through various colored filters (discontinuous light). In diffuse white light long, normal sporangiophores formed with sporangia on the part of the culture farthest from the center. Filaments in the center were short and thin. In red, yellow, blue, and violet light and darkness development was the same as in diffuse light. Heliotropism was strong all over the culture. (Lendner, A., 1897).

Mucor racemosus. Cultures were grown on Raulin's liquid medium for 8 days near a north window from which they received daylight through various colored filters (discontinuous light). In white and blue light mature sporangia with spores were produced. In blue light some sporangia did not develop spores but were filled with oil. In violet light mature sporangia were uncommon, others were filled with oil. In yellow light sporangia were rare but some spores were produced. In red light normal sporangia were very rare and the remainder were abortive; spores were slow in forming. In the dark sporangial production was sparse and no spores were ever produced. In all the cultures, the fungus produced mycelium with chlamydospores. Blocking the passage of ultra-violet rays had no influence on spore formation. On solid Van Tieghem medium (Van Tieghem solution with 2 percent agar) completely mature sporangia were produced in all cultures under the different light conditions. (Lendner, A., 1897).

Mucor rhamnoides. The fungus was grown for 6 weeks on potato-dextrose agar in darkness and in different qualities of light. All cultures developed mycelium. A response to light was not detected. (Bjornsson, I. P., 1956).

Mucor sp. Positive heliotropic curvatures are made by the sporangiophores. (Buller, A. H. R., 1909, p. 75).

Mucor sp. Zonation does not occur under conditions of total darkness. In red and orange light (daylight through liquid filter) alternating with darkness, and in continuous darkness uniform dense spore formation occurred over the entire surface of the medium. When blue light and ordinary light were alternated with darkness (natural diurnal cycle) distinct daily rings of alternating dense and sparse spore formation occurred. Green light in the same cycle produced less distinct rings of growth. Rings of sparse spore formation were formed during the day and the denser ones at night. Blue light inhibits spore formation. (Hedgecock, G. G., 1906).

Mucor stolonifer. Light may cause and accelerate streaming when alternated with darkness in those fungal filaments that are in a condition for streaming. (Andrews, F. M., 1912).

Mucor stolonifer. Protoplasmic streaming is accelerated by diffuse white light. (Schröter, A., 1905).

Mycotypha microspora. Plate cultures were subjected to artificial light during the night for several weeks. Other plates were kept in constant darkness for the same period of time. Both sets of cultures produced fertile heads. The conidiophores were positively heliotropic. (Fenner, E. A., 1932).

Peronospora parasitica. Unilateral daylight illumination did not produce a phototropic response in the germ tubes of the spores. (Robinson, W., 1914).

Phycomyces blakesleeanus. The phototropically sensitive zone contains carotene, particularly beta-carotene, which the author suggests may act as a light receptor. (Bünning, E., 1937a).

Phycomyces blakesleeanus. The author determined the action spectrum with respect to the phototropic curvature of the fungus. (Bünning, E., 1937b).

Phycomyces blakesleeanus (+ strain). A single-celled, elongating sporangiophore responds to a sufficient increase in intensity of illumination by an increase in growth rate. The reaction time is compound, consisting of an exposure period and a latent period (this comprising both the true latent period resulting from photochemical action and an "action time" necessary for the response). During the latter period the plant may be in darkness, responding nevertheless at the end of the latent period. (Castle, E. S., 1929).

Phycomyces blakesleeanus (+ strain). The reaction time of the direct growth response of the sporangiophore to light consists of a series of at least three major identifiable components: 1) an exposure period during which photochemical change occurs; 2) a latent period involving products directly consequent upon the photochemical action; and 3) an action-time occupying a further interval before the growth acceleration appears. The reaction time of the phototropic response of the sporangiophore following stimulation by unilateral illumination is also compound, and is made up of at least three components comparable to those of the direct growth response. The reaction time of each mode of response is constant for a particular intensity of illumination provided that the duration of the exposure period exceeds a certain value. Below that value the reaction time increases progressively as the exposure time decreases. (Castle, E. S., 1930).

Phycomyces blakesleeanus (+ strain). With sporangiophores of high sensitivity, illuminated from one side by light of 171 f.c., a state of phototropic "indifference" was found over a range of exposures extending from continuous illumination down to a duration of exposure of about 0.6 seconds. When the exposure is further shortened, positive phototropic bending occurs. Sporangiophores which exhibit such "indifference" are nevertheless shown to give a distinct direct growth response as a consequence of the same unilateral illumination. The date of "indifference" is therefore not characterized by the absence of photic excitation, but by the failure of the light to evoke a differential acceleration of growth on the two sides of the sporangiophore. Stimulation of sensitive "indifferent" sporangiophores by flashes of light of progressively reduced duration of exposure leads to the discovery of a critical duration below which "indifference" is abolished and phototropic bending occurs. The critical duration of exposure to light for the appearance of the phototropic response corresponds to the critical duration of exposure for minimum reaction time in the direct growth response. Phototropic bending appears, therefore, when the action of light on one side of the sporangiophore is submaximal. Conversely, "indifference" is due to equal and maximal photochemical action on both sides. (Castle, E. S., 1931a).

Phycomyces blakesleeanus (+ strain). The phototropic effects of different spectral regions were equated by means of cultures of elongating, sensitive sporangiophores placed in beams of light opposed at 180°. The relative intensities of the two beams were then adjusted until equal numbers of sporangiophores bent toward each source of light. At this point of equal phototropic effect, the efficiency of each spectral region was taken as inversely proportional to its relative energy content. Sporangiophores were found to be most sensitive to stimulation by light in the violet region (between 400 and 430 mμ). Toward the red (near 580 mμ) sensitivity falls to nearly zero, while in the near ultra-violet (around 370 mμ), sensitivity is still high. The action of light on the photosensitive meristematic region of the elongating sporangiophore leads to a temporary acceleration of growth. If the sporangiophore receives unequal illumination on opposite sides, phototropic bending typically occurs, directed toward the more intense source of light. (Castle, E. S., 1931b).

Phycomyces blakesleeanus. Using a small arc-lamp, a water screen, and a range of intensities, negative bending was never obtained with actively growing sporangiophores, even after 2 hours' exposure. Using a CuSO<sub>4</sub> solution screen, only phototropic "indifference" was found. In no case did negative bending occur. Negative bending was obtained by sufficiently intense and prolonged infra-red radiation but the author attributes this to a heating effect (thermotropism). (Castle, E. S., 1932).



Phycomyces blakesleeenanus (+ strain). When sporangiophores were exposed to ultra-violet light of wave length  $280\text{ m}\mu$ , negative curvatures began to develop after about 5 minutes, and after 20 to 30 minutes most of the sporangiophores had curves through at least  $90^\circ$ , pointing directly away from the light source (unfiltered green light, isolated from a General Electric H85C3 capillary mercury lamp by a Bausch and Lomb grating monochromator with quartz optics). Experiments with rotating cultures illuminated with ultra-violet light ( $280\text{ m}\mu$ ) show that growth is temporarily promoted by 50 to 100 percent. The negative curvature can therefore be ascribed to acceleration of growth on the near side. (Curry, G. M., and H. E. Gruen, 1957).

Phycomyces blakesleeenanus. When the fungus was cultured on the standard medium in the dark, beta-carotene production was only about one-half of that produced in the light, while the fat and dry weight were not affected. (Garton, G. A., T. W. Goodwin, and W. Lijinsky, 1950).

Phycomyces blakesleeenanus. When grown in the dark, the dry weight and lipid production by both plus (+) and minus (-) strains were indistinguishable from those obtained with cultures kept in the light. In both strains beta-carotene production was only one-half of that produced in cultures grown in the light. Cultures were grown in bottles wrapped with red, green, and colorless cellophane, respectively, to study the effect of wave lengths on beta-carotene production. As long as the fungus is exposed to light, it produces normal amounts of beta-carotene, irrespective of the wave length of the light. (Garton, G. A., T. W. Goodwin, and W. Lijinsky, 1951).

Phycomyces nitens. The sporangiophores are short when a culture is fully exposed to light, but attain a length of 20 to 30 cm if the fungus is grown on a layer of medium placed at the bottom of a tall vessel which allows light to enter only from the top. (Smith, G., 1946, pp. 204-207).

Phycomyces sp. A physical basis is demonstrated, in the case of a cylindrical cell illuminated with parallel light from one side, for greater photochemical action in the half of the cell farthest from the source of light, when the cell is surrounded by a medium of refractive index less than that of the cell. Factors governing the balance and magnitude of unequal action of light in the two halves of the cell are: the refractive index of the cell, the cell radius, and the absorption coefficient of the intracellular pigment. A limiting value of absorption coefficient is deduced which cannot be exceeded in cells of a particular size showing positive phototropism. In terms of this mechanism the positive phototropism of Phycomyces in air is explained. (Castle, E. S., 1933).

Phycomyces sp. The magnitude of the temporary growth acceleration produced by a brief flash of light increases with increasing length of the dark period before the flash. (Castle, E. S., 1935).

Phycomyces sp. The effectiveness of polarized light in stimulating growth of the sporangiophores depended on the plane of polarization. However, when sporangiophores were immersed in a medium of refractive index similar to that of protoplasm, this difference in effectiveness disappeared. The author interprets the latter result to indicate that the differences in air are due to simple Fresnel reflection losses and not to dichroism of oriented photoreceptors. (Shropshire, W., Jr., 1959).

Physoderma maydis. Sporangia failed to germinate in darkness. Under continuous illumination from a fluorescent light a measurable increase in germination occurred at 0.1 f.c. and the germination increased in a step-wise manner up to about 50 percent germination at 12 f.c. No further increase occurred with light intensities up to 393 f.c. Blue light was most effective. The mean percentage germination for two experiments was 0 in red or yellow light, 15 in green light, 49 in blue light, and 46 in white light. Three foot-candles of blue light resulted in 61 percent germination, while 72 f.c. of yellow light gave 0 percent germination. (Hebert, T. T., and A. Kelman, 1958).

Physoderma zeae-maydis (= P. maydis). Sporangia did not germinate in total darkness. Eighty-seven percent of sporangia which received light from a north window germinated. Sporangia also germinated in the presence of light from an electric lamp (50-watt Westinghouse daylight bulb). No germination occurred in direct sunlight. (Voorhees, R. K., 1933).

Phytophthora cambivora. For summary see Blepharospora cambivora. (Petri, L., 1925).

Phytophthora cinnamomi. Sporangia were produced in culture in continuous artificial light, in darkness, and in alternating light and dark periods. (Zentmyer, G. A., and L. A. Marshall, 1959).

Phytophthora faberi. When a suspension of sporangia was made in tap water, more sporangia discharged their contents when the suspension was well illuminated than when it was kept in darkness. Swarming occurred in the absence of light. When grown in the dark on maize-meal agar, cultures of all strains tested produced very few sporangia but these were, on the average, larger than those produced in cultures grown on the same medium in light. Light influences the size of chlamydospores in the same way that it affects the dimensions of sporangia. (Gadd, C. G., 1924).

Phytophthora faberi. Spores were produced copiously in all cultures after exposure to ordinary laboratory light for 4 days. If the cultures were kept in a dark chamber or incubator, free from light, only a few spores were formed. There were apparently more chlamydospores than conidia produced in darkness. Growth in light was more granular than that in darkness. (Reinking, O. A., 1923).

Phytophthora fagi. Conidial counts sometimes showed more conidia in the light than in the dark and sometimes just the opposite. Conidia were always quite numerous in cultures grown in the dark at 22° C. Therefore, the author thought it doubtful that light can be considered as one of the essential factors in conidial formation. (Waterhouse, G. M., 1931).

Phytophthora infestans. Cultures were placed in light and in darkness. An attempt was made to maintain the temperature constant by keeping ice with lighted cultures to overcome heat effects. Light, either direct or diffuse, did not influence germination. The cultures germinated equally well in both light and darkness. (Melhus, I. E., 1915).

Phytophthora parasitica. Light seems to influence the formation and emission of zoospores but germination does not seem to be affected by either light or darkness. (Dastur, J. F., 1913).

Phytophthora parasitica var. nicotianae. Air appears necessary for sporangial production, and light does not. (Gooding, G. V., and G. B. Lucas, 1958).

Phytophthora peoniae. Two-day-old cultures, when placed in red and yellow-orange lights for 4 days, ceased conidial and oospore production but when placed in amber, blue, bluish tint (transmitting full spectrum but absorbing infra-red), smoky violet, and canary lights, produced oospores and conidia in abundance. (Cooper, D. C., and C. L. Porter, 1928).

Pilobolus crystallinus. Complete normal development takes place in the absence of light. (Brefeld, O., 1889).

Pilobolus crystallinus. The sporangiophores turned toward the source of light. When the direction of the light source was changed the orientation of the sporangia also changed. (Jaczewski, A. de, 1910).

Pilobolus kleinii. The phototropically sensitive zone contains carotene, particularly beta-carotene, which the author suggests may act as a light receptor. (Bünning, E., 1937a).

Pilobolus kleinii. The author determined the action spectrum with respect to the phototropic curvature of the fungus. (Bünning, E., 1937b).

Pilobolus kleinii. A periodicity in the development of the asexual fruiting body (sporangiophores mature at the end of a dark period and immature at the end of a light period) was established under certain alternating periods of light and darkness of equal and unequal duration. Periodicity was displayed under 12-12 (hours), 16-16, 15-9, and 9-15 cycles. No periodicity was noted under continuous light and in total darkness, and also under 4-4, 8-8, 24-24, 4-20, and 20-4 cycles. (Klein, D. T., 1948).

Pilobolus kleinii. Trophocysts and sporangiophores were formed only after the mycelium had been exposed to light. Wave lengths between 380 and 410 m $\mu$  were found to be most effective in inducing the formation of trophocysts. Results of experiments to find which classes of compounds were involved in light absorption suggest that it is a flavin rather than a carotinoid which absorbs light to initiate trophocyst formation. Few sporangia were produced by trophocysts allowed to develop in darkness or continuous light but when cultures were exposed to light twice, the number of sporangia was proportional to the duration of the second exposure. (Page, R. M., 1956).

Pilobolus microsporus. Sporangioophores kept in the dark are greatly elongated and no sporangia are formed on them. (Brefeld, O., 1889).

Pilobolus microsporus. Reproductive periodicity is not inherent but rather is completely conditioned by the diurnal alternation of day and night. The periodicity can be made to disappear by subjecting cultures either to continuous light or continuous darkness. Maturation of sporangiophores, which normally takes place during the morning, can be made to occur at any hour of the day or night, by suitably adjusting the alternating 12-hour periods of light and darkness. (McVickar, D. L., 1942).

Pilobolus oedipus. Complete normal development takes place in the absence of light. (Brefeld, O. 1889).

Pilobolus sp. Sporangia are fired with about the same accuracy toward blue light as toward white light. The reaction to yellow light is much less accurate than that toward either blue or white, while that toward red light is very vague and uncertain. (Allen, R. F., and H. D. M. Jolivette, 1913).

Pilobolus sp. If cultures are placed in parallel in the light and in the dark, the cultures in the light develop spores promptly while those in the dark develop sporangiophores which do not form sporangia at the end. This growth in length continues for 10 to 14 days and sporangiophores attain a length of 8 to 10 inches but then degenerate without forming spores. A period of 2 hours of light is sufficient to make possible the formation of sporangia. In blue light spores formed as in white light, while in yellow light cultures showed continued elongation of sporangiophores as in the dark but without formation of sporangia. In yellow light sporangiophores showed a strong positive heliotropism. (Brefeld, O., 1881).

Pilobolus sp. Phototropic response takes place in every region of the spectrum. The presentation period decreases from red to violet, or conversely, the irritability increases from red to violet. There is no indication of intermediate maxima and minima. (Parr, R., 1918).

Protoachlya hypogyna. The experimental methods employed and the results obtained are similar to those for Achlya recurva. (Ziegler, A. W., 1948).

Rhizophlyctis rosea. For summary see Karlingia rosea. (Haskins, R. H., and W. H. Weston, Jr., 1950).

Rhizopus nigricans. For summary see Mucor stolonifer. (Andrews, F. M., 1912).

Rhizopus nigricans. For summary see Mucor stolonifer. (Schröter, A., 1905).

Rhizopus nigricans. A Petri dish with a culture of the fungus was clamped onto a microscope stage and the end of colony was examined. In diffused light the extension of the radiating hyphae could actually be seen and, after an hour and a half the edge of the colony had advanced almost half the diameter of the field. When the whole apparatus was placed in darkness, the advance was less than half that observed in the light, showing that in this species there was a very definite stimulation of vegetative growth by comparatively weak light. (Smith, G., 1946, pp. 204-207).

Rhizopus sp. Cultures were grown for 12 days in darkness and in continuous or cyclic blue, red, and white fluorescent lights. Cultures in the dark produced very few sporangia and then only at the upper end of the test tube. The rest of the tube was filled with white, intertwined



mycelial strands. White fluorescent light alone or with two blue filters produced the greatest number of sporangia. Cultures in cyclic white or blue light produced fewer sporangia. Sporangial production in continuous red light was inferior to that of the two above-mentioned cycles and the results in cyclic red light were similar to those in darkness. (Bjornsson, I. P., 1956).

Saprolegnia mixta. No noticeable difference was found in growth or zoospore formation between cultures grown in diffuse daylight and those grown in darkness. (Klebs, G., 1899).

Sporodinia grandis. Light and darkness had no effect on spore formation. (Baker, R. E. D., 1931).

Thamnidium elegans. Cultures on Van Tieghem liquid (with 4 percent beer wort) were placed near a north window from which they received daylight through various colored filters (discontinuous light). Sporangia were produced under all light conditions but were more numerous in red and yellow light and darkness than in blue or white light or behind an esculin solution screen (blocks out ultra-violet rays). Cultures in violet light showed intermediate features. Abundant mycelium was produced under all light conditions, and sporangioles were produced in all cultures. The fungus was also cultured on Raulin's liquid medium. In white light mycelium but no sporangia developed. In blue light sporangia and sporangioles were few in number, and sporangiophores were short. In red light and in yellow light many sporangia formed. Few sporangia and sporangioles were produced in violet light. In darkness numerous sporangia (maximum development) formed. (Lendner, A., 1897).

Thraustotheca primoachlya. When cultures were placed at approximately equal temperatures in the dark and in diffuse daylight on a laboratory table, it was noted that light was necessary for germination of the zygotes. (Ziegler, A. W., 1948).

#### ASCOMYCETES

Aleuria repanda. Fruit bodies were heliotropic. Not only do the stalks of the apothecia conform to the incidence of light but also the asci containing the ascospores curved so as to become parallel with the incidence of light. (Elliot, J. S. B., 1927).

Aleuria vesiculosa. Asci are heliotropic -- their free ends are all directed toward the apothecium's mouth. The paraphyses are also positively heliotropic. (Buller, A. H. R., 1934, 6: 286-304).

Anthracobia melaloma. Petri dish cultures, half of which were in the light (wrapped in cellophane) and the other half in the dark (wrapped in heavy black construction paper), were incubated at 24° C for 9 days. The light source was a 40-watt bulb. Mature apothecia were formed in both sets of plates. There were no observable differences between apothecia produced in the light and those produced in the dark. (Rosinski, M. A., 1956).

Ascobolus immersus. The asci are positively heliotropic. (Buller, A. H. R., 1909, 1933, 1: 121, 5: 359-365).

Ascobolus magnificus. Cultures kept in total darkness never formed apothecia. Cultures exposed to light from 5 minutes per day to continuous illumination formed many apothecia. The optimum amount of illumination was found to be about 1 hour per day under the conditions of this experiment. It was found that the blue rays were of primary importance in the formation of apothecia. (Yu, C. C. -C., 1954).

Ascophanus carneus. Cultures were exposed to 95 hours of uninterrupted light of the following qualities: red (630 mμ and up), yellow-green (500-550 mμ), blue-green (490-540 mμ), and blue (430-480 mμ). Cultures were kept in darkness before and after the light period and the temperature was controlled between 16°-17° C. Fruit bodies formed in the four regions in the following numbers (number of fruit bodies in 24 plates): 26, 189, 5731, and 5667, respectively. Blue and blue-green were effective wave lengths. In the red and yellow-green regions the fruiting bodies which were produced were not uniformly distributed over all the plates but were, for some unknown reason, limited to a few of the plates. (Stoll, K., 1936).

Ascophanus carneus. It was found that light is not only necessary for the production of apothecial initials but also for the complete maturation of the apothecia. (Ternetz, C., 1900).

Ascophanus sp. The number of fruiting bodies varied with the spectral region of the incident light as follows: 630 m $\mu$  (red end)-26, 500-550 m $\mu$ -189, 490-540 m $\mu$ -5731, 430-480m $\mu$ -5667. (Bünning, E., 1953).

Ascozonus woolhopensis. Light seems to be important for the production of apothecia, for in darkness these are rarely formed. (Page, W. M., 1955).

Botryosphaeria ribis. In culture this organism produces abundant pycnidiospores on many media at temperatures of 25° to 30° C, but only if exposed to sunlight or light from incandescent or fluorescent lamps. (Bragonier, W. H., 1949).

Botryosphaeria ribis. Conidia were never produced in culture in the absence of light and microconidia were rarely produced under any circumstances. (Fulkerson, J. F., 1957).

Botryosphaeria ribis. Cultures maintained under ordinary laboratory conditions of alternate light and darkness became zoned, but zonation did not occur in cultures grown in continuous total darkness. (Wolf, F. T., and F. A. Wolf, 1939).

Botryotinia (Sclerotinia) globosa. Three Petri dishes were placed in the dark in an inoculation room at 18° to 20° C, while three others were placed in the light by a window facing north where the temperature was about 20° C. After 10 days the cultures were examined. The cultures in the dark developed far more sclerotia than those in the light. (Buchwald, N. F., 1953).

Capnodium sp. Zone formation occurred when Petri dishes were exposed to the alternation of day and night at a constant temperature of 33° C, but none formed in darkness under constant temperature. Zonation was due to variation in density of the mycelium. Light is essential for pycnidium formation at low temperatures but pycnidia are formed even in the absence of light at 29° C. Strong light is not essential, for even diffuse daylight has a profound action in inaugurating pycnidium formation. (Sawhney, A., 1927).

Chaetomium spp. Culture plates were kept in the laboratory in diffuse light. The perithecial necks were not well-developed and were not sensitive to light. (Page, W. M., 1939).

Cheilymenia vinaceae. The asci exhibit heliotropic curvature. (Buller, A. H. R., 1934, 6: 285-286).

Ciliaria scutellata. The asci exhibit heliotropic curvature. (Buller, A. H. R., 1934, 6: 285-286).

Claviceps purpurea. Exposure to direct or diffuse sunlight induces pigment formation, which is identical to naturally occurring sclererythrin. (Gjerstad, G., 1956).

Claviceps purpurea. Experiments were carried out both indoors and outside with various colored "Corning" glass filters and a "Vita glass" clear filter. Production of a red color in the medium was found to be due to the shorter rays of the spectrum: the blue, violet, and perhaps "near" ultra-violet. (McCrea, A., 1928).

Claviceps purpurea. Sunlight produces a marked chromogenic effect upon the mycelium of this fungus by causing an intense coloration, carrot red. The stimulating rays for this color effect lie in the blue-violet region of the spectrum. When the fungus was grown in darkness, no aerial mycelium formed nor did any of the characteristic red color appear. (McCrea, A., 1931).

Claviceps purpurea. Natural light either stimulated or inhibited the synthesis, or accumulation, of ergot alkaloids depending on the nature of the growth medium used. (Taber, W. A., and L. C. Vining, 1958).

Coccomyces hiemalis. Cultures were tested in the laboratory. Ascospores and conidia germinated equally well in diffuse light and darkness. (Keitt, G. W., E. C. Blodgett, E. E. Wilson, and R. O. Magie, 1937).

Cochliobolus sativus. Mature perithecia were more numerous in cultures incubated in darkness than in cultures exposed to sunlight. Although perithecia formed under all light conditions, sunlight apparently inhibited to some extent the delimitation of ascospores. (Tinline, R. D., and J. G. Dickson, 1958).

Cochliobolus sativus. An unidentified pink pigment is reported from the mycelium of the fungus. Its production was photo-activated, wave lengths between 390 and 513  $m\mu$  being effective. Light in the range of 580-760  $m\mu$  was ineffective. (Tinline, R. D., and D. J. Samborski, 1959).

Coniothyrium sp. This fungus, which normally never produced pycnidia until the culture was very old and completely filled the Petri dish, produced numerous pycnidia, some superficial and some buried, after 10 seconds' exposure to a Cooper Hewitt quartz mercury arc. (Stevens, F. L., 1928).

Daldinia concentrica. When placed in continuous darkness, this fungus maintained periodic discharge for 12 days and then ceased to be periodic. When the culture was returned to alternating light (12 hours, 100 f.c.) and darkness (12 hours), periodicity was re-established immediately. In continuous light periodic discharge ceased in 2 or 3 days but was immediately re-established in alternating light (12 hours) and darkness (12 hours). When the fungus was placed under conditions of alternating light and darkness of 6 hours' duration each, two peaks of spore-output were soon developed in the 24-hour period. (Ingold, C. T., and V. J. Cox, 1955).

Dermea sp. Some culture flasks were stored in the laboratory in diffuse light, some kept in a greenhouse shaded from direct sunlight, and some kept in the dark at 15° C. Conidial fruiting bodies were produced under all of these conditions. (Groves, J. W., 1946).

Diaporthe batatatis. Four tubes were set on a laboratory table (diffuse daylight), four more were placed 1 foot from the window (direct daylight), and four others were placed in a tin crate and covered with black paper (darkness). After 48 hours no difference in mycelial growth could be seen. There was, however, a marked difference in the formation of fruiting bodies. Three days after inoculation numerous white specks (inceptive fruit bodies) appeared in the light-exposed cultures but not in those in darkness. The next day the bodies began to darken and pycnospores were found in them. Six days after inoculation a few scattered fruiting bodies were found in the dark cultures. These were much larger than those on light-exposed cultures. Fruiting bodies formed in darkness, though well-developed, were frequently sterile and at no time exuded spores. (Harter, L. L., and E. C. Field, 1913).

Diaporthe onocstoma (ATCC #11324). Cultures treated to daily and single light periods showed no differences from each other and from those grown in the dark. Ridging was produced in all conditions, as were stomatal layers. Perithecia were not produced in darkness nor in any of the light conditions tested. Cultures grown for 1 week in daily light cycles and for 1 week with one 18-hour light treatment showed some discoloration in all light conditions. When cultures were placed in total darkness for an additional week the coloration was greatly intensified. (Wishard, R. H., 1957).

Diaporthe phaseolorum var. batatatis. Cultures in Petri dishes with lids removed were placed 10 inches below a 15-watt General Electric germicidal lamp (2537 Å) and exposed to irradiation for various lengths of time. The results indicated that the same dosage of ultra-violet radiation may favor or inhibit the formation of perithecia depending upon the medium. Cultures were also incubated at 25° C under varying conditions of light. Maximum production of ascospores occurred under alternating light and darkness. Continuous total darkness was unfavorable to the formation of perithecia and pycnidia. Small pycnidia containing almost entirely beta spores were formed on most media and their production on certain media was increased by exposure to ultra-violet irradiation or continuous light. (Timnick, M. B., V. G. Lilly, and H. L. Barnett, 1951a).



Diaporthe phaseolorum var. caulivora. Alternate light and darkness were required for production of perithecial initials, but mature perithecia and viable ascospores developed from perithecial initials in total darkness. (Dunleavy, J., 1958).

Diaporthe sojae. Light is essential to pycnidial development, no pycnidia forming in cultures kept in total darkness during their entire growth period. No longer than 6 hours of exposure to one-half the intensity of bright diffuse light is required to bring about pycnidial production in cultures on favorable media. Artificial illumination is effective in inducing pycnidial production. (Lehman, S. G., 1923).

Dothidella quercina. Pycnidial formation was stimulated either in diffuse daylight or under electric light in comparison with darkness. (Coons, G. H., and E. Levin, 1921).

Elsinoë veneta. The fungus sporulated and grew as well in continuous darkness as in alternate diffuse light and darkness. No morphological differences were observed. Coloration was much paler in continuous darkness than in alternate diffuse light and darkness. (Kemp, W. G., 1953).

Emericellopsis spp. Light made little difference in the color or growth habit of the several species studied. (Durrell, L. W., 1959).

Endothia parasitica. Cultures on nutrient agar were incubated in a constant temperature room at 25° C in constant light, in continuous total darkness, and in 12-hour light-dark cycles using white, blue, green, yellow, and red light of known wave length. In continuous light approximately 10,000 small pycnidia and many conidia were produced while in continuous darkness approximately 50 large pycnidia and many conidia were formed. The following approximate numbers of pycnidia and conidia were produced under the different colors of light in the 12-hour cycle: white (6000 small pycnidia, many conidia), blue (1500 pycnidia and many conidia), green (1200 pycnidia, conidia present), yellow (600 pycnidia, conidia present), and red (200 large pycnidia, conidia present). (Barnett, H. L., and V. G. Lilly, 1953).

Endothia parasitica. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Endothia parasitica. This fungus forms pigment poorly under red or far-red or in the dark. (McClellan, W. D., H. A. Borthwick, I. Bjornsson, and B. H. Marshall, Jr., 1955).

Erysiphe graminis. Conidia sown in a drop of water and exposed to light -- both daylight and a 60-watt electric lamp -- from one side only did not show any phototropism. (Cherewick, W. J., 1944).

Erysiphe spp. Spores were germinated from several hosts in unilateral light, some grew germ tubes toward the source of light (collections from 16 different host plants), whereas others (collection from nine different host plants) showed only random orientation with respect to light source. (Neger, F. W., 1902).

Eurotium herbariorum. In general, experimental results show that light does not check vegetative growth but perithecial development is considerably depressed. (Gupta, D. D., 1951).

Fimetaria fimicola. The beaks of the fruit bodies are positively heliotropic. (Buller, A. H. R., 1933, 5: 103).

Galactinia badia. Asci exhibited positive heliotropism. (Buller, A. H. R., 1934, 6: 304-308).

Gelasinospora calospora var. autosteira. Light was found to be important in that few or no perithecia or protoperithecia were produced in cultures incubated in the dark. Pigmentation and aerial mycelium were more pronounced in cultures grown in the dark. (Tylutki, E. E., 1958).

Gelasinospora tetrasperma. Rudiments of perithecia developed in both light and darkness on bisexual mycelium, but the completion of development was more rapid in the light. (Dowding, E. S., and A. H. Buller, 1940).

Glomerella cingulata. Production of perithecia was stimulated by irradiating 4- to 7-day-old cultures with ultra-violet light from a quartz mercury arc. (Stevens, F. L., 1928).

Glomerella cingulata. Acervulus formation is strongly influenced by irradiation. About 50 monosporous cultures were studied. Some produced perithecia readily and others only acervuli. Some bore perithecia whether irradiated or not. Some produced no perithecia, others bore perithecia only when irradiated. Thus, numerous strains were recognized. (Stevens, F. L., 1930b).

Glomerella cingulata. Ultra-violet irradiation stimulated perithecial production. (Stevens, F. L., 1931a).

Guignardia bidwellii. The fungus appears to sporulate equally well in continuous light, darkness, and alternate light and darkness. (Lilly, V. G., M. B. Timnick, and H. L. Barnett, 1949).

Helotium ciliatosporum. When pieces of stem bearing the fungus were suspended in stoppered jars with the lower end dipping into water, apothecial rudiments at first grew straight out from the substratum, showing no reaction to light. When they were about 5 mm long their tips began to curve towards the light. As the cultures aged the tips lost all orientation with reference to light direction. (Barnes, B., 1933).

Helotium scutula. Developing apothecia show marked positive heliotropism, the effect varying with the intensity of the light. The young fruit bodies behave in blue light as in daylight and in orange light as in darkness. If young apothecia are exposed to the simultaneous influence of light and gravity, the former has the stronger influence. The power of response to the influences of light and gravity disappears as soon as the hymenial discs begin to form. Fruit bodies are initiated in darkness but cannot develop without the influence of light. If the early stages began in light, development can continue in darkness. (Grove, J. H., 1930).

Hypomyces solani. Cultures were exposed to darkness and to the natural diurnal light cycle on a laboratory table. No perithecia developed in the dark; light was necessary for their formation. (Hwang, S. W., 1948).

Hypoxyton fuscum. When subjected to a diurnal light cycle in a laboratory, with daylight from a north window and very small variations in temperature, the fungus discharged many more spores at night than during the day. The author indicates that light is a master factor in determining periodicity of spore discharge in some species and inhibits it in others. See also summary for Nectria cinnabarina. (Ingold, C. T., 1933).

Hysterographium fraxini. The fungus formed numerous fruiting body initials in the laboratory in the light, a few in darkness at room temperature, and none in darkness at 21° C. (Zogg, H., 1944).

Lambertella corni-marisi. Light appears to be a factor of importance in stimulating the formation of apothecia. Cultures wrapped in transparent cellophane formed mature apothecia. Cultures wrapped in white paper formed numerous long stipes. No fruiting structures were formed on cultures wrapped in black paper. (Harrison, T. H., and A. F. El-Helaly, 1935).

Melanospora destruens. Cultures were exposed to light on a laboratory bench beside other cultures wrapped in black paper. No significant difference occurred in the number of perithecia formed, but those produced in continuous darkness were much smaller. (Asthana, R. P., and L. E. Hawker, 1936).

Melastiza miniata. The asci show positive heliotropic curvature. (Buller, A. H. R., 1934, 6: 285-286).

Mycosphaerella cucumis. Seven-day-old cultures on potato-dextrose agar were irradiated with a Mercury-quartz lamp (Westinghouse Sterilamp) for various periods of time (1/2, 1, 5, 10, 15, 20, 30, and 40 minutes). After the treatment, all plates were kept in complete darkness at 24° C. Non-irradiated plates served as controls. On the fourth day after irradiation sporulation occurred in all the irradiated plates but was most abundant in those irradiated for

15, 20, and 30 minutes. None of the controls showed a trace of fruiting bodies. In another series of experiments on various media, it was shown that the amount of sporulation was increased on those media in which it occurred only sparsely without irradiation. (Chiu, W. F., and J. C. Walker, 1949).

Nectria cinnabarina. When a group of dry perithecia is first wetted the discharge of spores may occur at a high rate both night and day, but later a diurnal periodicity of discharge occurs with many more spores being ejected during the daytime. The effect is interpreted as being due to light. (Ingold, C. T., 1933).

Neurospora crassa. Zonation occurred in cultures grown with a light-dark cycle and also in continuous darkness, but was inhibited by continuous light. (Brandt, W. H., 1953).

Neurospora crassa. The Monilia stage was positively heliotropic. (Faull, A. F., 1930).

Neurospora crassa. Both phytofluene and the carotenoids are formed in the dark but only the production of the colored polyenes is stimulated by illumination during the growth period. Red light has no stimulatory effect on pigment production. The effective wave lengths are contained in a broad spectral region extending from 510-366 m $\mu$ . (Haxo, F., 1949).

Neurospora crassa. Light does not seem to influence the rate of growth of Neurospora when the temperature is held constant. Cultures kept in a water bath in a room well lighted during the day and dark at night showed no significant differences in growth rate between day and night. Light stimulates the production of yellow pigment at least in some strains and influences the formation of conidia in certain strains. (Ryan, F. J., G. W. Beadle, and E. L. Tatum, 1943).

Neurospora crassa. Visible light, mainly blue-violet light, applied during the growth of a mutant depressed both melanogenesis and tyrosinase activity in the mycelium. This light effect seems not to be mediated by the action of a tyrosinase inhibitor. Light is therefore believed to induce either a decreased production or an inactivation of the enzyme. (Schaeffer, P., 1953).

Neurospora crassa. The fungus was incubated for 4 days in a dark room, followed by 10 days' illumination with a 14-watt daylight fluorescent lamp at a distance of 50 to 60 cm. Certain cultures kept wrapped in tinfoil appeared almost colorless. Evidence indicated that light fosters the conversion of phytofluene into carotenoid pigments and also accelerates to some extent the formation of phytofluene. (Sheng, T. C., and G. Sheng, 1952).

Neurospora crassa. Submerged cultures, grown on liquid medium containing Tween 80, never produced conidia. These cultures remained colorless and pigmentation started only after exposure to light and oxygen. Illumination as short as 1 minute stimulated production of full color but was effective only in the presence of sufficient oxygen. Further synthesis could occur in the dark, but not under anaerobic conditions. (Zalokar, M., 1954).

Neurospora sitophila. Ascospores were ejected in the direction of a unilateral source of illumination. (Backus, M. P., 1937).

Neurospora sp. Production of carotenoids was proportional to the light dosage. The action spectrum was determined. There was no light action beyond 520 m $\mu$ . The action spectrum corresponded best to a spectrum of a riboflavin derivative, and no other pigments with a similar spectrum could be detected in the fungus. It was therefore assumed that a flavin was the photoreceptor. (Zalokar, M., 1955).

Neurospora sp. The mycelium, when grown in darkness, was pale orange in color. Exposure to white light for a day resulted in intensification of pigmentation. Extinction values of the total pigment increased greatly. Cultures illuminated continuously for the total growth period were bright reddish-orange, and their pigment content was about four times greater than that of parallel cultures grown in the dark. The absolute amounts of phytofluene present were practically independent of the illumination, while the biosynthesis of the colored polyenes was markedly stimulated by continuous illumination during the growth period. (Zechmeister, L., and F. Haxo, 1946).



Penicillioopsis clavariaeformis. The fungus was grown in the dark and produced an orange pigment,  $C_{30}H_{24}O_8$ , m.p.  $330^{\circ} C$  (decomp.), which was isolated and named "penicilliopsin." (Oxford, A. E., and H. Raistrick, 1940).

Philocopra curvicolla. Culture plates were kept in the laboratory in direct light. The necks of the perithecia were strongly phototropic. Spores were shot off in the dark and in increased numbers in the light. (Page, W. M., 1939).

Philocopra pleiospora. When culture plates were kept in the laboratory in direct light the necks of the perithecia were strongly phototropic. (Page, W. M., 1939).

Philocopra setosa. Plate cultures were kept in the laboratory in diffuse light. The necks of the perithecia were strongly phototropic. Spores were shot off in the dark and in increased numbers in the light. (Page, W. M., 1939).

Physalospora obtusa. Cultures on potato-dextrose agar did not ordinarily produce pycnidia in the absence of light. Cultures irradiated with fluorescent light of different intensities and qualities produced mature pycnidia. Light of 200 f.c. for 12 to 18 hours induced pycnidial production. No pycnidia were produced under transmitted red light, very few under the yellow, and a moderate number under the green or white light. All cultures irradiated under the transmitted blue light produced abundant pycnidia. Ultra-violet radiations had no effect on the process. (Fulkerson, J. F., 1955).

Pleospora herbarum. Variations in illumination had no apparent effect on zonation. (Ellis, M., 1931).

Podospora anserina. When plate cultures were kept in the laboratory in diffuse light, the necks of the perithecia were strongly phototropic. (Page, W. M., 1939).

Podospora curvula. The neck region of the perithecium points toward the incident light. Spores are discharged mainly between 10:00 A.M. and 4:00 P.M. (Ingold, C. T., 1928).

Podospora minuta. Plate cultures were kept in the laboratory in diffuse light. The necks of the perithecia were short but the entire perithecial body sloped toward the source of light. (Page, W. M., 1939).

Pyrenophora bromi. Germination of ascospores and conidia was equally good in light and darkness. (Chamberlin, D. W., and J. L. Allison, 1945).

Pyronema confluens. When exposed to light the fungus is induced to form fruiting bodies. High light intensities for short time periods were not as effective as low light intensities for longer periods. Under limiting light conditions the fruiting bodies developed but did not produce mature spores. (Kerl, I., 1937).

Pyronema confluens (P. omphaloides). Light energy can be utilized in the production of reproductive structures only if a check to vegetative growth has previously occurred. Using light filters of known wave length transmission, it was found that the blue end of the spectrum was responsible for pink pigment production and development of reproductive structures. (Robinson, W., 1926).

Sclerotinia fructicola. The fungus must have alternating light and darkness for the production of zones. When the fungus is grown in darkness sporulation is uniform and intense. (Hall, M. P., 1933).

Sclerotinia fructicola. For summary see Monilia fructicola. (Jerebzooff, S., 1958).

Sclerotinia fructigena. The fungus produced concentric zones of conidia only in cultures maintained under natural alternations of light and darkness. Reduction in hours of light decreased zonation. In darkness mycelial development was copious and only a single zone of conidia occurred in the center. (Bartels, G., 1954-55).

Sclerotinia fructigena. In darkness and in 12-hour alternations the fungus produced an irregular colony, in the latter case showing some zonation. Under all other conditions growth was regular. Growth was slowest in total darkness and faster in continuous light than in the 12-hour alternations. When the period of alternation was shortened the growth increased. (Dickson, H., 1939).

Sclerotinia fructigena. Spores of the fungus germinate as well in sunlight as in darkness provided the conditions of temperature and moisture remain near the optimum. (Doran, W. L., 1922).

Sclerotinia (Monilia) fructigena. The apothecia produced from peach sclerotia were positively phototropic. (Norton, J. B. S., W. N. Ezekiel, and R. A. Jehle, 1923).

Sclerotinia fructigena. In light the fungus develops vigorous aerial mycelium with numerous macroconidia. In the dark conidial formation is almost completely suppressed and the hyphae grow in contact with the agar. Cultures were grown in a 12-hour light-dark cycle with the light filtered through various Schotts filters. At wave lengths of 390-477 m $\mu$  strong zonation with conidial formation occurred during the light period. (Sagromsky, H., 1952b).

Sclerotinia laxa. Cultures must have alternating light and darkness for the production of zones. (Hall, M. P., 1933).

Sclerotinia libertiana. Apothecia produced under unequal illumination are strongly positively phototropic. Light is evidently the stimulus which causes the tip of the sprouts which come from the sclerotium to stop growing in length and to expand into the disks bearing the ascospores. (Stevens, F. L., and J. G. Hall, 1911).

Sclerotinia sclerotiorum. Sclerotia were incubated under various temperature and light conditions on sterile 1 percent water-agar slants. Light was not necessary for growth of stipes, but was apparently necessary for the production of apothecia. (Henson, L., and W. D. Valleau, 1940).

Sclerotinia sclerotiorum. Sclerotia were embedded in moist sand placed 1) in amber-colored bottles, 2) in black-painted bottles, and 3) in clear bottles tightly stoppered, and placed in a greenhouse. Mature apothecia developed normally in full light. Only stipes without hymenium developed in the amber and black-painted bottles. (McLean, D. M., 1958).

Sclerotinia sclerotiorum. Light was necessary for the normal development and expansion of apothecial discs but not for the formation of initials. After initials had appeared, mature expanded apothecia were formed by all isolates studied when exposed to either artificial or natural light. (Purdy, L. H., 1956).

Sclerotinia trifoliorum. Sclerotia, when placed in the dark, germinated and produced long slender stipes with no fruiting discs. With 50 lux of light, long stipes were produced with small fruiting discs. At 500 lux the stipes were shorter and discs larger. At 1000 lux, supplemented with a few seconds of direct sunlight, the stipes were still shorter and the discs broader. (Bjorling, K., 1951).

Sclerotinia trifoliorum. Sclerotia were incubated under various temperature and light conditions on sterile 1 percent water-agar slants. Light was not necessary for the production of apothecia. (Henson, L., and W. D. Valleau, 1940).

Sclerotinia trifoliorum. Apothecial initials were formed in the absence or presence of light between 15° and 20° C. Light, either daylight or artificial, is necessary for the maturation of the fundaments. Light from fluorescent, daylight, or white light bulbs, or from a north window is sufficient for apothecial maturation. (Lane, S. A., and T. Sproston, 1955).

Sordaria fimicola. For summary see Fimetaria fimicola. (Buller, A. H. R., 1933, 5: 103).

Sordaria fimicola. A rough action-spectrum curve (in the range of 400-600 m $\mu$ ) for light-stimulated spore discharge is compared with the absorption-spectrum curve of an ethyl alcohol extract of the fungus. The two curves show some agreement. (Ingold, C. T., 1958).

Sordaria fimicola. When grown in darkness or light the fungus can develop mature perithecia from which spores are discharged. Under alternating dark and light (12 hours-12 hours) each day spore discharge is periodic (low rate during dark period; a gradual rise to a relatively high rate in the light period, followed by a decline before the onset of the next dark period). Transfer from darkness to light always leads to an increase in the rate of discharge and from light to dark to a decrease. Experiments with light of different quality but roughly the same energy value show that the blue rays are mainly effective. From cultures on filter-paper yeast-extract medium an orange pigment with a maximum absorption in the visible spectrum at 470 m $\mu$  can be extracted. (Ingold, C. T., and V. J. Dring, 1957).

Sordaria fimicola. Culture plates were kept in the laboratory in diffuse light. The necks of the perithecia were strongly phototropic. Spores were shot off in the dark and the number discharged increased with the light. (Page, W. M., 1939).

Sordaria fimicola. Cultures all produced significantly larger spores when grown in the dark than when grown in light of approximately 120 f.c. (The light source was daylight fluorescent lamps.) (Williams, C. N., 1959).

Sordaria macrospora. Culture plates were kept in the laboratory in diffuse light. The necks of the perithecia were strongly phototropic. (Page, W. M., 1939).

Sporormia bipartis. The experimental methods employed and the results obtained are the same as for Sordaria macrospora. (Page, W. M., 1939).

Sporormia intermedia. The experimental methods employed and the results obtained are the same as for Sordaria macrospora. (Page, W. M., 1939).

Stromatinia gladioli. Cultures were grown for 4 weeks in continuous white, blue, and red fluorescent light or were left 1 week in darkness prior to 3 weeks under these lights. Control cultures were kept in darkness. Some sclerotia were formed under all conditions, but the fewest were formed in darkness. Cultures in continuous white or red fluorescent lights produced a considerable number of sclerotia. Cultures in continuous blue fluorescent light produced fewer sclerotia than those under the two above-mentioned conditions, but if cultures were left in the dark 1 week prior to the 3 weeks in blue light the greatest number of sclerotia were formed. (Bjornsson, I. P., 1956).

Valsa coenobitica. All the necks of the perithecia turned toward the light. (Defago, G., 1944).

Venturia inaequalis. Leaves, some with the ventral surface toward the light and some with the dorsal surface toward the light, were nailed onto a board out-of-doors. Perithecia were always produced on the side exposed to the light. Perithecia on apple leaves kept in the dark had a variety of abnormal shapes; in some cases several necks were formed, and ascospore viability was impaired. The admission of small amounts of light (20 minutes' daily illumination) promoted normal perithecial development, and one weekly exposure of the same duration induced formation of organs differing only in their profuse development of setae. (Holz, W., 1937).

#### BASIDIOMYCETES EUBASIDIOMYCETES

Armillaria mellea. Hyphal tip isolates were grown for 2 months on potato-dextrose agar under light of different qualities. No fruiting bodies were detected. Cultures grown in darkness reached a size double that attained in continuous blue, red, and white fluorescent lights. (Bjornsson, I. P., 1956).

Armillaria mellea. Cultures of the fungus grew better in darkness than in light. Growth was good in yellow light, less luxuriant in green light, and poor in red and blue lights. (Raabe, R. D., 1958).



Armillaria mellea. The total length of rhizomorphs and diameters of colonies were greater in plates wrapped in black paper than in unwrapped ones placed beside them on a well lighted window sill. The number of rhizomorphs produced did not differ significantly. Light does not inhibit the formation of rhizomorph initials, but it slows down rhizomorph elongation. (Townsend, B. B., 1954).

Armillaria mucida. All cultures grown in darkness produced pure white carpophores, whereas those grown in light were a dark brown or fuscous gray, turning light with maturity. When young cultures were transferred from light to darkness, or vice versa, the hue changed to that appropriate to the new condition. When cultures were transferred at a later stage no color changes occurred. Fructifications reached maturity equally well in the dark or the light. (Fischer, C. E. C., 1909).

Clitocybe illudens. Cultures were found to fruit in either light or darkness, although the first stages were always initiated in darkness. (Young, V. H., 1914).

Collybia radicata. Light appears to be unnecessary for sporophore production since a number of sporophores appeared in cultures kept in the dark. (Campbell, A. H., 1938).

Collybia velutipes. The fungus was grown in dark and light incubators at 10°, 15°, 20°, and 25° C, illumination being provided by a mercury vapor lamp and an incandescent lamp. Light was necessary for complete development of fruiting bodies, and only mycelium or fruit body rudiments with stipes but without pilei were produced in the dark. (Aschan, K., 1954).

Collybia velutipes. Cultures on a synthetic medium in continuous darkness produced highly clustered and delicate fructifications with minute pilei, these results suggesting that primordium and stipe production are independent of light. However, when these cultures were transferred to light during the developmental period pileus growth was promoted. (Plunkett, B. E., 1953).

Collybia velutipes. Light was required for normal cap development. (Plunkett, B. E., 1958).

Coprinus comatus. Complete normal development takes place in the absence of light. (Brefeld, O., 1889).

Coprinus comatus (ATCC #12640). Fruiting bodies were not produced in the darkness or under any light conditions tested. Ridging was noticeable under all light conditions and in darkness. It was most prominent at low intensities and in darkness. Coloration of the medium was greatest at low light intensities. (Wishard, R. H., 1957).

Coprinus ephemerus. In darkness the whole fruiting body is weak, lacking in turgor, and small, but when the fungus is placed in light the stipe becomes erect and the pileus develops normally. (Brefeld, O., 1877, pp. 109-116).

Coprinus lagopus. Blue light (400-500 mμ) is required for fruit body formation. Light of over 640 mμ is ineffective. Mechanical stimulation can substitute for blue light and make possible the development of the fruit body. (Borriss, H., 1934).

Coprinus lagopus. The fungus is not greatly affected by light. Although the stipe will elongate in the dark, light is required for pileus formation. The stipes are positively heliotropic. (Brefeld, O., 1877, pp. 98-108).

Coprinus lagopus. Complete normal development takes place in the absence of light. (Brefeld, O., 1889).

Coprinus lagopus. The fungus in an early stage of development was illuminated 10 times every half hour for a period of 2 1/2 days at different wave lengths. The intensity of illumination corresponded about to a white light of 65 lux. The author concluded that the response of Coprinus as measured by degree of stretching of the stalk of the fruit body corresponds more closely to the absorption spectrum of a lactoflavin than to that of a carotinoid. (Bünning, E., I. Dorn, G. Schneiderhöhn, and I. Thorning., 1953).

Coprinus lagopus. Fruiting, which did not commence in darkness until about the 15th day, was accelerated by continuous light or by brief exposures to light between the 7th and the 13th day of incubation. The response was restricted to the area of mycelium actually exposed. In continuous light fruiting generally began in 10 days. Exposures to white light as brief as 1 second at 25 f. c. or 5 seconds at 0.1 f. c. were effective. Only the blue range of the visible spectrum stimulated fruiting, the longest effective wave length being near 5200 Å. (Madelin, M. F., 1956).

Coprinus lagopus. An action spectrum was determined for effect of light in preventing elongation of the stipes of the fungus. The curve had a maximum between 440 and 460 mμ. The upper limit of effective wave length was about 530 mμ. (Schneiderhöhn, G., 1954).

Coprinus lagopus. Light is required for each step in the normal development of fruiting bodies. With continuous illumination a very low intensity is sufficient. If etiolated fruit bodies are placed in light of 2500-5000 lux for 1 hour, and then returned to darkness, a thickening in the stipe is noted in the region which develops shortly after the lighting period. (Vorderberg, K., 1950).

Coprinus myceliocephalus. The fungus required light for normal fruiting. In the dark long stipes developed with small brownish caps. The veil became very much reduced and the caps never opened, but collapsed after a while without ripening spores. Some cultures developed no buds at all in the dark. (Lange, M., 1948).

Coprinus nycthemerus. Fruiting body initials formed in light but not in darkness. (Brefeld, O., 1889).

Coprinus plicatilis. Fruiting body initials formed in blue light but not in yellow. When etiolated stipes were placed in white light, they formed secondary fruit initials all up and down the elongated stipes. (Brefeld, O., 1889).

Coprinus plicatiloides. Positive heliotropic curvature of the stipe causes the pilei to be brought out of crevices in the substratum into the open. (Buller, A. H. R., 1909, 1: 75).

Coprinus sp. Stipe elongation was inhibited by intermittent illumination more than by continuous light of the same quality. The optimum interval between illumination periods was about 15 minutes. Joint effects of successive shaking and illumination treatments are accentuated if they are separated by 30 minutes. (Bünning, E., M. Gröner, and S. Stiefel, 1950 (1951)).

Coprinus stercorearius. Sclerotial formation takes place in either light or darkness, but fruiting body initials form on the sclerotia very seldom in the dark and abundantly in bright daylight. Once the fruiting body initials have been formed, the stipe develops in dark or in light; the stipe is able to develop to a great length (as much as 4 feet) in the dark. Little or no pileus development occurs in the dark. In light the stipe is much shorter and the pileus develops normally. (Brefeld, O., 1877, pp. 13-97).

Corticium praticola. Test-tube cultures were placed in a dark box in an incubator at 24° C and similar tubes just inside the inner glass door of the incubator with the outer door left open to admit light. A 500-watt electric light was placed near the glass door so that daylight could be supplemented by electric light on cloudy days. Basidiospores were more abundant in the light cultures but sclerotia formed only in the cultures which were kept in the dark. (Kotila, J. E., 1929).

Cortinellus berkeleyanus. Sporophores were equally abundant in light and darkness under favorable temperature and moisture conditions. (Nishikado, Y., and Y. Miyawaki, 1943).

Dacrymyces ellisii. Single-point inoculations were made on plates of malt agar, which were then placed in darkness for 15 days. At the end of this period the colonies were whitish to pale buff. After 15 days they were exposed to light of varying intensity for 10 minutes to 10 days and then placed in the dark again. Controls were grown both in complete darkness and in continuous light for the entire experiment. Pigment did not form in darkness, but in light followed by darkness a colorless band formed indicating the amount of growth during darkness.

Once the pigment was formed the colonies did not lose their color on being replaced in darkness. (Bulat, T. J., 1954).

Dacrymyces ellisii. Cultures grown for 30 days in the light at room temperature were removed from the agar, homogenized, and extracted with acetone. The extract was evaporated and the pigments taken up in petroleum ether, saponified, and chromatographed. Ten pigments, of which the major one was beta-carotene, were isolated. A table of carotenoids extracted and related data are presented. (Hanna, C., and T. J. Bulat, 1953).

Fomes annosus. Conidia were formed from 0° to 22.5° C in light or darkness. (Rishbeth, J., 1951).

Fomes fomentarius. Cultures grown in light are darker than those grown in darkness. (Cartwright, K. St. G., and W. P. K. Findlay, 1950, pp. 102-104).

Fomes fomentarius. Diffuse light reduced the amount of growth in comparison with that observed in darkness and made the mycelial mat darker in color. (Fritz, C. W., 1923).

Fomes igniarius. Sunlight caused a decided limitation in growth and a deepening in color of the mycelial mat as compared with the growth and color in darkness or in diffuse light. (Fritz, C. W., 1923).

Fomes rimosus. Cultures grown on suitable media with exposure to sunlight produced sporophores while those grown in the dark did not. (Long, W. H., and R. M. Harsch, 1918).

Fomes roseus. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Fomes texanus. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Hydnum auriscalpium. Both continuous illumination and continuous darkness proved inhibitory to the development of new sporophores and proliferations, and the growing region showed only a weak positive phototropic reaction to unilateral illumination. (Harvey, R., 1958).

Hypochnus (Corticium) sasakii. Sclerotia formed more abundantly in light than in darkness. (Hemmi, T., and S. Endo, 1931).

Lentinus lepideus. The pilei were not produced without a morphogenic stimulus given by light. When a fruiting body is grown entirely in the dark it develops into a horn-like process with no pileus or hymenium. (Buller, A. H. R., 1909, 1: 20).

Lentinus lepideus. Normal fructifications do not form in the absence of light. Instead, coral-loid deformations typically occur. (Jaczewski, A. de, 1910).

Lentinus lepideus. The stipe of this wood-destroying fungus grows towards the light and the cap develops only when the intensity of the light exceeds a certain minimum. (Smith, G., 1946, pp. 204-207).

Letinus lepideus. Spores germinated with a unilateral source of illumination did not show any phototropic response. (Snell, W. H., 1922).

Lentinus tuber-regium. The fungus was grown on various agar media and different soil and organic materials at 24° C. The early stages of the fruiting body formed in darkness but the pileus formed only in light. (Gallegmore, H. B., 1949).

Lenzites sapiaria. Germ tubes of spores germinated with a unilateral source of diffuse day-light illumination showed no phototropic response. (Snell, W. H., 1922).

Lenzites trabea. Cultures were left in the dark 3 to 6 weeks and exposed for 10 minutes, 60 minutes, 24 hours, and 7 or 14 days to white fluorescent light alone, with two blue or red



filters, and to incandescent filament light with or without two red and two blue filters. Cultures were left for 4 or 8 weeks in the dark after treatments. Basidiocarps formed only in cultures receiving 2 weeks of white fluorescent light alone or with two blue filters or light from incandescent filament lamps. (Bjornsson, I. P., 1956).

Merulius lacrymans domesticus. The fungus was grown in complete darkness and in daylight. Whenever pigment formation occurred in light it also occurred in darkness. The nature of the growth medium had a considerable effect on production of color. Artificial white light, as well as red, yellow, green and blue lights, was used but without effects on color formation. Cultures in the dark showed a much greater tendency to produce mycelium that grew up the sides of the flask to the plug. (Zoberst, W., 1952).

Panaeolus campanulatus. When it is beginning to elongate, the stipe is ageotropic but positively heliotropic, pushing the pileus towards the open or light. After the pileus reaches the open the apical portion of the stipe becomes strongly negatively geotropic and ceases to respond to the stimulus of light. (Buller, A. H. R., 1922).

Panus sp. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Panus stypticus. Darkness appears to favor mycelial growth but not sporophore formation. Intensity of coloring appears dependent on light, for sporophores grown in diffuse light (temperature and humidity constant) are uniformly pale buff, but in bright light they are cinnamon or tan. (Johnson, M. E. M., 1920).

Pellicularia filamentosa. Cultures were placed in a white-walled room with two large windows and exposed to strong diffuse natural light during the day and normal darkness at night. Sporulation under natural light is a periodic function, with heaviest rate in daytime. (Carpenter, J. B., 1949).

Pellicularia filamentosa. For summary see Rhizoctonia solani. (Durbin, R. D., 1959).

Pleurotus ostreatus. When grown in the dark on bread, the mycelium is at first white; after 3 weeks the center becomes flesh ochre. On the same medium in the light drops of yellowish red liquid are exuded. (Cartwright, K. St. G., and W. P. K. Findlay, 1950, pp. 114-116).

Pleurotus ostreatus. Light is necessary for the formation of fruiting bodies, and for their completely normal development it must be strong (14 hours' daily light of 4000-8000 lux). (Koch, W., 1958).

Pleurotus ostreatus. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Pleurotus sp. Luminosity was independent of previous illumination of the fungus. (Bose, S. R., 1935).

Polyporus agariceus. The fungus can fructify in complete darkness but the rate of elongation and the length of the stipe are increased, and the size of the pileus is slightly reduced. Cultures were induced to fructify in 1 week at room temperature in diffuse light. The stalk of the sporophore was negatively geotropic during its growth but became positively phototropic after the formation of the flattened knob. (Chakrabarty, M., 1941).

Polyporus (Fomes) annosus. The fungus did not fruit in either light or darkness. (Koch, W., 1958).

Polyporus arcularius. Six cultures exposed to normal daylight were compared with six kept in darkness except for periods of daily observations. Over a period of 28 days the daylight-exposed ones gave rise to 51 sporophore initials, of which seven completed development, while those in darkness did not fruit but produced reddish-brown stromatic mycelium in the older parts. Later these dark-grown cultures were exposed to normal daylight and they developed

fertile sporophores. The effects of different periods of illumination and colored light on sporophore formation were also studied. Blue light and green light were effective; orange light was not. Recordings of sporophore formation made after 18 days showed an increase approximately in proportion to the time the cultures were exposed to light. (Gibson, I. A. S., and J. Trapnell, 1957).

Polyporus brumalis. Reductions of transpirational water loss over the approximate range of 6.5 to 0.0015 mg/cm<sup>2</sup>/hour at normal atmospheric levels of O<sub>2</sub> and CO<sub>2</sub> were associated with 1) delay of pileus production, 2) increased mean lengths of stipes at pileus initiation, 3) diminished numbers of pileate fructifications, 4) increased final lengths of pileate and epileate fruit bodies, and 5) diminished cap diameter. A very similar but less marked effect was obtained by reduction of light intensity from 160 to 40 f.c. at each transpiration level studied. The effects were additive so that with least light and lowest transpiration pileus suppression was complete in all fructifications. Total darkness prevented cap development even in dry moving air. Fewer fruit bodies were initiated when transpiration rate was low and when light intensity was zero or at low values. Low light intensity also delayed fruiting. (Plunkett, B. E., 1956).

Polyporus brumalis. Light was required for normal cap development. Larger average cap diameters resulted as light intensities were increased over a certain range. In low light the stalks were considerably longer than usual. (Plunkett, B. E., 1958).

Polyporus cinnabarinus. Isolates from various hosts were grown on different media in light and darkness. Most isolates failed to produce sporophores in darkness, while several did produce them on suitable media in light. Several other Polyporus species produced generally similar results. (Long, W. H., and R. M. Harsch, 1918).

Polyporus pargamenus. Darkness is conducive to the most vigorous vegetative growth but retards sporophore formation. The dimidiolate form of the sporophore is not to be ascribed solely to the stimulus afforded by light or to that by gravity, but to the combined action of both. The formation of pores and the production of spores, however, depend entirely on light. The presence or absence of light made no perceptible difference in the time required for spore germination. (Rhoads, A. S., 1918).

Polyporus (Daedalea) quercinus. The mycelial mat was at first white with a wide colorless margin and hyphae growing close on the surface of the medium. Growth was similar in light and in darkness, but was slower and denser in light and the colorless margin tended to disappear. A mature culture (1 month old) in light was colored Natal brown and became overgrown with a creamy white woolly mycelium. (Cartwright, K. St. G., 1951).

Polyporus radiatus. On malt agar in the light the fungus exhibits very little aerial development at first, but in the dark a loose cobwebby mycelium soon develops. The culture shows various yellow-brown tints, which are more pronounced in darkness. (Cartwright, K. St. G., and W. P. K. Findlay, 1950, pp. 124-126).

Polyporus schweinitzii. Isolates from a large number of sources were grown on nutrient agar in Petri dishes at a constant temperature (22° C) and exposed to electric light (but never to daylight) for a few seconds every 12 hours. Another series was cultured at room temperature (10° to 25° C) and exposed to diffuse daylight for a few seconds every 4 or 5 days. The fungus was sensitive to light and grew more slowly and displayed darker and more varied coloration when exposed, for even very short periods, to indirect daylight than when kept in darkness. On various substrata, neither sporophore production nor pore formation appeared to depend on exposure to daylight. (Childs, T. W., 1937).

Polyporus schweinitzii. Cultures were grown in tubes in darkness, diffuse light, and where they received about 3 hours' direct sunlight per day. Diffuse light permitted the development of a brilliantly colored mat. In light regular firm-walled hyphae group themselves in strands to form tufts which, growing massed together and perpendicular to the surface, produced a velvety appearance. They were deeply pigmented and without spores. In darkness the aerial mat presented a loose tangle of irregularly, much-branched threads. They were hyaline or slightly yellow in mass and contained chlamydospores. (Fritz, C. W., 1923).

Polyporus squamosus. The pilei cannot be produced without light. When a fruiting body is grown entirely in darkness, it develops into a horn-like process with no pileus or hymenium. If the fruit body is placed in darkness after development of the pileus has been initiated by the light stimulus, further development is normal. The liberation of spores is independent of light. (Buller, A. H. R., 1909, 1: 120).

Polystictus (Polyporus) versicolor. Two small birch branches with fruiting bodies of the fungus were brought into the laboratory and placed into similar moist chambers, one in darkness and the other in light. In darkness a large number of imperfectly formed fruiting bodies developed, none with a true bracket form or pores. In light small normal bracket-like sporophores appeared. When the branch in the dark was transferred to the light typical fruiting bodies formed. Germination of spores was not influenced by presence or absence of light. (Bayliss, J. S., 1908).

Polystictus (Polyporus) versicolor. The fungus requires at least 8 hours of light (1000 lux) per day to produce normal fruiting bodies. Abnormal fruiting bodies are produced in darkness. (Koch, W., 1958).

Poria ambigua. The fungus does not form hymenium and basidiospores in culture unless exposed to light. The blue end of the visible spectrum is effective, the red end is not. Short exposures to faint light are adequate. The effect of light extends into the mycelium, which grows in darkness after illumination. This suggests the production of a substance in light which moves into the mycelium formed later in darkness and induces reproduction. (Robbins, W. J., and A. Hervey, 1959).

Poria sp. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Poria xantha. When grown in darkness a mature culture shows an ill-defined spongy fructification with fine pores at the top of the slope, and below a mat of loose, branching strands appressed to the medium. In light practically the whole surface of the compact, rather chalky mat becomes covered with very fine pores and short tubes growing down from small protuberances. (Cartwright, K. St. G., and W. P. K. Findlay, 1950, pp. 201-202).

Ptychogaster cubensis. Color depended upon intensity of light and in weak illumination some isolations remained white or became only slightly "cream color" around the inoculum in 14 days. Test-tube cultures which were white at first became brown in diffused light. Cultures in darkness remained white. (Davidson, R. W., W. A. Campbell, and G. F. Weber, 1942).

Schizophyllum commune. Cultures were incubated in a constant-temperature room at 25° C in continuous light, in continuous total darkness, in a 12-hour white light-dark cycle, and in a 12-hour colored light-dark cycle. Wratten filters of known wave length transmission were used. No fruit bodies were formed in the absence of light. Several fruiting bodies were formed in continuous white light and in the 12-hour light-dark cycle and the 12-hour blue light-dark cycle. A few atypical fruit bodies formed in green light, a few small ones in the yellow light, and a few abortive ones in the red light of the 12-hour cycle. (Barnett, H. L., and V. G. Lilly, 1953).

Schizophyllum commune. Experiments were performed to test whether light 1) is necessary for fruiting, 2) is required for normal fruit morphology, and 3) by proper manipulation of duration and intensity, can enhance fruiting in genetically determined poor fruiting combinations. The authors state "It appears that light is not required for fruiting but it is required for normal fruiting, although the intensity and duration of light do not appear to be critical. It appears unlikely that the condition of illumination could induce fruiting in a genetically determined poor fruiting combination." (Raper, J., and G. S. Krongelb, 1958).

Sphaerobolus spp. Cultures kept in darkness or very diffuse light produced no basidiocarps. When cultures were placed several feet from a window, all basidiocarps formed pointed directly toward the source of light. The heliotropic response is limited to very young basidiocarps; the direction of light falling upon the maturing fruit body does not affect the direction of the discharge. (Walker, L. B., 1927).



Sphaerobolus stellatus. In the dark the fungus forms mycelium but no fruiting body initials. The latter form only in the light. Their further development into fruiting bodies takes place in either light or darkness, but is faster in light. (Brefeld, O., 1889).

Stereum umbrinum. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Stereum versiforme. The experimental methods employed and the results obtained are similar to those for Fomes rimosus. (Long, W. H., and R. M. Harsch, 1918).

Trametes serialis. Cultures on suitable media and exposed to sunlight produced sporophores, while those in the dark generally failed to do so. (Long, W. H., and R. M. Harsch, 1918).

Typhula gramineum. The production of the fruit body from the sclerotium was studied under several different light conditions: diffuse light, no cover (wave length shorter than 3420 Å), same with violet glass cover (wave length 3420-5050 Å), same with red glass cover (wave length 5400-6000 Å), and darkness. The normal fruit body developed only under diffuse light or light which passed through the vita-glass cover, giving rise to true hymenia and basidiospores. (Tasugi, H., 1935).

Typhula sp. To determine the character of light waves which stimulated fructification, a series of filters were used in an out-of-doors experiment. Glass filters of various wave length transmission were placed over wet cheesecloth-covered boxes containing sclerotia on moist sand. Where ordinary glass (not transmitting waves shorter than approximately 3250 Å) was used, no sporophores were produced. Under a Vitaglass filter (2650-6690 Å) normal fruiting took place. Fertile sporophores were produced under Corning glass filter No. 970 Corex (transmitting 60 percent in region of 3020 Å with a sharp decrease to 10 percent at 2700 Å). Therefore the region which apparently stimulates normal fructification is approximately between 2700 and 3250 Å. Fructification also occurred when artificial illumination from an ultra-violet source was used. (Remsburg, R. E., 1940).

#### RUSTS AND SMUTS

Cronartium ribicola. Telia were exposed to constant darkness and to constant white light (770 f.c., fluorescent white-light bulbs). Sporidium production occurred under both conditions. (Bega, R. V., 1959).

Melampsora lini. Aeciospores and urediniospores germinated equally well in both light and darkness. (Hart, H., 1926).

Neovossia horrida. Studies on the light requirements for germination of over-wintered chlamydospores showed that 46 hours under a fluorescent lamp of 50 f.c. or 2 hours in direct sunshine was sufficient to promote subsequent germination in darkness. The light reaction was not influenced by temperature, and illumination of dry spores was not effective. (Lin, C.-K., 1955).

Phragmidium mucronatum. When spores were illuminated laterally with light of low intensity no phototropic response was observed. (Cochrane, V. W., 1945).

Phragmidium subcorticium. The germ tubes of uredospores germinated on gelatine agar and exposed to a unilateral source of illumination (lamplight of approximately 200 lux) showed negative phototropism. (Gettkandt, G., 1954).

Puccinia antirrhini. The germ tubes of uredospores germinated on gelatine agar and exposed to a unilateral source of illumination showed no phototropic response. (Gettkandt, G., 1954).

Puccinia coronata. Uredospore germ tubes exhibited negative phototropism to white and blue light. They made no phototropic response to green or red light. Blue rays, and to a lesser extent violet, are responsible for the negatively phototropic response of the sporelings to white light. (Forbes, I. L., 1939).

Puccinia coronata. The experimental methods employed and the results obtained are similar to those described for Phragmidium subcorticium. (Gettkandt, G., 1954).

Puccinia coronifera. Uredospores germinated equally well in light or darkness. Germ tubes were negatively phototropic. (Stock, F., 1931).

Puccinia dispersa. The experimental methods employed and the results obtained are similar to those described for Phragmidium subcorticium. Also, working with P. triticina and P. dispersa, Gettkandt determined the action of different wave lengths. She used glass filters 2 mm thick and obtained the following results:

<u>Filter Designation</u>	<u>Wave Lengths</u>	<u>Orientation of Germ Tubes</u>
RG <sub>2</sub>	Over 600 mμ	Random
OG <sub>2</sub>	Over 550 mμ	Random
GG <sub>14</sub>	480-over 500 mμ (mostly over 500 mμ)	Random
VG <sub>9</sub>	450-560 mμ (max. at 520)	Weakly negatively phototropic
BG <sub>12</sub>	325-520 mμ	Strongly negatively phototropic
UG <sub>1</sub>	290-400 and 700-1100 mμ	Negatively phototropic

(Gettkandt, G., 1954).

Puccinia dispersa. Uredospores germinated equally well in light and darkness. Germination decreased slightly in blue light. Germ tubes were negatively phototropic. (Stock, F., 1931).

Puccinia emiliae. Teleutospores germinated more readily and produced many more sporidia in alternate light and darkness than in continuous darkness. (Maneval, W. E., 1927).

Puccinia glumarum. The experimental methods employed and the results obtained are similar to those described for Puccinia antirrhini. (Gettkandt, G., 1954).

Puccinia graminis. Germ tubes were negatively phototropic. (Stock, F., 1931).

Puccinia graminis avenae. The experimental methods employed and the results obtained are similar to those for Puccinia coronata. (Forbes, I. L., 1939).

Puccinia graminis tritici. Uredospores of Puccinia graminis var. tritici form specialized structures during the infection process. Germinated spores were induced to form these on artificial substrates by proper adjustment of environmental conditions. Under optimal conditions of sunlight at 2000 to 5000 f.c., temperatures of 80° to 85° F and a saturated atmosphere, appressorium-like structures formed in 2 to 3 hours, penetration pegs in 3 to 4 hours, and vesicles in 4 to 6 hours. When this period was followed by 16 to 18 hours of darkness at 85° + 2.5° F in a saturated atmosphere, formation of vesicles was completed and infection hyphae developed. Conditions above 9000 f.c. and 88° F inhibited the formation of the infection-type structures. If any one factor deviates sufficiently, development and/or differentiation or both stop and do not resume if the factors are brought back in balance. (Emge, R. G., 1958).

Puccinia graminis tritici. Uredospore germ tubes exhibited negative phototropism to white and blue light. No phototropic response to green, violet, and red light occurred. (Forbes, I. L., 1939).

Puccinia graminis tritici. Uredospores exhibited good germination in darkness and with 300 f.c. of daylight illumination. At intensities above 300 f.c. germination decreased. No germination occurred at 1000 f.c. (Sharp, E. L., C. G. Schmitt, J. M. Staley, and C. H. Kingsolver, 1958).

Puccinia helianthi. The experimental methods employed and the results obtained are similar to those for Puccinia emiliae. (Maneval, W. E., 1927).

Puccinia magnusiana. The germ tubes of aeciospores germinated with unilateral daylight illumination showed no phototropic response. (Gettkandt, G., 1954).

Puccinia malvacearum. Sporidia were placed in darkness and with illumination laterally from a window. After 16 hours germination was equally good in light and darkness. Germ tubes of those spores illuminated laterally grew away from the source of the light. (Robinson, W., 1914).

Puccinia menthae. The experimental methods employed and the results obtained are similar to those described for Phragmidium subcorticium. (Gettkandt, G., 1954).

Puccinia poarum. The germ tubes from aecidiospores germinated with exposure to a unilateral source of illumination (lamp-light) showed a slight tendency toward phototropic behavior. (Gettkandt, G., 1954).

Puccinia poarum. Aeciospores were placed in darkness and with illumination laterally from a window. After 16 hours germination was equally good in both light and darkness. Germ tubes in light and dark were indifferent in direction of growth. (Robinson, W., 1914).

Puccinia rhamni. Uredospores were exposed to unilateral illumination from a window. Germ tubes grew away from the source of light. (Fromme, F. D., 1915).

Puccinia simplex. The experimental methods employed and the results obtained are similar to those described for Phragmidium subcorticium. (Gettkandt, G., 1954).

Puccinia suaveolens. The experimental methods employed and the results obtained are similar to those described for Puccinia antirrhini. (Gettkandt, G., 1954).

Puccinia triticina. Uredospore germ tubes exhibited negative phototropism in white light and mostly the same in blue light, but no clear-cut response occurred in red, violet, or green light. (Forbes, I. L., 1939).

Puccinia triticina. The germ tubes of uredospores germinated on gelatine agar and exposed to a unilateral source of illumination showed strong negative phototropism, that is, they grew away from the source of light (daylight). For additional experimental data on this fungus see the summary for Puccinia dispersa. (Gettkandt, G., 1954).

Puccinia triticina. The experimental methods employed and the results obtained are similar to those for Puccinia coronifera. (Stock, F., 1931).

Puccinia xanthii. The experimental methods employed and the results obtained are similar to those for Puccinia emiliae. (Maneval, W. E., 1927).

Tilletia brevifaciens. In preliminary tests about 60 percent of the spores germinated within 8 weeks under light and at cool temperatures; optimum germination occurred at approximately 5° C under constant light. Germination seldom occurred in darkness. (Baylis, R. J., 1955).

Tilletia brevifaciens. Exposure to diffuse daylight hastened the beginning of spore germination and increased the maximum percentage of spores which germinated. The highest percentage germination attained was 4.5. (Böning, K., F. Wagner, and A. v. Minckwitz., 1953).

Tilletia contraversa. Only an occasional chlamydospore germinated in the absence of light. Continuous exposure to fluorescent light of 150 to 200 f.c. at 5° C resulted in good germination. (Baylis, R. J., 1958).

Tilletia horrida. Chlamydospores were germinated on water agar under light of different qualities. Earliest and best germination took place under blue and white light. Microscopic examination revealed that the growth of germ tubes and mycelium differed under white light and in darkness. (Kreitlow, K. W., 1938).

Tilletia secalis. Chlamydospores germinated profusely in light and darkness on sterilized soil emulsion. (Niemann, E., 1954).



Tilletia sp. Light stimulates spore germination. Apparently the spores (at least some species) germinate only at low temperatures, but also require some illumination. In no case, however, did the percentage germination exceed 4. The maximum light intensity used (1500 lux) gave 2.5 percent germination of dwarf smut spores after 50 days. (Gassner, G., and E. Niemann, 1954).

Uromyces pisi. The experimental methods employed and the results obtained are similar to those described for Puccinia magnusiana. (Gettkandt, G., 1954).

## FUNGI IMPERFECTI

Acrothecium lunatum. When exposed to alternations of light and darkness the fungus produced two zones of growth every 24 hours, a pink circle during the day and a white one at night. No zonation was produced in continuous darkness. (Nigam, B. S., 1936).

Alternaria brassicae var. dauci. Evidence is presented to show that conidial formation can be divided into two physiological phases. Light is necessary for formation of sterigmata; conidia are formed in the dark. In constant fluorescent light the hyphae were clearly septate, thick-walled, and with many sterigmata but no conidia. In constant darkness, hyphae were thin-walled and a few conidia formed in the area of the inoculum. When constant-light cultures were subsequently placed in the dark, 50 to 60 percent of the sterigmata formed conidia. With light-dark cycles, rings due to mycelial color and number of conidia are produced. (Witsch, H. v., and F. Wagner, 1955).

Alternaria solani. The fungus was given various doses of ultra-violet light from a Hanovia lamp. Within a few hours after irradiation conidiophores were visible and spores matured after 18 to 24 hours. (Charlton, K. M., 1953).

Alternaria solani. Five-week-old cultures on various media were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f.c.), alternate light (8 hours) and dark (16 hours) periods, and darkness. While band spectrum limits were not considered, the peak of relative energy with incandescent light was between wave lengths of 610-730 m $\mu$ , whereas that of fluorescent light was 460-550 m $\mu$ . Room temperature and 26° C were used. Slow-speed fans were employed to minimize the radiant heat but dissipation of the heat energy from light striking the surface of the medium was not controlled. Illumination effected changes in conidial shape in all strains tested. The "typical muriform conidium" was consistently obtained in cultures incubated in continuous darkness and to a less extent in those subjected to diurnal variation. Under increasing light intensities the conidia produced were elongate and narrow. Under 1000 f.c. (fluorescent or incandescent source) the conidia were invariably attenuated. Light seemed to increase the tendency toward the formation of an attenuated once-branched rostrum. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Alternaria solani. Cultures which were scraped and placed on a window sill sporulated readily. Undisturbed cultures of most isolates of the fungus produced few or no spores. Cultures irradiated by an open mercury arc lamp sporulated abundantly. Irradiation through colored glass filters markedly affected sporulation. Greatest sporulation was obtained with filters whose lower limits of transmission ranged from 249-254 m $\mu$ . (McCallan, S. E. A., and S. Y. Chan, 1944).

Alternaria solani. Sporulation is induced by a high intensity of visible white light. Continued high light intensities increase pigmentation. (Weston, W. A. R. Dillon, 1936).

Alternaria sp. Germ tubes of conidia exposed to unilateral daylight illumination during germination showed no phototropic effect. (Robinson, W., 1914).

Alternaria tenuis. A culture subjected to diurnal changes of light and darkness showed zonation. Cultures under the same conditions of temperature but in continuous light or in continuous darkness showed no zones. Zones were produced in cultures in orange, red, or blue light alternating with darkness but not in those in continuous darkness under the same temperature conditions. (Gallemaerts, V., 1910).

Amphichaeta punicae. Fruit bodies were formed in darkness but not in light. (Chaudhuri, H., and J. Singh, 1935).

Ascochyta gossypii. The fungus produces abundant pycnidia when growing in complete darkness. Chlamydospores and hypn cysts are also produced, both in complete darkness and in light. (Chippindale, H. G., 1929).

Ascochyta imperfecta. Red clover isolates required light for sporulation on potato-dextrose agar and varied considerably in culture, while isolates from alfalfa sporulated under all conditions of light and darkness and were very uniform. (Schenck, N. C., 1955).

Ascochyta pisi. When 40 isolates of the fungus were grown in complete darkness, the sporulation in the cultures ranged from none to moderate. Under daylight and continuous fluorescent light all isolates sporulated profusely. The effective wave lengths were thought to be in the ultra-violet. (Leach, C. M., 1959).

Ascochyta viciae. Pycnidial formation was stimulated in diffuse daylight or under electric light in comparison with darkness. (Coons, G. H., and E. Levin, 1921).

Aspergillus fumigatus. Spinulosin (3:6-dihydroxy-4-methoxy-2:5-toluquinone) was isolated from the metabolic solution of cultures grown on Raulin-Thom medium for 25 to 26 days at 24° C in the dark. (Anslow, W. K., and H. Raistrick, 1938).

Aspergillus giganteus. When in darkness the fungus produced conidiophores 1 to 2 mm in height with small conidial heads, but in light it produced also giant conidiophores as long as 7 to 8 mm with clavate heads 1 mm or more long. Light sensitivity was confined to the lower half of the visible spectrum. (Gardner, E. B., 1949).

Aspergillus giganteus. Conidiophore elongation occurs so long as any white light is present but at low intensities the length of the induction period varies inversely as the intensity and is optimum at 5 f.c. Certain values are derived for the necessary length of light exposure before elongation starts and for the necessary length of the dark period which must precede the light period. Wave length of incident light was more important than intensity for the production of tall conidiophores, but intensity exerted proportionate effects when wave length was constant. The shorter visible wave lengths (those below 500 mμ) were most effective while those above this point were incapable of causing the reactions necessary for elongate growth. The near ultra-violet portion of the sub-visible spectrum was particularly effective in stimulating elongation, its relative effect being greater than could be accounted for by the increased energy value of the quanta in this region. (Gardner, E. B. W., 1950).

Aspergillus giganteus. The photic response to wave lengths between 400 and 500 mμ is apparently mediated by a yellow carotenoid, probably beta-carotene, as the light-absorbing substance. Sensitivity to wave lengths between 300 and 380 mμ may involve a colorless carotenoid which absorbs highly in this region of the spectrum. (Gardner, E. B., 1955).

Aspergillus giganteus. Higher intensities of light appear to give greater elongation of conidiophores. In direct unfiltered light short periods of light daily are almost as effective as long periods. Total darkness tends to retard conidiophore formation entirely. Conidiophores seem to be phototactic only so long as they are elongating. Once heads had started to form elongation ceased. Light of wave lengths longer than approximately 512 mμ did not seem to cause elongation. The critical wave length for elongation appeared to be between 470 and 512 mμ. Infra-red did not of itself cause elongation. (Webb, P. H. W., 1942).

Aspergillus glaucus. In darkness perithecia were produced abundantly and conidia only very sparsely. In light strong conidial formation occurred but few perithecia. The fluffy growth characteristic in darkness or subdued light is suppressed in strong light. (Chona, B. L., 1932).

Aspergillus glaucus. For summary see Eurotium herbariorum. (Gupta, D. D., 1951).

Aspergillus niger. See summary for Sterigmatocystis nigra. (Lendner, A., 1897).

Aspergillus ornatus (NRRL # 2256). The fungus produced few or no conidial heads in darkness, while heavy sporulation occurred in continuous white light of low intensity. When mycelium which has been incubated in the dark is placed in light, heavy sporulation occurs at the margin of the colony but not on the older parts. Illumination by a spectrum projected across a plate which had been uniformly inoculated with spores resulted in sporulation in blue light. (Personal communication from Dr. P. J. Allen.) (Raper, K. B., D. I. Fennell, and H. D. Tresner, 1953).

Aspergillus spp. The influence of natural and artificial light on 67 varieties of Aspergillus and Penicillium was studied. Transparent and darkened containers with sample cultures raised on agar media were exposed for 15 minutes to 24 hours to solar radiation, dispersed solar light, and electric light with intensities of 4500, 640, 180 and 120 lux. Temperature, humidity, aeration, and pH were held constant. Undispersed sun rays were filtered through distilled water to eliminate the effect of heat. Electric light was filtered through blue, red, green, and yellow light filters. Light inhibited the growth of mycelia and stimulated the development of conidia. Intense light retarded the ascomycetous stages in A. nidulans, A. repens, A. amstelodami, A. chevalieri and P. ucrainicum, and the development of sclerotia in A. carbonarius, A. alliaceus, A. candidus, A. flavus, and A. thomi. Weak light stimulated the development of conidia. Darkness stimulated the growth of mycelia, but protracted cultivation without light inhibited conidial development and yielded sterile and degenerated strains. Weak light increased the intensity of conidial formations in partly degenerated forms; this increased intensity was preserved in subsequent generations. Blue rays of electric light spectra retarded the development of mycelia, ascomycetous stages, sclerotia, and red, orange, and yellow pigments in P. rubrum, A. amylovorus, and P. purpurogenum. In contrast, red rays did not decolorize the pigments and did not inhibit mycelial, ascomycetous, and sclerotial development. Green and yellow rays produced intermediate effects. (Tatarenko, E. S., 1954).

Beauveria. Three isolates, one with the capacity to produce a yellow pigment, one blue-green, and the third, red, were studied. The yellow and blue-green pigments formed in light or darkness, but the red pigment formed only in light. (MacLeod, D. M., 1954).

Botryodiplodia theobromae. Cultures grown in darkness showed almost complete suppression of pycnidia, loss of greenish color in the mycelium, and an absence of stromata. Cultures exposed to daylight exhibited good stromatal development. In cultures with columnar fructifications, these were positively heliotropic. (Wardlaw, C. W., 1932).

Botrytis cinerea. The conidia germinated with unilateral lamplight at about 200 lux and showed strong negative phototropism. (Gettkandt, G., 1954).

Botrytis cinerea. The fungus formed conidia only at night, not in daylight. Red-yellow light (potassium dichromate filter) acted like darkness in permitting conidia to form, while blue-violet light (ammoniacal copper oxide) prevented conidial formation. (Klein, L., 1885).

Botrytis cinerea. Sclerotia are formed more freely in darkness than in the light. Spores are formed more freely in light. (Paul, W. R. C., 1929).

Botrytis cinerea. Cultures in the dark or red light (potassium dichromate filter) produced sclerotia but few conidia, whereas those under blue light (ammoniacal copper oxide) formed a thick layer of conidia as in white light. (Reidemeister, W. v., 1909).

Botrytis gladiolorum. Light affected sporulation, ridging, and sclerotial formation. With white fluorescent light for 7 hours or more, spore production increased with intensity. Following no more than 3 days of darkness, ridges were produced by a minimum of two 24-hour cycles of at least 8 hours of white fluorescent light and 1 hour of darkness. Sclerotia formed in cultures exposed to 4 to 7 days of darkness prior to an exposure of less than 30 minutes to white fluorescent light. Blue light and the shorter wave lengths appeared to accelerate sporulation and ridging. Red light favored sclerotial formation. (Bjornsson, I. P., 1956).

Botrytis gladiolorum. Petri dishes were inoculated and placed 1) in a window with direct illumination for about 4 hours per day; 2) in diffused light, and 3) in the dark. After 4 days



normal erect gray conidiophores developed in the dishes in direct light but not in the other two sets. (Peiris, J. W. L., 1949).

Botrytis sp. Germ tubes of spores germinated with unilateral daylight illumination grew away from the light. (Robinson, W., 1914).

Botrytis squamosa. When the fungus was exposed to a cycle of 12 hours in darkness followed by 12 hours in light, sclerotia were formed in zones. The light used consisted of daylight fluorescent lamps or the same in conjunction with incandescent bulbs. Temperature cycles in the dark also produced sclerotia in a zonate pattern. The author stated "Although the experiments were conducted under conditions in which temperature was rigidly controlled, it is difficult to eliminate the influence of light absorbed by the fungus and by the medium and transformed to heat." (Page, O. T., 1956).

Botrytis squamosa. When maintained at constant temperature the fungus was unaffected in growth and rate of respiration by light levels as high as 100 f.c. for several days and by levels of 250 f.c. for a few hours. (Stinson, R. H., R. S. Gage, and E. B. MacNaughton, 1958).

Camarosporium sp. When half of a plate culture was irradiated from an artificial ultra-violet source and the other half protected from radiation, the irradiated half subsequently developed many more pycnidia. (Stevens, F. L., 1930a).

Centrospora acerina. Pigment production was a response to light. After 4 days' incubation in darkness, dishes were exposed to daylight for periods of 4 minutes to 8 1/2 hours. Two days later all light-exposed dishes showed a circle of red pigment and the width varied with the amount of exposure. (Neergaard, P., and A. G. Newhall, 1951).

Centrospora acerina. Growth and cultural characters of the fungus were studied at 21° C in darkness and in light from a fluorescent lamp. The fungus grew almost equally well under both conditions. Pigment was produced in the cultures in the light but not in those in the dark. Abundant spores were produced within 48 hours by irradiating with ultra-violet light. (Srivastava, S. N. S., 1958).

Cephalosporium sp. The fungus was exposed to a 450-watt General Electric sun-lamp at a distance of 50 cm for 1, 5, 15, 30, and 60 minutes on three consecutive days. The longer exposures inhibited the growth of the fungus colonies and caused them to take on a darker brown color. The fungus was not killed and sporulation was not materially altered. (Goss, R. W., and P. R. Frink, 1934).

Cephalothecium roseum. When cultures were kept in constant light and constant darkness, no zonation occurred. When they were subjected to alternating light and darkness with only slight variation in temperature, zonation occurred. The effect was found to be due to light, not to temperature, because in these experiments 9° C variation in temperature did not produce zonation. Zones were produced when cultures were grown in orange, red, or blue light alternating with darkness but not in cultures in continuous darkness under the same temperature conditions. (Gallemaerts, V., 1910).

Cephalothecium roseum. Zonation does not occur in total darkness. In red and orange light (daylight through liquid filter) alternating with darkness and in continuous darkness, uniform dense spore formation occurred over the entire surface of the medium. When blue light and ordinary light were alternated with darkness (natural diurnal cycle) distinct daily rings of alternating dense and sparse spore formation occurred. Green light in the same cycle produced less distinct rings of growth. Rings of sparse spores were formed during the day and the denser ones at night. Blue light inhibited spore formation. (Hedgecock, G. G., 1906).

Cephalothecium roseum. Ring formation could be brought about by a change in temperature or by passing a stream of air over the cultures. The action of light was considered to be indirect. (Munk, M., 1912).

Cercospora apii. The fungus was grown in darkness in a ventilated metal chamber, in the diffuse light of the laboratory, and in a dark room with a 50-watt Mazda bulb. Light effects

were not very marked. On corn meal agar in the dark the aerial mycelium was slightly darker gray. The fungus sporulated in light and darkness. (Klotz, L. J., 1923).

Cercospora beticola. Blue light was comparable with diffuse daylight in the production of zonation, but red light induced only traces of zonation. (Coons, G. H., and F. G. Larmer, 1930).

Cercospora beticola. Conidia were produced in flask cultures on sterilized beet, white cabbage, and leek leaves with a substratum of soil (compost or sand). They were formed as freely in total darkness as in light. (Frandsen, N. O., 1953).

Cercospora beticola. Three strains of the fungus were grown in complete darkness for 11 days at 20° C. A red and a yellow pigment were produced in darkness and also when the cultures were incubated with a normal daylight-darkness sequence. These results may be contrasted with those of Neergaard and Newhall (1951), who found Centrospora acerina (re-garded by Frandsen as a Cercospora) very light-dependent in respect to pigment production. (Frandsen, N. O., 1955).

Cercospora sesami. The rate of linear growth was found to be greater in alternate light and darkness, less in continuous darkness, and least in continuous light. The retarding effect of continuous darkness and continuous light became more evident with time. Distinct zones were formed in cultures kept outside exposed to light during the day and to darkness during the night, but cultures in continuous light or continuous darkness showed no zones. Continuous light or continuous darkness inhibited sporulation while cultures in alternating light and darkness sporulated earlier and more copiously. When cultures which had been kept in darkness were exposed to light, spore formation was stimulated. (Chowdhury, S., 1944).

Cercospora sp. Five-week-old cultures on various media were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f. c.), alternate light (8 hours) and dark (16 hours) periods, and darkness. The treatments had no influence on conidial production. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Cercospora spp. Cultures in dishes exposed to daylight sporulated more abundantly than did those in dishes incubated in darkness; however, darkness did not suppress sporulation completely. (Kilpatrick, R. A., and H. W. Johnson, 1956).

Cercospora herpotrichoides. Spores formed as rapidly and as freely in darkness as in the daylight. (Glynne, M. D., 1953).

Cercospora kikuchii. The fungus formed a red-violet pigment in daylight or artificial light but not at all in darkness. When cultures grown in the dark were transferred into light, pigment formed. Pigment formation depended on an acid reaction of the substrate and presence of light and oxygen. (Deutschmann, F., 1953).

Colletotrichum falcatum. Cultures under white and blue light showed abundant sporulation and those in red light less. Cultures in darkness produced the most aerial mycelium but the fewest spores. (Kreitlow, K. W., 1938).

Colletotrichum lagenarium. Perithecia were produced abundantly by ultra-violet irradiation. There were more setae per acervulus on the irradiated side of the colony than on the non-irradiated side. (Stevens, F. L., 1931b).

Colletotrichum lindemuthianum. Sporulation did not appear to be influenced by variations of daylight, ultra-violet light, or aeration. (Mathur, R. S., H. L. Barnett, and V. G. Lilly, 1950).

Colletotrichum phomoides. About 24 hours after irradiation, cultures (half irradiated and half not exposed to irradiation) showed numerous acervuli, mostly in clumps, in the irradiated half while the non-irradiated half remained free from acervuli until about 8 days old. Maximum development of acervuli resulted from exposures of 30 seconds to 1 minute; longer exposures accelerated formation of acervuli, but they were produced in smaller quantities. (Hutchinson, A. H., and M. R. Ashton, 1930).

Colletotrichum sp. When half of a plate culture was irradiated from an artificial ultra-violet source and the other half protected from radiation, the irradiated half subsequently developed many more acervuli. (Stevens, F. L., 1930a).

Colletotrichum trifolii. Cultures in the light grew at practically the same rate as those in darkness. Spore germination was essentially identical in light and dark chambers. (Monteith, J., Jr., 1928).

Coniothyrium concentricum. Pycnidia were formed in light and in darkness. (Leonian, L. H. 1924).

Coniothyrium fuckelii. Parallel series were grown on copper-containing and copper-free media. Growth rates for isolate #1 were identical in both series when supplied with thiamin and kept in light. In darkness growth was normal only when the isolate had been grown on a copper medium previously. On the medium containing biotin, thiamin and i-inositol growth was normal in darkness whether or not the fungus was previously grown on copper. (King, T. H., E. Krog, and H. W. Schroeder, 1952).

Coniothyrium sp. Eight-day-old colonies were irradiated with a Hewitt quartz mercury arc for periods ranging from 1 second to 3 minutes. With 1 second there was very slight stunting, which became distinct at 5 seconds. With 10 seconds' exposure numerous superficial or buried pycnidia were formed. (Stevens, F. L., 1928).

Coryneum longistipitatum. Cultures at 24° to 27° remained sterile in darkness and subdued light. They may be stimulated to sporulate by the action of sunlight. (Zagallo, A. C., 1941).

Curvularia lunata. Five-week-old cultures on various media were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f.c.), alternate light (8 hours) and dark (16 hours) periods, and darkness. (For other conditions, see Alternaria solani, Johnson and Halpin, 1954.) In general, sporulation occurred earlier under illumination than in darkness. Sporulation under light began 13 to 16 hours after incubation began, while cultures incubated in the dark began sporulating after 41 hours. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Curvularia trifolii. Cultures in continuous white fluorescent light produced an abundance of spores while those in darkness produced only a few. In an experiment in which light was varied from 1 to 24 hours by hourly intervals, certain cultures receiving cycles of 8 to 11 hours of light per day showed a striking zonation, while in cultures receiving over 16 hours of light alternating with 8 hours of darkness zonation did not occur. (Bjornsson, I. P., 1956).

Cytospora mendax. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Dendrophoma obscurans. Cultures on nutrient agar were incubated in a constant temperature room at 25° C in continuous light, in continuous total darkness, and in 12-hour light-dark cycles using white, blue, green, yellow, and red light of known wave length. No pycnidia formed in the absence of light or under red light in the 12-hour cycle, while many pycnidia and conidia were produced under white and blue light in the 12-hour light-dark cycle and under continuous white light. Few pycnidia and conidia were produced under green and yellow light in the 12-hour cycle. (Barnett, H. L., and V. G. Lilly, 1953).

Dendrophoma obscurans. When the fungus was grown in continuous darkness extremely few pycnidia were formed, but when it was grown in constant artificial illumination or in alternate light and darkness at the same temperature large numbers were produced. (Lilly, V. G., and H. L. Barnett, 1951).

Diplodia gossypii. Cultures were grown in darkness and in continuous light of different qualities. Pycnidia did not form in cultures in the dark but formed under all light conditions. Cultures under red fluorescent lamps with two red filters produced fewer, larger, and longer-necked pycnidia than did those under other light conditions. (Bjornsson, I. P., 1956).

Diplodia gossypina. The experimental methods employed and the results obtained are the same as for Camarosporium sp. (Stevens, F. L., 1930a).



Epicoccum spp. Several cultures were shown to produce a pinkish or red color in oatmeal agar in response to exposure to bright sunlight or strong artificial light when temperature was not controlled. (Schol-Schwarz, M. B., 1959).

Fusarium bulbigenum. Exposure to sunlight favored the production of long conidia, as compared with those formed in darkness. Light from an incandescent lamp induced the formation of macroconidia; microconidia formed in darkness. (Harter, L. L., 1939).

Fusarium cepae. Spore production was definitely stimulated by exposure to ultra-violet radiation from a quartz mercury arc. Greatest spore production occurred with filters with transmission between 2535-2800 Å. Long exposure to direct sunlight through filters transmitting no lower than 3120 Å induced abundant sporulation. (Ramsey, G. B., and A. A. Bailey, 1930).

Fusarium cepae. Conidial color varied from light brown when in darkness to ochraceous salmon or light ochraceous buff when in diffuse light. (Walker, J. C., and E. C. Tims, 1924).

Fusarium coeruleum. The fungus showed no difference in growth in light or darkness. (Buxton, E. W., 1955).

Fusarium coeruleum. The experimental methods employed and the results obtained are similar to those for F. bulbigenum. (Harter, L. L., 1939).

Fusarium culmorum. Two hitherto undescribed crystalline coloring matters, "rubrofusarin" ( $C_{15}H_{12}O_5$ , m.p. 210-211°, glistening red plates) and "aurofusarin" ( $C_{30}H_{20}O_{12} \cdot H_2O$ , m.p. above 360°, orange-yellow prisms), were isolated from cultures grown in the dark at 24° C on Raulin-Thom medium. (Ashley, J. N., B. C. Hobbs, and H. Raistrick, 1937).

Fusarium culmorum. The fungus showed no difference in growth in light and darkness. (Buxton, E. W., 1955).

Fusarium culmorum. Cultures were given one irradiation for different periods of time with light from a sun lamp. The primary reaction was retardation. Subsequently, however, these irradiated cultures sporulated very abundantly whereas the non-irradiated cultures sporulated sparsely. (Weston, W. A. R. Dillon, 1932).

Fusarium discolor sulphureum. Cultures from a dark incubator were exposed to bright daylight for only 1/4 to 1/2 second. A ring of conidia was produced visible to the naked eye. Cultures kept in the dark produced no rings. A 6-minute exposure to a 25-candlepower carbon lamp produced a noticeable ring, while 2-to 2 1/2-minutes' exposure to a tungsten filament induced zone formation. (Bisby, G. R., 1925).

Fusarium episphaeria. Pigment (different shades of orange) developed only in light. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium eumartii. Spore production was stimulated by a very short exposure to ultra-violet light from a mercury arc lamp. (Smith, E. C., 1935).

Fusarium fructigenum. The fungus must have alternating light and darkness for the production of zones. Exposure to light promoted a sporiferous type of growth in contrast to the sterile type obtained in darkness. (Hall, M. P., 1933).

Fusarium lateritum. Pigment (pinkish tint) developed only in light. Bluish patches were present in cultures grown in light or in darkness. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium martii var. pisi. The experimental methods employed and the results obtained are similar to those for F. bulbigenum. (Harter, L. L., 1939).

Fusarium moniliforme. Five-week-old cultures were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f.c.), alternate light (8 hours) and dark (16 hours) periods, and darkness. For other conditions see Alternaria solani. The treatments did not influence conidial production. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Fusarium moniliforme (ATCC # 10052). Sporulation occurred readily under all light conditions and in darkness. Light was necessary for the production of pigment; the intensity of the color increased as light intensity was increased. Pigment was restricted to those areas of the mycelium which had received the light treatment. Cultures become sensitive to light on the second day after inoculation. The lowest intensity which would induce pigmentation was 150 f.c. with an illumination period of 34 minutes, and the shortest illumination period which would induce pigmentation was 17 minutes at 800 f.c. (Wishard, R. H., 1957).

Fusarium moniliforme. Pigment (pinkish tint) developed only in light. Optimum requirements for typical development were diurnal fluctuation in light and fluctuating temperature of 20°-23° C. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium oxysporum. Cultures were grown in continuous light (fluorescent) and continuous darkness for 20 days. The dark cultures exhibited a deep vinaceous-purple color with sparse cottony aerial mycelium. Macroconidia (straight) were rare, but chlamydospores (spherical) were common. Pionnotes and sclerotia were absent. In the light cultures were orange with very sparse aerial mycelium. Macroconidia (curved) were abundant, but chlamydospores (oval) were very rare. Pionnotes were abundant and dark-blue sclerotia were common. Under blue light (15 days) cultures were orange with abundant pionnotes but no sclerotia. Under red light (15 days) cultures were pale vinaceous with no pionnotes or sclerotia. (Buxton, E. W., 1955).

Fusarium oxysporum. Cultures on a wide variety of media were incubated at constant temperature under light and dark conditions. Light promoted the formation of orange (carotenoid) pigments and of macrospores, whereas darkness favored the formation of diffusible red and purple (naphthoquinone) pigments and chlamydospores. Dark-grown cultures have not been known to produce sporodochia or sclerotia. Three-day-old cultures were exposed to a mercury-vapor lamp; the temperature was kept at 20°-21° C. Exposure for 1 hour produced perceptible pigmentation and exposure for 10 hours, a strong color. Most coloration occurred in darkness during the 24 hours following irradiation and was limited to the mycelium that was irradiated. New growth was colorless. (Carlile, M. J., 1956).

Fusarium oxysporum. Pigment (pinkish tint) developed only in light. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium rigidiuscula. The fungus showed pronounced zonation when grown under fluctuating light or fluctuating temperature. Pigmentation (rose) was more conspicuous in cultures grown in darkness as compared with that of those grown in light. Sporulation occurred under all conditions except in the series in darkness, but spores produced under most of these conditions showed abnormalities. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium roseum. The fungus had pronounced zonation when grown under fluctuating light or fluctuating temperature. It had more conspicuous pigmentation (rose) in darkness than in light. It developed perithecia under various conditions, the cultures exposed to fluctuating light and continuous temperature of 20° C producing them in abundance. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium solani. The fungus exhibited pronounced zonation when grown under fluctuating light or fluctuating temperature. It showed abundant sporulation under all conditions studied and produced sporodochia or pionnotes in complete darkness at a constant temperature of 20° C. As compared with cultures exposed to light, those in darkness showed more conspicuous pigmentation (olive green). (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).

Fusarium sp. (six strains). In general, the aerial mycelium of cultures kept in alternating day and night is short-lived. In its place are pustules of spores (sporodochia), which show a distinct tendency to zonal arrangement and are definitely correlated with alternation of light and darkness. When cultures are grown in darkness the aerial mycelium lasts longer and covers the whole plate, the amount of sporulation is reduced. When subsequently exposed to light some of the mycelium develops spores. Upon a short exposure to light, spore production will be initiated and the formation of spores will then take place in darkness. The region of greatest sensitivity to light is a short distance behind the growing margin of the colony. The

rate of growth of the colony was not appreciably affected by variation of the conditions of illumination. Cultures grown in light had a slight pink color. (Brown, W., 1925).

Fusarium sp. Cultures at room temperature were exposed to diffuse daylight. Sporulation was more profuse and normal under these conditions. (Oswald, J. W., 1949).

Fusarium spp. Fifty-nine species were exposed to ultra-violet rays between 2650 and 2300 Å. In most species sporulation increased, and sometimes pigmentation in the mycelium did also. A marked increase in macrospore percentage was noticed in several species after three daily 15-minute treatments under vita-glass (transmitting up to 2650 Å). Some other species gave favorable although not such striking results in macrospore increase while many species showed little or no macrospore increase after irradiation. With very few exceptions, the tendency to respond or not respond to irradiation with macrospore production was consistent and seemed characteristic of the species or variety. The most extensive spore production induced by irradiation occurred in species of sections Sporotrichiella, Gibbosum, Discolor subsection Saubineti, Martiella, and Elegans subsection Oxysporum (excluding vascular parasite group). Initiation of sporulation in F. culmorum was hastened. A strain of F. coeruleum which had never produced conidia during its period of culture in this laboratory and one of F. sambucinum the activity of which was in abeyance were induced to sporulate. One strain of Fusarium (section Gibbosum) which had never produced spores in the laboratory produced many spores when irradiated. Most species tested gave maximum macrospore production under vita-glass. A 15-minute irradiation period on each of 3 successive days was better than one longer period. In responsive species old cultures (filling the dish) could be made to produce macrospores by irradiating them. Neither three 15-minute exposures through vita-glass at 40 cm from the arc nor three (or fewer) 4-second direct exposures at 21 cm from the arc succeeded in inducing the production of perithecia of the 14 species with known perfect stages which were treated in these tests. (Bailey, A. A., 1932).

Fusarium spp. Cultures grow equally well in light or darkness, but the colors produced are much more vivid in rather bright light. (Bisby, G. R., 1917-1920).

Fusarium spp. Exposure to light from an incandescent lamp increased the size and number of septations of the conidia. (Harter, L. L., 1941).

Fusarium spp. On lima bean agar the fungus shows no difference in cultures in a dark incubator and in diffuse light. On potato-glucose agar a more intense purple color appeared when the fungus was grown in the light incubator than when it was grown in the dark incubator. Cultures in darkness developed conidia with uneven septations and form. (Morris, H. E., and G. B. Nutting, 1923).

Fusarium spp. A number of Fusarium species were studied. Light affected macrospore production in a number of species. Macrospore production and the ratio of macrospores to microspores increased with increasing light intensity. Both carbon and nitrogen sources were also important in determining the kind and amount of sporulation in the species tested. Colony growth was appressed in light, and pigmentation of the mycelium often was produced in response to light. (Reid, J., 1958).

Fusarium spp. Three species were grown in light and darkness. Single-spore cultures subjected to light only for the first 4 days of growth failed to develop in the same manner as those allowed to remain in light. Such characters as color, zonation, type of colony, presence or absence of sporodochia, size, shape and septation of macroconidia, and even the occurrence of a perithecial stage, cannot be used successfully in taxonomy unless these fungi are grown in adequate light. (Snyder, W. C., and H. N. Hansen, 1941).

Fusarium tricinctum. Pigment (pinkish tint) developed only in light. Optimum requirements for typical development were diurnal fluctuation in light and a temperature fluctuating within narrow limits but never higher than 20° C. The fungus failed to sporulate under any environmental conditions in this experiment. (Zachariah, A. T., H. N. Hansen, and W. C. Snyder, 1956).



Fusicladium cerasi. Light, either daylight exposure in the laboratory or artificial light in an incubator, hastened the production of conidia. (Schweizer, H., 1958).

Gliocladium roseum. Isolates tested produced a yellow pigment when they were grown on corn meal agar in the absence of light. When they were cultured on corn meal agar and exposed to daylight they produced a pink pigment. Cultures incubated in darkness for 36 to 72 hours produced a yellow pigment, but when these cultures were then exposed to daylight for 24 hours or more the pigment changed to pinkish-orange. (Huber, D. M., and A. M. Finley, 1959).

Gliocladium roseum. The fungus grew as rapidly and produced conidia as abundantly in darkness as in light. When it was incubated in darkness the subaerial mycelium and spore masses remained white, but when it was exposed to daylight they assumed normal salmon-pink color and the younger parts of colonies began to show typical concentric zonation. (Isaac, I., 1954).

Helicodendron triglitzensis. This fungus, if kept in light for a few days, sporulates over the entire surface of the colony. If kept in darkness it never sporulates. (Glenn-Bott, J. I., 1955).

Helicodesmus albus. Culture experiments indicate that conidium production depends on light. Four tubes were placed in a light-tight box, and four were left outside as close to the box and under conditions otherwise as nearly the same as possible. At the end of 2 weeks the exposed cultures had produced a white zoned veil of spores, while the cultures in the dark had made abundant mycelial growth with but very few spores around the point of inoculation. (Linder, D. H., 1925).

Helminthosporium avenae. Cultures were grown in two Petri dishes. Three days later the covers of the Petri dishes were replaced with discs of Sanalux glass. One-half of each disc was painted with India ink. Both cultures were then irradiated for 10 minutes with a Hanovia quartz mercury-vapor lamp. Subsequent irradiation was made for 10 minutes, 6 days later. Seven days later cultures were examined microscopically. The mycelia of irradiated halves were strongly pigmented and abundant sporulation had taken place. Pigmentation was very slight on the non-irradiated halves and no sporulation had taken place. (Weston, W. A. R. Dillon, 1933).

Helminthosporium avenae. The fungus sporulated abundantly when exposed to visible white light of high intensity. Continued high light intensities increase pigmentation. (Weston, W. A. R. Dillon, 1936).

Helminthosporium cyclops. For summary see Podosporiella verticillata. (Wallace, H. A. H., 1959).

Helminthosporium gramineum. Abundant normal sporulation was obtained within 48 hours on agar cultures held outdoors to expose them to diurnal changes of environment. In the absence of light no sporulation occurred on agar slants or on mycelium growing from diseased leaves either outdoors or indoors. In light but under continuous high indoor temperatures, again, no sporulation was obtained. Light, preferably outdoor daylight, was necessary for the induction of sporulation. Relatively high temperatures throughout the growing period as well as extended periods of light resulted in excessively long conidiophores, few of which produced conidia. This was true of agar cultures and of pieces of diseased leaves. A temperature drop during half of each 24-hour period gave best results. When diseased leaf pieces were placed on potato-dextrose agar and incubated in the dark at various temperatures from 8° to 35° to obtain sporulation, conidiophore length increased and conidium length decreased as the temperature increased. (Houston, B. R., and J. W. Oswald, 1946).

Helminthosporium leersii. When the fungus was grown in darkness, two hitherto undescribed mold metabolic products, namely "luteoleersin",  $C_{26}H_{38}O_7$  (yellow blunt-ended needles), and "alboleersin",  $C_{26}H_{40}O_7$  (colorless silky needles), were isolated in crystalline form. (Ashley, J. N., and H. Raistrick, 1938).

Helminthosporium sativum. Conidia were produced abundantly in cultures incubated in continuous darkness. (Christensen, J. J., 1926).

Helminthosporium sativum. Five-week-old cultures on various media were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f.c.), alternate light (8 hours) and darkness (16 hours) periods, and darkness. For other conditions see Alternaria solani. Illumination effected changes in conidial shape in all strains tested. Conidia produced in cultures exposed to incandescent and fluorescent light at 500 f.c. were characteristic of those produced on the host. Conidia in cultures incubated continually in darkness were invariably shortened and aborted. The majority of conidia produced by colonies exposed to 50 and 100 f.c. and to alternate light (intensities up to 500 f.c.) and darkness were short, single-celled or at most bisepitate, but were not aborted as were those from cultures incubated in darkness. At 200 f.c. conidia approached the size of "typical" ones but usually possessed fewer septa. Sporulation occurred earlier under illumination than in darkness. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Hendersonia sp. Light was necessary for pycnidial formation. (Leonian, L. H., 1924).

Hormodendron cladosporoides. Cultures were left for 14 days in a controlled-temperature room in continuous light and in continuous darkness. No zonation occurred. The cultures were then placed in the laboratory and after 3 days of exposure to alternating daylight and darkness three very distinct zones were observed. In another experiment, cultures submitted to alternating daylight and darkness produced zones, but cultures under the same temperature conditions in continuous light or continuous darkness produced no zones. Zones were produced when cultures were grown in orange, red, or blue light alternating with darkness but not in cultures grown in continuous darkness under the same temperature conditions. (Gallemaerts, V., 1910).

Hormodendron sp. Zonation does not occur under conditions of total darkness. In red and orange light (daylight through liquid filter) alternating with darkness and in continuous darkness uniform dense spore formation occurred over the entire surface of the medium. When blue and ordinary light were alternated with darkness (natural diurnal cycle) distinct daily rings of alternating dense and sparse spore formation occurred. Green light in the same cycle produced less distinct rings of growth. Rings of sparse spore formation were formed during the day and denser ones at night. Blue light inhibits spore formation. (Hedgecock, G. G., 1906).

Isaria farinosa. This fungus was identified as Isaria farinosa or a fungus closely resembling it. Coremia subjected to unilateral illumination grew directly toward the light source. (Schaposchnikow, W., and A. Manteifel, 1924).

Isaria virescens. The fungus can form at least seven different pigments under different conditions of culture media and light. On sugar-peptone agar, cultures grown in darkness are colorless, whereas the same cultures in diffuse daylight are reddish or orange-red. (Danilov, A. N., 1925).

Kellermania yuccagena. Pycnidia were formed in both light and darkness. (Leonian, L. H., 1924).

Macrophomina phaseoli. Thirty-five isolates of the fungus were studied for factors influencing pycnidium formation. Complete darkness inhibited sporulation in all cases. Diurnal exposure to light was more favorable than constant light. (Ashworth, L. J., Jr., 1959).

Macrosporium tomato. Spore production is definitely stimulated by exposure to ultra-violet radiation from a quartz mercury arc. Greatest spore production occurs with filters with transmission between 2535-2800 Å. Long exposure to direct sunlight through filters transmitting no lower than 3120 Å induced abundant sporulation. (Ramsey, G. B., and A. A. Bailey, 1930).

Melanconium fuligineum. Cultures sporulated equally well in light or darkness. (Timnick, M. B., V. G. Lilly, and H. L. Barnett, 1951b).

Microcera coccophila. Formation of coloring matter in the mycelium is provoked by the action of diffused daylight upon cultures which have grown in darkness, but the pigmentation of the conidia is a fixed characteristic unrelated to environment and due to the genetic constitution of the species. (Pulselli, A., 1927).

Monilia fruticola. Under different light intensities, photoperiods, and photocycles, the growth of the conidiophores of the fungus depends on the amount of light energy received. Conversion to the conidial phase is a function of the quantity of energy furnished by a photocycle of 1 hour within the range of 20-200 lux-min/hr. (Jerebzoﬀ, S., 1958).

Monilia fruticola. Low temperatures favor and prolong the growth in height of conidiophores which begin to grow in darkness in the same way as it does the elongation of their cells, but strongly reduces sporulation. Light (even of short duration -- 1 hour) furnished before the application of low temperatures or 2 days afterward inhibits totally or partially the said prolonged growth. (Jerebzoﬀ, S., 1959).

Monilinia fruticola. The fungus sporulates freely under red or far red light or in darkness. (McClellan, W. D., H. A. Borthwick, I. Bjornsson, and B. H. Marshall, Jr., 1955).

Naemosphaera sp. Pycnidia were formed in both light and darkness. (Leonian, L. H., 1924).

Nigrospora sphaerica. Spore discharge took place in all directions from the surface even when illumination was unilateral. Spore discharge also occurred in darkness. (Webster, J., 1952).

Oidiodendron fuscum. The fungus was grown in darkness and from the growth medium there was isolated a hitherto unreported metabolic product, "fuscin" ( $C_{15}H_{16}O_5$ , orange plates, m. p. 230°), accompanied by its reduction product, "dihydrofuscin" ( $C_{15}H_{18}O_5$ , colorless rhombic crystals, m. p. 206°). (Michael, S. E., 1948).

Ollula sp. Pycnidia were formed in both light and darkness. (Leonian, L. H., 1924).

Penicillium africanum. The fungus produced a red coloring material in both light and darkness. (Doebelt, H., 1909).

Penicillium album. Zonation does not occur under conditions of total darkness. In red and orange light (daylight through a liquid filter) alternating with darkness, and in continuous darkness uniform dense spore formation occurred over the entire surface of the medium. When blue light and ordinary light were alternated with darkness (natural diurnal cycle) distinct daily rings of alternating dense and sparse spore formation occurred. Green light in the same cycle produced less distinct rings of growth. Rings of sparse spores were formed during the day and denser ones at night. Blue light inhibits spore formation. (Hedgecock, G. G., 1906).

Penicillium claviforme. The coremia are markedly phototropic. (Raper, K. B., and C. Thom, 1949).

Penicillium cyclopium. When incubated at 24° C in the dark, the fungus formed pigment erratically, the growth obtained was often white with little color in the reverse. Exposure to light appears to be essential for maximum pigment production. Optimum conditions were met by incubating the flasks in the laboratory at an average temperature of 20°-21°. Under these conditions about five times as much coloring matter was isolated as from the duplicate flasks incubated at 24° in darkness. Emodic acid and gamma-hydroxyemodin were isolated from the mycelium. (Anslow, W. K., J. Breen, and H. Raistrick, 1940).

Penicillium funiculosum. The fungus produces an orange-red color when grown in daylight. When it is grown in darkness the coloration is much weaker and delayed. (Ebeling, R., 1938).

Penicillium gladioli. Cultures were grown in continuous white, blue, green, and red fluorescent lights and in darkness. Cultures receiving white and blue light were covered with spores and aerial mycelium was absent; those receiving green light were also covered with spores, but some aerial mycelium was present. Cultures in red light and in darkness developed very few spores but a great amount of aerial mycelium. (Bjornsson, I. P., 1956).



Penicillium glaucum. Cultures submitted to variations of light are zoned. Zones were produced when cultures were grown in orange, red, or blue light alternating with darkness but not in cultures grown in continuous darkness under the same temperature conditions. (Gallemaerts, V., 1910).

Penicillium glaucum. The germ tubes from spores germinated with a unilateral source of day-light illumination exhibited no phototropic response. (Robinson, W., 1914).

Penicillium herquei. When grown in total darkness or at high light intensities (over 200 f.c.) the organism failed to sporulate. However, it sporulated rather abundantly at 100 f.c. Yellow colonies exposed to sunlight rapidly turn green. The results indicated that the reaction was a photocatalytic oxidation, perhaps mediated by a fluorescent pigment. They also indicated that the living organism possessed the ability to reverse the color change, that is, green to yellow. (Riedhart, J. M., and C. L. Porter, 1958).

Penicillium isariaeforme. Coremia are strongly positively phototropic. (Stolk, A. C., and J. Meyer, 1957).

Penicillium islandicum. (NRRL # 1175). The fungus was grown in darkness and several coloring materials were chromatographically separated. One of these was chrysophanic acid (chrysophanol, 4:5-dihydroxy-2-methyl-anthraquinone). (Howard, B. H., and H. Raistrick, 1950).

Penicillium islandicum. (NRRL # 1175). The fungus was grown in darkness and two hitherto undescribed coloring materials, namely "skyryn" ( $C_{30}H_{18}O_{10}$ , orange-red rods or yellow hexagonal plates, m.p. above  $380^{\circ}$ ), and "flavoskyryn" ( $C_{15}H_{12}O_5$ , yellow needles, m.p.  $215^{\circ}$  (decomp.)), were isolated. (Howard, B. H., and H. Raistrick, 1954).

Penicillium luteum. Cultures were incubated under five different conditions: 1) diffuse day-light on a laboratory table, 2) constant darkness, 3) daylight through a blue liquid filter, 4) daylight through a yellow liquid filter, and 5) a cycle of 2 days' darkness-2 hours' daylight-3 days' darkness-2 hours' daylight repeated for a period of 23 days. All colonies showed the same total diameter of growth. In 1) there were 23 rings, corresponding to the number of days of the experiment. The same thing occurred in 3), that is, blue light acted like daylight. In 2) and 4) no ring formation occurred. In 5) there were rings of more translucent zones corresponding to the long dark periods alternating with more dense zones corresponding to the light periods. Light was necessary for conidial formation. (Knischewsky, O., 1909).

Penicillium luteum. Cultures of old degenerate strains (sterile aerial mycelium) of the fungus formed typical conidiophores after a few hours' exposure to bright light. (Smith, G., 1946. p. 221).

Penicillium nalgiovensis. The fungus was grown in darkness and two hitherto undescribed coloring materials, namely "nalgiovensin" ( $C_{18}H_{16}O_6$ , orange needles or plates, m.p.  $199-200^{\circ}$ ) and "nalgioxin" ( $C_{18}H_{15}O_6Cl$ , yellow needles or plates, m.p.  $248-248.5^{\circ}$ ), were isolated. (Raistrick, H., and J. Ziffer, 1951).

Penicillium schneeggii. The fungus produced an orange pigment in both light and darkness. Color production was much dependent on the nature of the carbon source. Coremia are positively heliotropic. (Boas, F., 1914).

Penicillium sclerotiorum. The fungus was grown in darkness and a chlorine-containing substance, "sclerotiorine" ( $C_{20}H_{20}O_5Cl$ ), was extracted from the mycelium. Growth in darkness resulted in greater production of pigment and mycelium than did growth in light. (Curtin, T. P., and J. Reilly, 1940).

Penicillium sp. In constant darkness many conidia were formed and growth was uniform. In constant light (900 lux) production was uniform, but fewer conidia were produced than in constant darkness. Light limited the number of conidia produced but did not inhibit production. White light (900 lux) in a 12-hour light-dark cycle produced zonation (a concentration of conidia alternating with few conidia); the effect was related to intensity. Tests on intensity showed the lower limit of effectiveness to be 6 lux. Far-red, red, and orange light had no effect on

conidial formation, but long ultra-violet, green, and blue light (390-530 m $\mu$ ) had a definite effect. (Sagromsky, H., 1952a).

Penicillium sp. In a 12-hour light-dark cycle definite zonation occurred. Conidia-rich areas were produced in darkness and conidia-poor areas in light. Light suppressed conidial formation. A green color which was principally confined to the conidia was produced. (Sagromsky, H., 1952b).

Penicillium spp. For summary see Aspergillus spp. (Tatarenko, E. S., 1954).

Pestalotia guepini. Pycnidia were formed in both light and darkness. (Leonian, L. H., 1924).

Pestalotia sp. The fungus sporulated freely under fluorescent, mazda, or blue light but not under red or far-red (about 7000 Å and above) light or in darkness. A mutant of the fungus sporulated freely under all light conditions tested. (McClellan, W. D., H. A. Borthwick, I. Björnsson and B. H. Marshall, Jr., 1955).

Phoma apicola. Pycnidia formed in both light and darkness. (Bennett, C. W., 1921).

Phoma herbarum var. medicaginis. Isolates were studied for their ability to sporulate on potato-dextrose agar in total darkness, in alternating light and darkness, and in continuous light. After 14 days the fungus had sporulated uniformly under all light conditions. (Schenck, N. C. and J. W. Gerdemann, 1956).

Phoma insidiosa. When grown on corn meal agar in light, the fungus produced a pink discoloration of the medium. This was especially marked in plates exposed to light just after germination of the conidia. Each conidium was the center of a pink spot. If the culture was left undisturbed for several days, a series of concentric pink and white circles radiating from the conidium formed. A count showed the white circles marked the spaces traversed by the hyphae during the night, the pink circles during the day. The pink color faded as the culture aged. Old and slowly growing mycelium did not produce the color. (Koch, E., and C. Rumbold, 1921).

Phoma trifolii. Isolates from red clover required light for sporulation on potato-dextrose agar and varied considerably in culture. Isolates from alfalfa sporulated under all conditions of light and darkness and were very uniform. (Schenck, N. C., 1955).

Phoma trifolii. Isolates were studied for their ability to sporulate on potato-dextrose agar in total darkness and in continuous light. After 14 days the fungus had sporulated well in continuous light, only fairly well in alternating light and darkness, and not at all in total darkness. (Schenck, N. C. and J. W. Gerdemann, 1956).

Phoma urens. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Phomopsis sp. Pycnidial formation occurred after 20 to 25 days and was accelerated by ultra-violet irradiation. The pycnidia produced under these conditions were smaller than normal. (Abe, T. and C. -T. Yeh, 1956).

Phomopsis vexans. The experimental methods employed and the results obtained are the same as for Camarosporium sp. (Stevens, F. L., 1930a).

Phyllosticta shaminella. The experimental methods employed and the results obtained are similar to those for Camarosporium sp. (Stevens, F. L., 1930a).

Phyllosticta solitaria. The fungus sporulated equally well whether the cultures were kept in light or darkness. (Mix, A. J., 1933).

Piricularia oryzae. Five-week old cultures on various media were subjected to continuous illumination by incandescent or fluorescent light (50 to 2100 f.c.), alternate light (8 hours) and dark (16 hours) periods, and darkness. For other experimental conditions see Alternaria solani. Striking changes in conidial shape were obtained. Conidia produced by cultures in-

cubated in artificial light of 50 and 100 f.c. were the most nearly characteristic of the species. Colonies subjected to 200, 500, or 1000 f.c. produced conidia which were considerably attenuated and occasionally non-septate. Conidia from colonies incubated in darkness varied from the elongate type found in higher intensity culture incubation to those characteristic of the species produced on host tissue. No variations in conidial shape were induced at temperatures ranging from 15° to 35° C (5-degree increments). The peak of conidial production occurred at the 500-f.c. level. (Johnson, T. W., Jr., and J. E. Halpin, 1954).

Plenodomus destruens. Pycnidia were formed both in darkness and in light. (Leonian, L. H., 1924).

Plenodomus fuscomaculans. Certain cultures were placed in a light-tight cupboard; others were placed in a room in strong diffuse light. At times of strongest light the illuminated cultures were 2 degrees (C) warmer than those in darkness. Those in light formed pycnidia. Those in darkness never formed pycnidia, but mycelial growth was stronger than that of those in light. Sclerotia also formed in darkness. (Coons, G. H., 1916).

Podosporiella verticillate. Light does not appear to be essential for development of synnemata. Synnemata formed in culture are positively phototropic. (Wallace, H. A. H., 1959).

Rhizoctonia carotae. Cultures were grown for 2 months in darkness or in continuous fluorescent light with two blue or red filters. Cultures in the dark produced a thin grayish-yellow mat of mycelium, while cultures under all the light conditions produced, in addition, scattered, sclerotia-like bodies. (Bjornsson, I. P., 1956).

Rhizoctonia solani (Pellicularia filamentosa). Gross differences were evident in the morphology of 96 clones grown in constant fluorescent light and constant darkness. About one-fourth of these produced sclerotia in light but not in darkness. Another quarter produced no sclerotia under either treatment. The remaining half always produced sclerotia, but sclerotial morphology was decidedly different in most cases. In constant light, the sclerotia were more appressed and compact and occurred mostly in clusters nearer the center of the Petri dish. Illuminated cultures showed a distinct tendency toward less aerial mycelium, thinner surface stroma, and lighter pigmentation. (Durbin, R. D., 1959).

Rhizoctonia solani. There was no clear distinction between the quantity of sclerotia produced in periodic light or in continuous darkness. (Townsend, B. B., 1957).

Sclerotium rolfsii. Cultures on a variety of media were given one of the following treatments in a constant-temperature room at 25° C: 1) continuous light (8 f.c. at level of medium outside of culture vessel), 2) continuous darkness except for an exposure of 10 minutes to 8 f.c. after 4 days' growth, 3) continuous darkness but exposed for 1 second after 4 days' growth, and 4) continuous darkness. No significant differences in weights of mycelia occurred under 2), 3), and 4), but 15 to 20 percent more mycelium was produced in continuous light. The dry weight of sclerotia produced by one of the two isolates studied was 30 percent higher in continuous light and four times as many were formed. (Abeygunawardena, D. V. W., and R. K. S. Wood, 1957).

Sclerotium rolfsii. Cultures on potato-dextrose agar kept in darkness showed a thinner, more attenuate mycelium than cultures from the same mycelial source kept in light. Sclerotial initials were formed, but the hard dark mature form of the sclerotia did not develop. Plates that had been kept continuously in darkness for a month without developing sclerotia produced abundant normal-looking and viable sclerotia after 2 days in light. (Clinton, R. K. S., 1957).

Sclerotium rolfsii. The fungus produced few or no sclerotia in the absence of light. In light sclerotia formed abundantly. (McClellan, W. D., H. A. Borthwick, I. Bjornsson, and B. H. Marshall, Jr., 1955).

Sclerotium rolfsii. No clear distinction occurred between the quantity of sclerotia produced in periodic light or in continuous darkness. (Townsend, B. B., 1957).



Scolecotrichum graminis. Irradiation of cultures with ultra-violet light from a Cooper-Hewitt lamp induced sporulation when other methods were unsuccessful. (Braverman, S. W., 1958).

Septoria nodorum. Cultures incubated under continuous light (approximately 100 f. c.) near 20° C produced abundant pycnidia and conidia. Cultures incubated under low light intensities (18° or 24°) produced few or no pycnidia or conidia. (Richards, G. S., 1951).

Sphaeropsis malorum. Cultures on nutrient agar were incubated in a constant-temperature room at 24° C in continuous light, in continuous total darkness, and in 12-hour light-dark cycles under white, blue, green, yellow, and red light of known wave length. In continuous darkness and also in red light in the 12-hour cycle an isolate from apple produced full-sized, apparently mature pycnidia, but no conidia, while another isolate (from quince) produced only small immature pycnidia. Darkness favored the production of microconidia in both isolates. In continuous light in the 12-hour cycle (white or blue light) many pycnidia and conidia were formed in both isolates. Many pycnidia with few conidia were produced under green and yellow light in the 12-hour cycle. (Barnett, H. L., and V. G. Lilly, 1953).

Sphaeropsis malorum. The presence of light strongly favored spore formation in this fungus. (Mohendra, K. R., and M. Mitra, 1930).

Spondylocladium atrovirens. Germ tubes put out by the spores show no phototropic response if light is admitted from a single side but after a time mycelium developing from the spores grows away from the source of light. (Burke, O. D., 1938).

Spondylocladium atrovirens. Formation of the germ tube was not influenced by light, and no reaction to light was observed until the germ tube was a few millimeters long. Then, the tube turned away from the light and subsequent mycelial development occurred on the side of the conidia farthest from the source of light. (Schultz, E. S., 1916).

Stagonospora collapsa. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Stagonospora gigantea. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Stagonospora vitensis. Colonies grown for 15 days on oatmeal agar at 20° C in a light incubator (100 f. c.) produced many pycnidia, whereas parallel cultures in darkness produced only a few. (Cunnell, G. J., 1956).

Stemphylium floridanum. Cultures incubated in darkness produced few spores, while other cultures incubated in the laboratory with supplementary light from a 60-watt incandescent lamp at night showed abundant sporulation without zonation. Cultures growing at room temperature with a normal cycle of daylight illumination produced conidia in conspicuous zones. (Hannon, C. I., and G. F. Weber., 1955).

Stemphylium radicinum. The fungus was grown in darkness and a yellow pigment ( $C_{12}H_{12}O_5$ ) which crystallized in the medium under certain conditions was secreted. (Clarke, D. D., and F. F. Nord, 1953).

Stemphylium solani. Copious production of conidia was obtained when cultures were irradiated with ultra-violet light. Radiant energy of wave lengths 312-546 mμ was primarily involved in the stimulation of conidial formation. (Diener, V. L., 1955).

Stemphylium sp. The fungus was grown at 55° F for 1, 2, or 3 days in light or darkness. A yellow mat of mycelium without spores was produced in continuous darkness and a black mat of spores with a small growth of white mycelium was produced in continuous light. (Bjornsson, I. P., 1956).

Stemphylium sp. The fungus sporulates freely under fluorescent, mazda, or blue light but not under red or far-red (about 7000 Å and above) light or in darkness. (McClellan, W. D., H. A. Borthwick, I. Bjornsson, and B. H. Marshall, 1955).

Stemphylium trifolii. The fungus grows well on common laboratory media. It produces both conidia and sclerotial bodies when exposed to diffused light and primarily sclerotial bodies when kept in darkness. (Graham, J. H., 1957).

Sterigmatocystis nigra. Cultures on Raulin liquid medium were placed near a north window from which they received daylight through various colored filters (discontinuous light). Light had no perceptible influence on the development of conidia. Cultures in light and darkness were essentially the same. (Lendner, A., 1897).

Stigmina platani. Cultures were kept for a month in test tubes of different media in darkness at room temperature. No appreciable difference in growth was noted as compared with growth of cultures kept in diffuse light at room temperature. Few spores formed under either condition. (Apostolides, C. A., 1929).

Trichoderma lignorum. Cultures on nutrient agar were incubated in a constant-temperature room at 25° C in continuous light, in continuous total darkness, and in 12-hour light-dark cycles under white, blue, green, yellow, and red light of known wave length. Many conidia were produced in continuous light, and under white, blue, green, and yellow light in the 12-hour cycles. The effect of continuous total darkness was to delay the formation of conidia and reduce their number. Conidia formed slowly in red light under the 12-hour cycle. (Barnett, H. L., and V. G. Lilly, 1953).

Trichoderma lignorum. Cultures exposed to continuous artificial illumination for 3 days at 25° C showed a more or less even distribution of conidia. Cultures under the same temperature conditions but exposed to alternate light and darkness (12 hours each) produced rings of conidia. No conidia were produced in cultures incubated in continuous darkness. (Lilly, V. G., and H. L. Barnett, 1951).

Trichoderma lignorum. Few conidia developed in cultures grown in darkness but brief exposure to light from a 25-watt incandescent lamp caused profuse sporulation. Repeated experiments gave somewhat varying results, but on the average an exposure of about 1 minute to light of one candle-power intensity suffices to induce sporulation. The violet and blue wave lengths from a mercury lamp were much more effective than the green, but the yellow had no effect. Further experiments with incandescent lamps as light sources indicated that yellow and red were non-stimulating. (Miller, J. J., N. S. Webb, and J. Reid, 1952).

Trichoderma lignorum (ATCC # 8751). Spores were not produced in cultures kept in total darkness until the seventh day after inoculation. A series of cultures was grown in total darkness and then several cultures of the series were subjected to a single 18-hour light treatment (800 f.c.) on successive days after inoculation for a total of 7 days. No spores were produced in darkness. Cultures became sensitive to light on the third day after inoculation with maximum sporulation in cultures which were irradiated on the fourth day. Cultures given light treatment after the fourth day showed a gradually diminishing amount of sporulation. Those grown for 7 days and treated with an 18-hour photoperiod of 800, 400, 150, 60, or 10 f.c. showed a definite depression in mycelial growth. Maximum sporulation occurred at 400 and 150 f.c. Coloration of the medium increased as intensity decreased. A series of cultures was treated with light periods varying from 1 minute to 18 hours at intensities of 800, 400, 150, and 10 f.c. Spores were produced with 18 hours of light at all intensities. No spores were produced in any of the other light conditions. (Wishard, R. H., 1957).

Trichoderma sp. Sporulation but not growth was affected by light. The number of spores increased as a logarithmic function of intensity from 1 to 50 f.c. of white fluorescent light, with time (1 minute) constant. An action spectrum of sporulation showed that the most effective wave lengths were from 4300 to 4900 Å and the wave lengths beyond 5000 Å were ineffective. (Björnsson, I. P., 1956).

Trichoderma viride. Sporulation of five isolates was strongly stimulated by exposure to light from 40-watt daylight fluorescent lamps, while continuous darkness caused failure of or marked delay in spore formation. Light induced sporulation only during a definite stage in the development of the mycelium. (Gutter, Y., 1957).

Trichothecium roseum. Cultures were exposed to light from Schotts filters in a 12-hour darkness-12-hour light cycle. Zonation occurred at wave lengths between 562 m $\mu$  and 860 m $\mu$ . The light caused increased conidial production. Light sensitivity could be extended in the red by adding methylene blue to the culture medium. (Sagromsky, H., 1956).

Trichothecium roseum. Cultures all produced significantly larger spores when grown in darkness than when grown in light of approximately 120 f.c. (The light source was daylight fluorescent lamps). (Williams, C. N., 1959).

Vermicularia circinans. Pycnidia formed in both light and darkness. (Leonian, L. H., 1924).

Verticillium albo-atrum. The fungus formed zones not only in constant light but also in constant darkness. Zones appeared at a lower temperature than 25° C only when the Petri dishes were continuously lighted. For cultures on solid media in darkness, zonation is confined to a temperature of about 25°; there is no zonation at 24° or 26°. In light, however, such cultures show zonation at about 23°. (Chaudhuri, H., 1923).

Verticillium albo-atrum. The fungus sporulates freely under fluorescent, mazda, or blue light, but not under red or far-red (about 7000 Å and above) light or in darkness. Abundant microsclerotia are produced under red or far-red or in darkness. (McClellan, W. D., H. A. Borthwick, I. Bjornsson, and B. H. Marshall, Jr., 1955).

Verticillium albo-atrum. The fungus was cultured on Czapek's liquid medium and on nutrient agar. When it was exposed to daylight a pigment which imparted a pink coloration to the whole mycelium was produced. (Pegg, G. F., 1957).

Verticillium intertextum. Colonies grown for 10 days on Dox's solution and subjected to bright sunlight were orange-red in color, those incubated in darkness were white, and those continuously illuminated (60-watt bulb 18 inches from culture plates) were cream-colored. Pigment production ran parallel with increasing light intensity. (Isaac, I., and R. R. Davies, 1955).

Verticillium lateritium. Light, after a period of darkness, stimulated spore production, resulting in zonation in cultures exposed alternately to light and darkness. A noticeable increase in sporulation was produced by an artificial light source of 1500 lux used for a time interval as short as 10 seconds. Violet, blue, and blue-green light stimulated spore production, while colors at the red end of the spectrum did not. (Isaac, I., and G. H. Abraham, 1959).

Verticillium nubilum. Four strains were cultured on a wide variety of media. When they were grown in normal daylight marked zonations of the undersurface were observed as contrasted with the uniformly black undersurface when they were grown in darkness. (Isaac, I., 1953).

Verticillium sp. If the fungus is exposed to a 12-hour light-dark cycle distinct zonation occurs. Alternating areas of numerous and few conidiophores are produced. Growth is almost the same in light as in darkness, but in darkness zones with considerably more conidiophores (darker zones) are produced. Light does not influence mycelial growth, but it does limit the formation of conidiophores. Only wave lengths 350-530 m $\mu$  were effective. (Sagromsky, H., 1952b).

Verticillium tricorpus. The fungus was cultured on a wide variety of media. When it was grown in normal daylight marked zonations of the undersurface were observed as contrasted with the uniformly black undersurface when it was grown in darkness. (Isaac, I., 1953).

Volucrispora aurantiaca. Neither coloration nor rate of growth was noticeably affected by light. Cultures grown in complete darkness, normal daylight, and in continuous light showed no noticeable color or growth rate differences. (Haskins, R. H., 1959).



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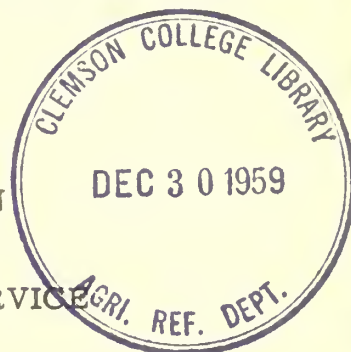


# THE PLANT DISEASE REPORTER

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CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE



UNITED STATES DEPARTMENT OF AGRICULTURE

THE EPIDEMIC OF BARLEY YELLOW DWARF  
ON OATS IN 1959

Supplement 262

December 15, 1959



The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.



MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch

Plant Industry Station, Beltsville, Maryland

Plant Disease Reporter  
Supplement 262

December 15, 1959

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H. C. Murphy<sup>1</sup>

## INTRODUCTION

In 1959, barley yellow dwarf (BYD) was the most destructive disease affecting oats in the United States. The losses incurred in certain portions of the heavy-oat-producing North Central Region were fully equal to those sustained during years when crown rust and Victoria blight were most destructive. Many oat fields in the heavily affected areas in Missouri, Kansas, Nebraska, South Dakota, Minnesota, Wisconsin, Iowa, Illinois, and Indiana were so severely damaged by BYD as to be not worth harvesting. Although record losses were sustained in certain areas, from a national standpoint the total loss to the oat crop was somewhat less than those suffered from the more widespread epiphytotics of Victoria blight and crown rust in years such as 1947 and 1953, respectively. More widespread epiphytotics of BYD in earlier years, such as 1949 and 1907, also doubtless resulted in greater total loss to the national oat crop than that of 1959.

In the heavily affected areas in the North Central Region, the greenbug appeared to be the principal vector of the barley yellow dwarf virus (BYDV). Although obvious damage from direct greenbug feeding was evident in restricted areas, the typical BYD symptoms and oat varietal reaction indicated that the major damage was caused by BYDV. W. F. Rochow, H. Jedlinski, and others recovered BYDV from many oat specimens collected in the heavily infected areas.

Many observations and reports indicated that oats were generally damaged more severely

than barley by BYD in 1959. The greater susceptibility of oats had not been generally observed in previous epiphytotics. The relatively later stage of development of the oat plants, and the possible differences in the species and strains of the aphid vector present, as well as in strains of the virus involved, might account for the heavier infection observed on oats.

Oat varieties and selections previously found to possess some degree of resistance to BYD by Suneson (1957)<sup>2</sup>, Endo and Brown (1957), Arny (1959), Endo (unpublished data), and Rochow (unpublished data) were consistent in being outstanding for moderate resistance at all locations in BYD epiphytotic areas where they were observed in 1959. Saia (*Avena strigosa*), C.I. 7010, and several other diploid strains were highly resistant to BYD at all locations. Among the named agronomic varieties observed

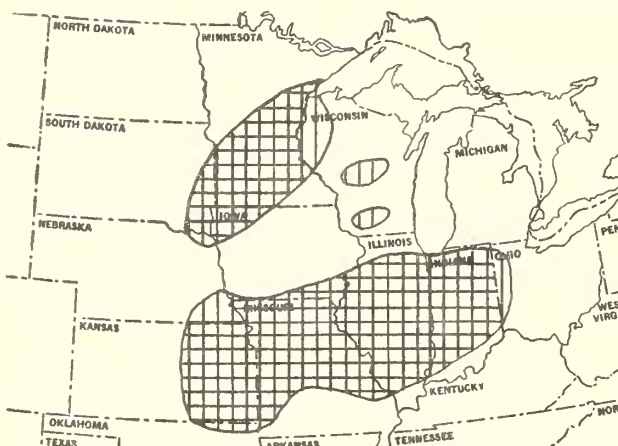


FIGURE 1 Areas of heavy BYD infection in the North Central Region in 1959.  
(See explanation in text)

by the author to be moderately resistant under epiphytotic conditions at several locations in the North Central Region in 1959 were the following: Albion, C.I. 729; Fulghum, 1915; Newton, 6642; Putnam, 6927; and Tonka (Early Clinton), 7192.

The map (Fig. 1) of the North Central Region shows the approximate areas of heavy BYD infection in 1959. It was prepared on the basis of information in this Supplement; additional information supplied by M. B. Moore, D. E. Western, and other oat workers; 1959 oat variety yield data published by Dreier (1959) and Pendleton and Scott (1959); and personal observations. Severity of infection varied considerably within the marked areas depending upon variety, date of seeding, fertility, and so forth; and varying amounts of BYD infection were present in much of the unmarked areas. The boundaries for the cross-hatched areas, which indicate uniformly heavy infection, were fairly definite, while the areas marked with perpendicular lines indicate spotted infection and lack of adequate observations to establish definite boundaries.

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<sup>2</sup> Literature references refer to bibliography given at the end of this Supplement.



NOTES ON THE EPIDEMIOLOGY OF BARLEY YELLOW  
DWARF VIRUS IN EASTERN ONTARIO IN 1959<sup>1</sup>

J. T. Slykhuis<sup>2</sup>, F. J. Zillinsky<sup>3</sup>, M. Young<sup>2</sup>, and W. R. Richards<sup>4</sup>

Summary

The isolation of barley yellow dwarf virus (BYDV) from overwintered winter wheat and winter rye, as well as from several species of perennial grasses, indicates that winter reservoirs of the virus are common in eastern Ontario.

Bird cherry oat aphids (*Rhopalosiphum padi* (L.)) that emerged on *Prunus padus*, growing at Ottawa, became infective only after they had fed on plants diseased with BYDV. The numbers of *R. padi* declined in early May before spring oat crops were planted and were seldom found on spring grains until late summer. *R. maidis* (Fitch.), the corn leaf aphid, became common on barley in June and July. The English grain aphid (*Macrosiphum avenae* (Fab.)) was observed on spring oats in mid-May before it was found on perennial grasses. The first BYDV infections in spring grains were associated with *M. avenae* and were scattered over the fields, indicating the vector was initially widely dispersed and had settled down only after prolonged flight. Oats caged in the field on May 20 and 27 remained aphid free, but when caged June 3 to 17, large populations of *M. avenae* developed, and their feeding reduced yields 40 to 90 percent below the yields of non-caged plants on which the numbers of aphids remained low. BYDV spread in the field from late May to late September, but the rate of spread was most rapid during late June and early July. By mid-July 1 to 5 percent of the plants in most oat fields showed yellow dwarf symptoms. Diseased plants usually occurred in small patches in which yields were reduced as much as 42 percent. The percentage of diseased plants in light stands was higher than in heavy stands of oats.

INTRODUCTION

During the summer of 1958 barley yellow dwarf virus (BYDV) and three aphid vectors, *Rhopalosiphum padi* (L.) (the bird cherry oat aphid), *R. maidis* (Fitch.) (the corn leaf aphid), and *Macrosiphum avenae* (Fab.) (= *granarium* (Kirby)) (the English grain aphid), were found to be common on spring grains in eastern Ontario (7). The disease was first observed in spring oats on June 20, and incidence of the disease increased as the season advanced. None of the vectors were noticed until late May. The first one observed was *R. padi*, which appeared to be the most important vector; but *M. avenae* and *R. maidis* also became common during the summer. There were variations in the incidence of disease in oats and barley planted in different locations, indicating that local sources of virus and vectors may be important in the inception and development of infections.

Results from further experiments and observations that indicate the local overwintering reservoirs of BYDV, the sources of vectors, and the relationship of vectors to the spread of the viruses in spring grains in 1959 are reported.

WINTER RESERVOIRS OF BYDV

In eastern Ontario a high proportion of the volunteer oats, barley and other annual grasses that are common in the fall are usually infected with BYDV and infested with aphids, but these plants do not survive the winter and are not important as reservoirs of infection of spring grains.

In May 1959 several plants of winter varieties of wheat, barley and oats sown the previous September at the Central Experimental Farm were found with yellow dwarf symptoms, and the virus was isolated from them with *M. avenae*. The virus was also transmitted from over-

<sup>1</sup>Joint contribution: Plant Research Institute Contribution No. 31; Genetics and Plant Breeding Research Institute Contribution No. 18; and the Entomology Research Institute, Canada Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Plant Research Institute.

<sup>3</sup>Genetics and Plant Breeding Research Institute.

<sup>4</sup>Entomology Research Institute.

wintered rye by *R. padi*. Limited acreages of winter wheat and rye are grown in eastern Ontario, but winter barley and oats are not grown except in small experimental plots.

Several workers have shown that many perennial grasses can be infected with BYDV (1, 3). Timothy and perennial ryegrass have been found naturally diseased in Europe (6, 8), and infected timothy has already been reported in Ontario (7). Further tests were conducted to determine if perennial grasses commonly harbor the virus over winter in the Ottawa area.

Samples of perennial grasses were collected to test for BYDV infection. Some plants in experimental nurseries were selected because they were stunted and chlorotic. Other plants were collected at random from lanes and fence rows. The collections were transplanted into pots and boxes to facilitate handling and identifying of the samples. For the transmission tests, succulent young leaves from plants were placed in beakers with moist sand or in test tubes with moist blotting paper. Non-viruliferous *R. padi*, *R. maidis* and *M. avenae* were fed on the leaves for 2 days, then transferred to Clintland oats test plants on which they fed for 2 days before being killed with a malathion spray. The test plants were placed in a greenhouse at about 20° C. Grasses that tested positive were retested to ascertain infection. BYDV was isolated from plants of the following species (Table 1): *Phleum pratense*, *Bromus inermis*, *Poa pratensis*, and *Festuca rubra*, which are common in the area, and also from *Lolium perenne*, *Agropyron intermedium*, and hybrids of *Triticum* x *A. intermedium*, which are grown only in experimental plots.

Table 1. Test for BYDV in perennial grasses collected in the vicinity of Ottawa. Clintland variety was used for the oat test plants.

Grass	: Samples diseased, of total tested	: Symptoms on oats induced by aphids after feeding on grasses		
		: <i>M. avenae</i>	: <i>R. padi</i>	: <i>R. maidis</i>
Agropyron intermedium	2/5	0	mild	0
		mod.	mod.	-
Bromus inermis	3/21	mild	mild	-
		mild	mild	-
		mod.	mild	-
Festuca rubra	1/4	mild	mild	mild
Lolium perenne	2/2	mod.	severe	mild
		mod.	severe	0
Phleum pratense	6/16	mod.	mod.	mod.
		mod.	mod.	mod.
		0	severe	0
		0	severe	0
		severe	severe	-
		mod.	severe	mild
Poa pratensis	1/16	-	severe	mod.
Triticum x Agropyron hybrid.	2/4	mod.	mild	-
		0	0	mild
Agropyron cristatum	0/3			
Agropyron obtusiusculum	0/1			
Agropyron repens	0/4			
Agrostis canina	0/2			
Agrostis palustris	0/1			
Alopecurus pratensis	0/2			
Arrhenatherum elatius	0/1			
Dactylis glomerata	0/1			
Deschampsia caespitosa	0/2			
Festuca arundinacea	0/1			
Festuca pratensis	0/1			
Phalaris arundinacea	0/2			

#### APHID INCIDENCE IN RELATION TO SPREAD OF BYDV

Since the above results indicate that naturally diseased perennial grasses provide continuing reservoirs of BYDV in eastern Ontario, the time and numbers of aphids moving from perennial grasses into young spring grain crops appear to be of great importance to the

annual initiation and subsequent development of the disease.

There is evidence that all three species of aphids known to be vectors of BYDV in the area can survive the winter in some form in eastern Ontario. R. padi overwinters as eggs on several native and introduced species of Prunus, including P. hortulana, P. nigra, P. padus, P. pensylvanica, P. virginiana, and P. virginiana var. demissa (4). Both R. maidis and M. avenae have sometimes been observed in early spring, presumably having overwintered on grasses in the area. In 1958 R. padi was the first aphid observed in spring oats and appeared to be the major vector of BYDV throughout the crop season. There were also indications that proximity of oats to Prunus padus, on which R. padi eggs overwintered, favoured a high rate of infection early in the summer (7).

Starting on April 13, 1959, inspections for the presence of aphids on known winter hosts and on wild and cultivated grasses were made two to three times weekly at nine locations near Ottawa. Regular inspections were also made to determine the earliest aphid infestations, and the first evidence of disease in spring-sown grains. Dates on which observations of particular interest were noted are as follows:

- April 13 -- Aphid eggs, but no aphids, on Sorbus spp., Crataegus spp., and Prunus spp., in the Arboretum at Ottawa.  
No evidence of aphids in winter grains or perennial grasses.  
Spring grains not yet sown.
- April 17 -- Rhopalosiphum padi found on Prunus padus.  
Aphids also present on Sorbus spp., and Crataegus spp.
- May 4 -- Aphids very scarce on Prunus padus, Coccinelidae very abundant.
- May 14 -- A few winged aphids, probably M. avenae, found on spring oats.
- May 26 -- Young, wingless as well as a few winged M. avenae were found in some plantings of spring oats which was now in the 2- to 3-leaf stage.
- May 29 -- English grain aphids found in spring wheat, and small numbers in most oat fields examined.
- June 5 -- Corn leaf aphids found in winter barley.
- June 9 -- Yellow dwarf symptoms well developed on scattered plants in a field of spring oats. M. avenae was the only aphid found on the oats.
- June 12 -- Rhopalosiphum padi found on spring oats.
- June 22 -- M. avenae caught in net sweepings of grass. Corn leaf aphids (R. maidis) common in barley.
- July 8 -- First observations of large numbers of R. padi in spring oats, but only in one location.

In April, when aphid eggs were hatching on Prunus padus trees in the Arboretum at Ottawa, several small branches were caged with 32 mesh per inch dacron cloth. This confined the aphids that emerged from eggs and developed on the branches. Some of these aphids were Rhopalosiphum padi. They were tested for infectivity on Clintland oats, but none proved infective until after they had fed on diseased oat plants. By May 4, aphids could be found only rarely on P. padus and other trees on which aphids had been abundant earlier, but Coccinelidae were very abundant and were probably responsible for reducing the aphid numbers. R. padi was not found in oats until June 12; this species was rare until late July, therefore it does not appear to have been important in spreading the virus to spring grains in 1959.

M. avenae was the first aphid species observed in spring grains. It was probably the species observed on May 14. It was definitely present in some oat fields on May 24 and wingless young were found on May 26. On June 9 well developed symptoms caused by BYDV were found in spring oats, along with M. avenae. Although this aphid was never abundant up to the end of July, it was the only aphid commonly found in oats. It appears to have been the primary vector of BYDV in oats in 1959.

R. maidis was not found in barley until June 5, and did not appear to be associated with a noticeable spread of BYDV.

#### INCIDENCE, DISTRIBUTION, AND EFFECTS OF BYDV IN SPRING GRAINS IN 1959

At weekly intervals during June and July estimates were made of the percentages of diseased plants occurring in plots of Clintland oats, Montcalm and York barley, and Selkirk wheat planted on May 8, in duplicated rod row plots at seven locations on the Central Experimental Farm. Up to June 24 only one plot contained more than 1 percent diseased plants. In this plot percentage infections in the different varieties were, 8 in Clintland, 4 in Montcalm, 2 in York and 0 in Selkirk. This plot was situated at the edge of a bare summer fallowed field. By



July 14 there were no striking differences between plots at different locations. The percentages of infected plants in different plots ranged from 5 to 15 for Clintland, 1 to 10 for Montcalm and York barley, and 2 to 7 for Selkirk wheat.

Between 1 and 5 percent of the plants in most oat fields showed yellow dwarf symptoms by mid-July. There were no examples to show that diseased plants were more abundant at the edges of the fields than in the fields, hence there was no indication that the vector had moved into the fields from adjacent sources. Instead, the initial infections were scattered widely over the fields. Local spread around the initial infections resulted in the development of small groups of diseased plants, and sometimes there were patches several feet in diameter in which up to 75 percent of the plants were diseased. Outside these small groups and patches, very few of the plants were diseased even as late as mid-July.

On July 14 when the plants in a field of 5055-13 oats were in the flowering stage and the symptoms of yellow dwarf were readily distinguishable, four areas containing 30 to 60 percent diseased plants were measured and staked out for harvesting. An area of identical size but with few or no diseased plants was similarly marked within 2 meters of each selected area of diseased plants. When the oats were mature it was harvested and the grain yields measured and compared (Table 2). The yields from the patches of severely diseased plants were 26 to 42.2 percent lower than the yields in adjacent areas which were more representative of the field as a whole. These data highlight the effect of the patchy distribution of the disease and indicate that if the disease had spread more rapidly after its inception into the field, severe yield losses would have resulted.

Table 2. Yield reductions caused by BYDV infections occurring in patches in an oat field.

Area number	:	Yield per 3 meters of row		:
	:	(in grams)		:
	:	Diseased	Normal plants	:
	:	patch	nearby	:
				Percent yield reduction caused by disease
1		119	206	42.2
2		146	204	28.5
3		137	185	26.0
4		128	202	36.6

#### EFFECTS OF DATE OF CAGING OATS IN THE FIELD

As an aid in determining the date at which vectors of BYDV entered an oat field, cages 1 meter square and 1 meter high, made of lumite saran screen on wooden frames, were set on Clintland oats in a field on eight different dates. The first cage was set out on May 20, the day after the oats were sown, and another was added each week until July 8. Although the oats were observed through the cages each week, the cages were not opened until July 14. At that time the oats were examined to determine the species and approximate numbers of aphids on the plants, and the numbers of plants with yellow dwarf symptoms (Table 3). No aphids of the species known to be vectors were found on the plants caged May 20 or May 27, but large numbers of *M. avenae* were found on the plants caged on June 3. This indicates that this species infested the oats in this field between May 27 and June 3. Successively smaller numbers of *M. avenae* were present on plants caged on each of the four dates following June 3, and no aphids were found on plants caged July 8 or on the oats not caged at all. Apparently the cages favored the multiplication of the aphids by excluding predators and by providing other favorable changes in environment. Even though aphid numbers were very high in some cages, there were only six plants with symptoms of yellow dwarf out of 250 in one cage, and five in another, but none were found in any of the others. In the non-caged oats in this field, about one plant per square meter was diseased.

Although the caging experiment just described was not replicated nor otherwise planned for measuring the effects of aphids on yields of oats, large differences seemed inevitable, hence yields were measured (Table 3). The plants from which aphids were excluded by cages set out on May 20 and May 27 produced the highest yields. It is not assumed that the exclusion of aphids was the main reason for increased yields of these plants over yields of the non-caged oats. The weather was hot and dry in early summer, and the plants sheltered by the cages suffered less acutely from drouth, and grew more vigorously. The most striking feature of the results was the inverse correlations between the grain yields and aphid numbers on

Table 3. Effect of date of caging on aphid populations and BYDV infections on Clintland oats.

Date caged	Observations on July 14		Grain yield (grams/square meter)
	Number of diseased plants	Estimated numbers of aphids	
May 20 <sup>a</sup>	0 <sup>b</sup>	0	136
May 27	0	1 per plant, species undetermined	148
June 3	6	300 per culm, <u>M. avenae</u>	9
June 10	0	250 per culm, <u>M. avenae</u>	15
June 17	0	100 per culm, <u>M. avenae</u>	57
June 24	0	several per culm, <u>M. avenae</u>	114
July 1	5	several per culm, <u>M. avenae</u>	98
July 8	0	rare	92
not caged	1	rare	95
not caged	1	rare	100

<sup>a</sup>Oats seeded May 19.<sup>b</sup>Diseased plants out of approximately 250 in each cage.

the plants in different cages. The extremely heavy populations of M. avenae caused severe reductions in yield, even when there was little or no evidence of virus.

#### DATE OF SEEDING IN RELATION TO INFECTION IN OATS

To indicate the rate of virus transmission in the field during the summer and fall, Clintland and Garry oats were sown in duplicated rod row plots at intervals of 2 or 4 weeks from May 1 to September 15. There were about 100 plants in each row. The diseased plants were counted 6 to 8 weeks after seeding, when the maximum numbers showed recognizable symptoms. In the May 1 planting 14 percent of the plants developed disease symptoms. This was comparable to the highest disease counts obtained in other observation plots mentioned before, but higher than the average infection observed in any field of oats in 1959. In the May 15 and June 1 plantings 18 and 21 percent became infected. The highest infection, 29 percent, occurred in the June 15 planting, indicating that the virus spread rapidly in these plots in late June and early July. The low infection, 5 percent, that developed in the July 15 planting indicated a low rate of spread in late July and early August, but an increase in transmission rate was indicated for late August and early September by a 21 percent disease count in the August 15 planting. In the plots sown September 15, yellow dwarf symptoms were observed on one plant before mid-October, when severe frosts damaged the leaves.

#### PLANT SPACING IN RELATION TO INCIDENCE OF DISEASE

Two susceptible strains of oats, 5055-46 and 4832-3-1-1, were sown in rows 10 feet long and 1 foot apart. The rows were seeded at different rates, with replicates of each rate randomized throughout the planting area. On July 14, 2 months after seeding, counts were made of the numbers of plants per row and the numbers of plants with yellow dwarf symptoms. The two strains of oats were indistinguishable in susceptibility, hence the data for the two are combined in Table 4. Although the incidence of disease in the area of these plots was lower

Table 4. Relationship of plant spacing to incidence of yellow dwarf symptoms in oats.

Number of plants per row	Number of rows	Total number of diseased plants	Number of diseased plants/row	Percent of plants diseased
100	7	8	1.1	1.1
25-50	12	7	0.6	1.9
15-20	8	8	1.0	5.5
10-14	10	12	1.2	11.0
5-9	10	9	0.9	15.5
1-4	14	6	0.4	15.8

than in some nearby fields, the diseased plants appeared to be uniformly distributed throughout the plots. The number of diseased plants per row was remarkably constant, averaging about 1 per row, therefore the percentage of diseased plants was lowest in the rows with the largest numbers of plants.

#### DISCUSSION

In 1958 *R. padi* was the most common and probably the most important vector of BYDV in eastern Ontario. There was evidence that local overwintering sources of these aphids contributed to disease development. In 1959 *R. padi* were observed in April on *Prunus* spp., but they were exceedingly scarce during June and early July, the most critical period for infection of spring grains. Instead, *M. avenae* was common and, although not abundant, it appeared to be the most important vector. At least in some years the English grain aphid has been the most important vector of BYDV in New York (5).

Despite careful searching during the spring, *M. avenae* was not found on perennial grasses until after it had been observed on spring grains. It remains uncertain whether the initial infections in spring grains originated from vectors that acquired the virus from local perennial grasses that harbor BYDV, or from vectors that migrated from considerable distances. The widespread distribution of initial infections does not suggest that the vector moved into spring grains from adjacent or nearby sources, but instead that the vectors had arrived from a distance, or at least that they became widely dispersed before they landed on the spring grains.

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CANADA DEPARTMENT OF AGRICULTURE



OBSERVATIONS ON THE BARLEY YELLOW DWARF VIRUS DISEASE  
OF OATS IN FLORIDA

H. H. Luke, W. H. Chapman, and P. L. Pfahler<sup>1</sup>

The barley yellow dwarf virus disease of oats has been present in Florida for more than 20 years. Experiment Station records and observations over the past decade indicate that this disease is present, to some degree, each year during the oat-growing season. However, in 1949, 1956, and 1959 the disease was widespread in the northwestern part of the State, but was not prevalent east of the Suwannee River during the past decade. This difference may result from the fact that strains of the virus in the eastern area are not readily transmitted by the endemic species of aphid.

The winter of 1958-1959 was mild, and aphid infestations were heavy during the fall and at various periods during the winter. Therefore, early infection occurred and yellow dwarf symptoms were observed during the first week of March at Gainesville and 2 weeks later at Quincy. Infection spread rapidly and the disease was very prevalent at the North Florida Experiment Station by April 14. Even though 80 percent of the nursery exhibited signs of infection, no distinct sources of resistance were observed. The disease, however, was more prevalent and severe on Camellia and the Red Rustproof types than on some of the earlier maturing varieties, obviously because the late types were exposed to infection longer than the early maturing varieties. It was estimated that the yield of certain late maturing varieties was reduced 5 to 10 percent in the Quincy area.

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BARLEY YELLOW DWARF VIRUS AT TIFTON, GEORGIA IN 1958-59Darrell D. Morey<sup>1</sup>

Barley yellow dwarf virus caused widespread damage on oats in the Tifton, Georgia nursery in 1959. Plants in rather large areas in fields of Radar 2 oats were severely stunted (rosetted) and grain yields were lower. Barley yellow dwarf virus was isolated by W. F. Rochow from C.I.<sup>2</sup> 7172 and Radar 2 oats collected at Tifton on April 27, 1959. Rochow stated, "The strain in your area appears to be similar to that in many parts of the east in that it was transmitted only by English grain aphids."

Clear-cut resistance to barley yellow dwarf virus was not noticed, but varieties such as Red Rustproof types, C.I. 7171, C.I. 7172, and Radar 2, seemed very susceptible. Over 2000 F<sub>2</sub> head rows of spaced oat plants were practically ruined by the disease. A few single-plant selections were saved, but they may have escaped infection. Barley yellow dwarf virus was more severe on spaced plants and on plants at the ends of rows.

Oats (3318 entries) in the world collection have been planted at Tifton in the hope that these lines from many sources can be evaluated for susceptibility to barley yellow dwarf virus in 1960. About 140 lines from F. A. Coffman are being grown also because they appeared resistant to barley yellow dwarf virus at Aberdeen, Idaho in the summer of 1959.

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BARLEY YELLOW DWARF IN IDAHO IN 1959Frank C. Petr and Harland Stevens<sup>1</sup>

Plants with symptoms now known to be typical of barley yellow dwarf virus have been observed in experimental and commercial plantings in Idaho for a number of years. The percentage of diseased plants was small and the losses were not of consequence in commercial plantings before 1958. In recent years there has appeared to be a gradual build-up of the disease in Idaho. In 1957 it was necessary to spray some late-planted experimental plots of barley and oats to protect against direct aphid damage and possible virus infection. In 1958 diseased plants appeared in greater frequency in late-planted experimental plots and extension agents and farmers reported greater disease incidence in several agricultural areas of the State. Reduction in quality of some early-planted barley and nearly complete loss of some late-planted fields were observed.

Reports and observations in 1959 indicate widespread distribution of the barley yellow dwarf virus. Damage to commercial fields in southern Idaho was apparent for the first time during the 1959 season, although damage to commercial plantings in northern Idaho was reported in 1958. In both instances, symptoms of and apparent damage from the disease were more evident under conditions of below optimum moisture or above normal temperatures.

In 1959 incidence of the disease in experimental plots at Aberdeen appeared to be proportionately greater on oats than on other grains as compared with previous years. This might indicate a possible shift in the aphid species.

The increased incidence of barley yellow dwarf may possibly be attributed to higher minimum and maximum mean monthly temperatures during most of the spring and early summer in both 1958 and 1959. Under dryland conditions, higher temperatures, coupled with below optimum moisture, resulted in more observable damage, especially blast and sterility of infected tillers of oats and barley. Symptoms similar to those reported by other workers were observed at Aberdeen in 1959. These included the water-soaked areas prior to yellowing, the blackening of tissue at leaf tips, and the premature dying of severely infected plants.

In 1959 certain varieties observed in experimental plots were noticeably more susceptible than others. A late-planted field of Bonneville was plowed under because of almost complete infection of the plants. Craigs-after-lea (C.I. 7026)<sup>2</sup> and some hybrids derived from it were especially susceptible. Black Mesdag appeared to be completely susceptible, while a derived tetraploid, C.I. 7232, was resistant. Progeny of an apparent cross between these showed segregation for resistance and susceptibility<sup>3</sup>. Both Bonneville barley and Craigs-after-lea oats produce abundant foliage. Earlier work at the University of California indicated that some varieties with heavy foliage produce unusually large aphid populations, resulting in a higher incidence of plants infected with yellow dwarf virus.

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<sup>3</sup>Observation made by F. A. Coffman.



BARLEY YELLOW DWARF VIRUS ON OATS IN ILLINOIS IN 1959<sup>1</sup>H. Jedlinski and C. M. Brown<sup>2</sup>Summary

The occurrence of barley yellow dwarf on oats in 1959 in Illinois is described. The potential of this disease, which in most years has been considered of only minor importance, was evident in 1959. The reaction and performance of some oat varieties and selections during an epiphytotic year are also reported.

The 1959 Illinois oat crop was severely damaged by a barley yellow dwarf (BYD) epiphytotic. The performance of several oat varieties in advanced nurseries (Table 1 and Table 2) exemplifies the damage sustained in different parts of the State. West-central and central parts of the State appeared to be most severely affected. Many fields were replanted to other crops and many others were not harvested. Similar conditions prevailed in localized areas in east-central Illinois. The damage in the very southern and northern parts of Illinois was much less severe. Generally the damage in these two areas occurred in scattered patches and along the margins of the fields. Throughout Illinois, oats planted on fields of low fertility or those planted late suffered more damage. Oats following soybeans were superior to those following corn where no fertilizer was applied.

## IDENTIFICATION OF BYDV INFECTIONS

The barley yellow dwarf virus (BYDV) infection was largely characterized by various degrees of stunting, chlorosis, reddening of the leaves, and necrosis. Many plants failed to develop panicles, and blasting of kernels in various degrees was also fairly prevalent. Close examination of individual plants in the fields suggested strongly that these symptoms were identical with those described for BYD (7, 8, 11, 17, 18). Precise identification of this disease in the field is frequently difficult (7, 15, 17). The symptoms most commonly associated with the disease may also be induced by a number of different factors (5, 6). Therefore, positive identification should be supported by transmission studies.

From the middle of May until the end of July, field samples of what was considered to be BYDV-infected plants were collected in various parts of Illinois. Care was exercised to keep the samples in isolation in order to prevent contamination with aphids naturally occurring on the plants. The collected plants were transplanted to 4-inch pots and covered with insect-proof cages, previously described by Takeshita (Endo) (17). After 1 week the plants were examined for the presence of aphids. In the absence of natural colonies, non-viruliferous *Rhopalosiphum padi* (L.) were introduced for a 2-day acquisition feeding. Aphids were then transferred onto healthy Clintland oat seedlings, in the two-leaf stage at the rate of five per plant and allowed to feed for 3 days. After killing the aphids with a 0.1 percent malathion spray, the caged plants were incubated in the greenhouse. Two weeks later the indicator plants were examined for positive transmission. The results reported in Table 3 definitely show that the symptoms observed in the field were induced by BYDV infection. Existence of vector specific strains, as reported by Rochow (12, 13), and Slykhuis et al. (14), could explain the inability of the aphid species tested to transmit the virus from some diseased plants.

The yellow dwarf epiphytotic observed in Illinois was associated with large numbers of *Toxoptera graminum* (Rond.) which appeared toward the end of April and in some areas built up to large populations. Very likely there was some aphid feeding damage in some areas. Fields, however, that were sprayed with insecticides to control the greenbug did not escape heavy infection by BYDV. At the Urbana Agricultural Experiment Station the BYD oat nursery

<sup>1</sup> Joint contribution of Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Departments of Plant Pathology and Agronomy, Illinois Agricultural Experiment Station, Urbana.

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Identification of the *Rhopalosiphum padi* (L.) by H. L. C. Stroyan and M. A. Watson is gratefully acknowledged. Indebtedness is expressed to Dr. W. C. Jacobs for kind assistance in the statistical analysis.

Table 1. Yield, test weight, and percent of yellow dwarf infection of 14 oat varieties grown at several locations in Illinois in 1959a.

Variety	LOCATION											
	Brownstown (Southern Ill.)			Hartsburg (West-Central Ill.)			Urbana (East-Central Ill.)			Oneida (W North-Central Ill.)		
	Yield Bu./A	Test Wt. Lbs./Bu.	BYD Infection %	Yield Bu./A	Test Wt. Lbs./Bu.	BYD Infection %	Yield Bu./A	Test Wt. Lbs./Bu.	BYD Infection %	Yield Bu./A	Test Wt. Lbs./Bu.	BYD Infection %
Newton	72	37	5	31	30	43	84	40	10	94	36	10
Putnam	52	31	8	40	31	23	73	38	16	80	37	10
Tonka	69	38	5	28	33	63	84	42	14	74	37	10
Mo. O-205	58	33	10	26	29	57	67	35	24	86	35	10
Minhafer	61	33	9	24	27	67	63	35	29	76	32	10
Goodfield	51	35	13	17	31	70	53	39	38	67	35	10
Clarion	63	34	8	22	29	83	61	37	39	73	33	10
Nemaha	53	33	14	21	26	77	50	34	43	60	34	10
Fayette	47	26	26	30	26	70	40	30	50	54	28	17
Nehawka	56	33	14	15	25	80	61	34	50	76	32	17
Clinton	50	34	18	9	24	90	43	34	55	60	32	23
Clinton 60	57	31	23	8	24	93	34	33	67	56	31	17
Minton	59	30	19	11	24	97	34	29	78	72	28	13
Clintonland	50	32	29	4	24	100	30	33	79	66	32	10
												15

a Each figure represents averages of three replications at Hartsburg and Oneida and four at the remaining locations. Estimate of infection was based on percent of plants with visible yellow dwarf symptoms after heading time.

Table 2. Summary and results of analysis of covariance on yield, test weight, and percent of yellow dwarf infection of 14 oat varieties grown at several locations in Illinois in 1959.

Variety	AVERAGE ALL LOCATIONS				
	Yield	Adjusted Yield <sup>a</sup>	Test Wt.	Adjusted Test Wt.	BYD Infection %
	Bu./A	Bu./A	Lbs./Bu.	Lbs./Bu.	
Newton	80.2 a <sup>b</sup>	72.2 a	36.5 a b	35.8 a b	13.3 a
Putnam	66.5 c	58.6 c d e	35.0 a b c	34.3 a b	13.6 a
Tonka	73.8 a b	68.1 a b	38.2 a	37.7 a	18.1 a
Mo. 0-205	67.9 b	63.1 b c	33.5 a b c	33.0 b c	20.0 a b
Minhafer	66.5 c	63.0 b c	32.6 a b c d	32.7 b c	22.5 a b
Goodfield	60.7 c d	59.8 c d	35.8 a b c	35.8 a b	28.1 b c d
Clarion	61.5 c d	60.9 c d	33.6 a b c	33.5 a b	28.6 b c d
Nemaha	50.7 e	51.0 f	32.1 b c d	32.1 b c	30.6 c d e
Fayette	51.1 e	53.2 e f	28.6 d	28.8 c	34.4 d e f
Nehawka	58.5 d e	60.7 c d	31.7 b c d	31.9 b c	34.4 d e f
Clinton	47.1 e	51.3 f	31.5 b c d	31.9 b c	38.6 e f g
Clintonland 60	45.0 e	51.6 f	30.3 c d	30.9 b c	43.6 f g
Minton	48.4 e	56.1 d e f	27.5 d	28.2 c	45.8 g
Clintonland	45.2 e	53.5 e f	30.9 c d	31.6 b c	47.2 g

<sup>a</sup> Adjusted to the BYD mean 29.9 percent.

<sup>b</sup> Means associated with one or more of the same letters are not significantly different at the 5 percent level; based on Duncan's Multiple Range Test.

Statistics:  $b = -.4829^{**}$

$r = -.6317^{**}$  when  $Y =$  yield and  $X = B, Y, D.$

$b = -.0428^{**}$

$r = -.4138^{**}$  when  $Y =$  test weight and  $X = B, Y, D.$

<sup>\*\*</sup> Significant at 1 percent level.



Table 3. Summary of transmission studies with BYDV from field samples in 1959.

Number of sample	Origin of sample	Plant source	Vector source		
			Non-viruliferous		
			Field sample	greenhouse culture <sup>a</sup>	
			T. graminum	R. padi	of R. padi
1	South-Central Illinois (Brownstown area)	Oat	2/4 <sup>b</sup>	5/5	16/18
2	West-Central Illinois (Hartsburg area)	Oat	3/6	4/4	10/10
3	W North-Central Illinois (Oneida area)	Oat	0/0	0/0	10/12
4	North-East Illinois (DeKalb area)	Oat	0/0	0/0	14/15
5	East-Central Illinois (Champaign-Urbana area)	Oat	10/15	6/10	21/24
		Wheat	0/0	0/0	11/12 and 10/15

<sup>a</sup> Non-viruliferous aphids were tested as checks. In no case did symptoms of BYD develop on Clintland oat plants used as indicators.

<sup>b</sup> Numerator indicates number of samples from which BYDV was recovered and denominator the number of sample plants tested for the virus.

Table 4. Performance of several BYD resistant and susceptible varieties of oats and selections involving their crosses grown at Urbana in 1959.

Variety or cross <sup>a</sup>	Number of rep- lications	Number of se- lections <sup>b</sup>	Yield per acre (in bushels)	Test weight per bushel (in pounds)	Percent BYD infection <sup>c</sup>	Average	Range
Albion	6		69	64-73	32	31-33	12 10-15
Newton	6		79	72-87	39	38-39	15 5-25
Fayette	6		50	38-64	31	29-32	36 25-50
Clarion	4		61	49-70	37	36-37	39 25-55
Clintland	6		55	40-71	34	32-35	51 25-75
Albion x Fayette	1	14	80	67-96	31	29-33	8 5-20
Albion x Clarion	1	24	73	58-88	31	27-34	10 5-15
Albion x Newton	1	4	71	66-77	35	34-36	13 10-15
Fulghum x Newton	1	10	78	66-98	35	32-37	10 10-15
Fulghum x Clintland	1	4	76	60-84	35	32-38	10 5-15
(Cherokee x Ark. 674)							
x							
Newton	1	7	80	59-91	33	26-37	9 5-15
(Cherokee x Ark. 674)							
x							
Fayette	1	5	78	67-90	33	31-37	13 5-25

<sup>a</sup> The varieties Albion and Fulghum are classed as moderately resistant and Newton and Cherokee x Ark. 674 moderately susceptible to BYD. All other varieties are susceptible.

<sup>b</sup> Number of selections replicated once each.

<sup>c</sup> Estimate of infection was based on percent of plants with visible yellow dwarf symptoms.

was periodically sprayed with approximately 0.1 percent malathion. The population of greenbugs was greatly reduced, and consequently the feeding damage, as judged by the decreased number of reddish-brown feeding spots. Yet the prevalence of BYD was essentially the same as in unsprayed parts of the field. No other diseases were observed to be present in damaging amounts.

#### RESULTS FROM ARTIFICIAL FIELD INOCULATIONS

A section of experimental one-row plots with four hills in each row planted to different varieties and selections is shown in Figure 1, A, B. The first hill in each row was artificially inoculated with BYDV by means of viruliferous *R. padi* and the other three were left as unin-



FIGURE 1. Reaction of some oat varieties to barley yellow dwarf virus infection. A -- From left to right, 4-hill, one-row plots of Albion, Clintland, Fayette, Newton, Albion x Clarion, Albion x Fayette. In the background, additional crosses with Albion as one of the parents. B -- Close view of the same picture showing the reaction of Clintland.

oculated checks. Little difference could be seen between the inoculated and uninoculated hills. This lack of difference was attributed to the rather early natural infection by BYDV, which was very prevalent in the field. There was, however, a striking difference between the rows as illustrated from left to right: moderately resistant Albion, susceptible Clintland and Fayette, moderately susceptible Newton, and two advanced generations of crosses involving the susceptible and moderately resistant parents Clarion, Fayette, and Albion. A closer view of the highly susceptible variety Clintland is shown in Figure 1, B. Similar reactions of these varieties were observed in previous years by Endo (3) and Endo and Brown<sup>3</sup> (4).

<sup>3</sup> Unpublished data obtained by R. M. Endo and C. M. Brown.



## REACTION OF OAT VARIETIES TO NATURAL INFECTION

Although no resistance to BYD was observed in commonly grown oat varieties when they were artificially inoculated in the greenhouse or in the field<sup>3</sup>, some differences were noted in their performance in 1959. Yields, test weights, and percent BYD infection of 14 oat varieties grown at several locations in Illinois in 1959 are shown in Table 1. A summary of the data averaged over all locations along with the analysis of covariance is presented in Table 2. The data clearly show that BYD was a major factor influencing yield at the several locations. Highly significant negative correlations of .6317 and .4138 were obtained between BYD and yield and test weight, respectively, when the random correlation was computed from the analysis of covariance. This indicates that approximately 39 percent of the random variation in yields and approximately 17 percent of the random variation in test weights were accounted for by BYD infection. When correlation coefficients were computed for all observations over all locations the values increased to .8221 and .5930 for yield and test weight, respectively. Likewise, when only variety means were considered, the correlation coefficients increased to .9261 and .8081 for yield and test weight, respectively. Although the over-all correlations between BYD and yield and test weight were very high, the analysis of covariance shows that much of the random variation in yield and test weight was not accounted for by BYD infection as measured by the observations recorded in the tests. Obviously some of this variation was accounted for by normal differences that occur among varieties; however, other factors that could not be accurately differentiated, such as time of infection, differences in virulence of the virus strains, preferential feeding of vectors, could have also contributed to some of the variation in yield and test weight.

Some varieties were damaged more than others. Putnam, Newton, and Tonka (Early Clinton) were observed to be affected less than Clintland 60, Clinton, Clintland, and Minton. Generally, varieties with high BYD infection produced lower yields of grain with somewhat lower test weights. The data show also that BYD damage was much greater at some locations than at others, with west-central Illinois being extremely severe.

## BREEDING FOR RESISTANCE TO BYDV

A breeding program designed to produce BYD resistant varieties has been in operation at Illinois for several years. The performance of certain selections that originated from this program might be of special interest to oat workers. Yields, test weights, and percent of BYDV infection of several varieties moderately resistant and susceptible to BYD and selections involving their crosses are shown in Table 4. These selections now in the fifth or sixth generation were made only on the basis of BYD resistance as obtained from artificial greenhouse and field inoculations<sup>3</sup>. It is interesting that most of them performed very well under a rather heavy epiphytotic of BYD at Urbana in 1959, even though they had not been selected for yield or agronomic desirability. For example, the average yield of 14 selections from the cross Albion x Fayette was 80 bushels per acre with a range of 67 to 96, while the average yield of Albion was 69 bushels and of Fayette 50. These data would indicate that susceptible Fayette combined well with moderately resistant Albion to produce selections, many of which performed better than either parent. Many of these selections are of relatively poor agronomic type with little resistance to crown and stem rusts. However, neither rust was a factor influencing yield of oats in Illinois in 1959. It should be emphasized, however, that the true nature of resistance to BYD in oats is not well understood and that the performance of different selections could have also been influenced by factors such as preferential colonization and feeding by vectors, different time of infection, escape, and secondary infections by soil pathogens, as well as by variability in naturally occurring strains of the BYDV.

## DISCUSSION

Barley yellow dwarf, first described as an aphid-transmitted virus disease by Oswald and Houston in 1951, has since received increased attention and worldwide distribution (1, 2, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17). The potential of this disease, which in previous years has been considered of only minor importance, was recognized in 1959 in Illinois. The development of resistant varieties appears to be quite promising for BYD control. It should be emphasized, however, that further study of different strains varying in virulence and vector specificity as well as of the vectors and their preferential feeding on the hosts is needed for a full understanding of the epidemiology and practical means of control. Furthermore, the effect of BYD as a predisposing factor to other diseases, especially to root rots, should be explored.



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## YELLOW DWARF INFECTION ON OATS AND WHEAT IN INDIANA IN 1959

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Oats in 1959 suffered the most severe attack from the barley yellow dwarf virus yet recorded in Indiana. Damage ranged from little in early sown fields to complete destruction in many later sown fields. Until approximately June 1, oats gave promise of record or near record yields, as they did in 1958 when the State average was 51 bushels per acre. However, the September 1, 1959 estimate of yield by R. E. Straszheim, State-Federal Agricultural Statistician, was only 37 bushels per acre. Moisture was near marginal in some parts of the State for maximum yields, yet at Lafayette, in the driest area of the State, yields commonly exceeded 100 bushels per acre in experimental plots protected from yellow dwarf infection by means of aphid control. Moisture limitation is therefore ruled out as a major factor in yield reduction, except as it may have interacted with yellow dwarf in suppressing plant vigor. In the absence of any other significant disease outbreak or deleterious environmental factor, it is believed that the yield reduction of 1959 may be charged almost entirely to the yellow dwarf disease. On the basis of a potential yield of 51 bushels per acre, as in 1958, the 37 bushel yield of 1959 represents a yellow dwarf loss of 27.5 percent of the oat crop.

Primary infection occurred early and abundantly, resulting in severely stunted plants, and apparently was followed by extensive secondary spread over a period of at least 2 weeks. Both early and later infected plants displayed the characteristic intergrading red to yellow foliage coloration characteristic of the disease.

Other years of serious outbreak have been observed previously, notably 1949, when the disease developed later and resulted in only slight stunting but prevented development of the normal bright yellow straw color. Observation near maturity by oat producers of areas of such off-color straw resulted in the popular designation of the disease as "gray spot." In these spots there was much blasting of florets and the kernels that developed were small and low in test weight. In contrast to this, growers in 1959 were immediately aware of the stunted and brilliantly colored plants at the early shooting stage. Most of the early infected plants failed to head and those heads produced probably averaged not over 18 inches in height. Many severely infected fields were not harvested.

The possibility of comparison of varieties and lines of spring oats in the breeding and test nurseries for resistance or tolerance to BYDV was excluded by the very effective control of spread of the virus with Dimethoate insecticidal sprays. However, in unsprayed and comparable drilled plots of a number of back-cross derivatives of each of the varieties Clintland and Putnam, an excellent comparison was available. The Clintland derivatives were severely injured by yellow dwarf and a large proportion of the tillers were greatly stunted. In contrast, plots of the Putnam derivatives developed vigorously and produced well. Although conspicuous symptoms occurred on some tillers of the Putnam derivatives, it was clear that the visibly affected tillers were fewer and the symptoms generally milder than in the adjacent derivatives of Clintland.

Winter wheat also showed extensive symptoms characteristic of infection with barley yellow dwarf virus. Such symptoms have been observed rather extensively in previous years, but have never approached the abundance displayed in 1959. The chief symptom was the intergrading foliage color from bright red to yellow. Stunting was not obvious, nor was damage apparent. Varieties that normally produce reddish colored straw and sheaths showed the symptoms most strikingly. Flag leaves of such varieties as LaPorte developed brilliant red color in the flag leaves. Many fields were observed in which nearly 100 percent of the plants displayed symptoms. Yellow strawed varieties showed mainly yellow or pinkish-yellow flag leaf colors.

Experiments attempting to transfer the virus to oat seedlings were not successful; however the results are of little value owing to high greenhouse temperatures encountered. Transfers from field infected oats to oat seedlings were also negative. It is tentatively assumed that a high percentage of winter wheat as well as oats was infected with BYDV in 1959.

The average wheat yield for the State as of August 1 has been estimated by the Federal-State agricultural statisticians at 26.0 bushels per acre as compared with a record 32.0 bushels per acre in 1958 and an average of 24.8 bushels per acre for the 10-year period 1948 to 1957. In view of reduced wheat stands resulting from winter injury in 1958-59, it appears that 26.0 bushels per acre represents a relatively high yield for this year. Therefore it follows that yellow dwarf may have caused little yield reduction in wheat despite a presumed high level of infection.

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PROTECTION OF OATS AGAINST TRANSMISSION OF BARLEY YELLOW DWARF VIRUS  
THROUGH CONTROL OF APHIDS WITH DIMETHOATE<sup>1</sup>

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The yellow dwarf (red leaf) disease of oats, caused by the barley yellow dwarf virus, was observed at a relatively early date (May 13) in the spring oat experimental plots at Lafayette, Indiana, in 1959. At this time unusually heavy populations of the English grain aphid (*Macrosiphum granarium* (Kby.)) and the greenbug (*Toxoptera graminum* (Rond.)) were also found. An attempt was therefore made to control the aphid populations in an effort to prevent disastrous further spread of the disease by these vectors.

The oat foliage on the experimental plots was sprayed on May 20 with a systemic insecticide, Dimethoate (0, 0-dimethyl S(N-methylcarbamoyl-methyl) phosphorodithioate), at the rate of 2/3 pint (containing 46 percent soluble concentrate) in 15 gallons of water per acre at 80 pounds' pressure. The spray was applied with a tractor mounted sprayer. This application produced no obvious damage to the host. In examinations made almost daily, beginning on the first day after spraying, no living aphids were found. This freedom from aphids was maintained for at least 2 weeks and until the population of aphids became greatly reduced naturally on nearby unsprayed oats. There was no apparent subsequent build-up of aphid populations in the sprayed plots, although routine detailed examinations were not continued after 2 weeks.

The sprayed plots contained oat experiments seeded at an early, a medium, and a late date of seeding. The entire nursery was sprayed in the interest of the original experimental plan, thus providing no check on the effect of the spray on yields. However, "filler" oats of the Clintland variety seeded around the experimental plots were not sprayed except where the sprayer was turned around at the ends of the plots. These filler oats, seeded at the time of the latest experimental planting on May 1, provided an excellent check on the development of the disease in comparison with the several varieties seeded in four replications at the latest date of seeding (Fig. 1).

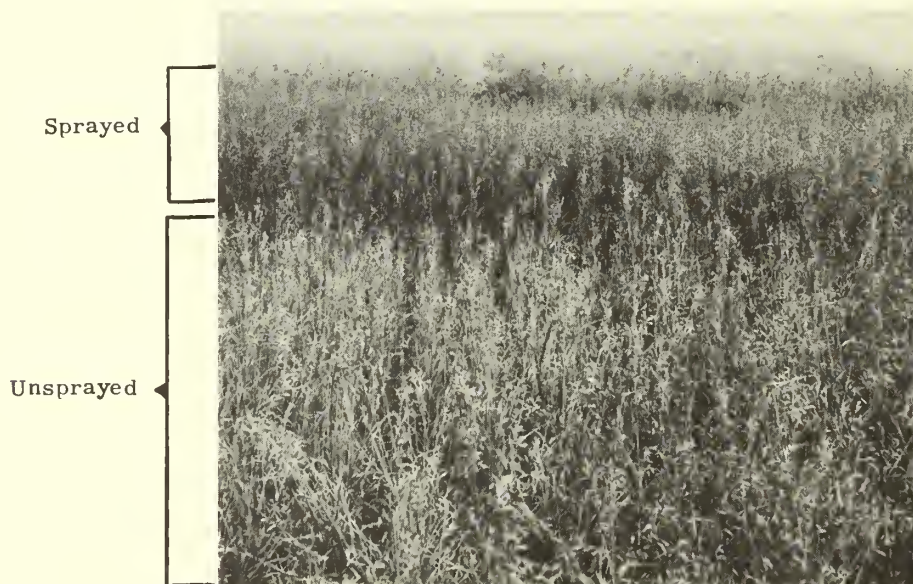


FIGURE 1. Control of transmission of the barley yellow dwarf virus in oats by a single spray of a systemic insecticide, Dimethoate. Foreground shows diseased plants in the unsprayed area; background shows normal plants, sprayed 20 days after seeding. Taller plants in rear were seeded earlier and also sprayed.

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The yellow dwarf disease was devastating to late seeded Clintland oats over areas of several acres. The plants were 100 percent infected, greatly stunted, and most tillers failed to produce fruiting panicles. The better panicles produced were not over 18 inches high. The crop was a total loss and was not harvested. In contrast, the adjacent sprayed plots seeded at the same time produced nearly normal stands of fruiting tillers with very satisfactory yields for the delayed seeding date. Clintland yielded 76.3 bushels per acre in four sprayed replications. There was no unsprayed check for comparison with the sprayed early and medium season seedings.

The proportion of diseased tillers was not accurately determined in the sprayed plots; however, it was evident that some infection had occurred. It is estimated that approximately 10 percent of the tillers in the sprayed plots showed some symptoms of yellow dwarf previous to ripening. This infection could have occurred before the sprays were applied. Inasmuch as sprayed plots were adjacent to the large unsprayed areas of BYDV infected oats where heavy aphid populations existed, it seems apparent that the Dimethoate provided prolonged protection against spread of the virus by aphids migrating from the unsprayed areas.

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## YELLOW DWARF OF OATS IN IOWA IN 1959<sup>1</sup>

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### Summary

Yellow dwarf of oats was severe in southeastern and northwestern Iowa in 1959 and caused a reduction in yield estimated at 12 percent for the entire State. Significant positive correlations between yellow dwarf ratings of varieties in three oat-variety tests were obtained, and significant negative correlations between yellow dwarf ratings and yields were obtained. Putnam and Newton varieties were resistant to the yellow dwarf disease; Richland, Bonham, Cherokee, Nemaha, Minhafer, Clarion, Burnett, Beedee, C.I. 7154, Macon, and Nehawka were intermediate in response; and Fayette, Clintland, Clinton, Clintland 60, Sauk, Garry, C.I. 7272, Goodfield, and Minton were susceptible. Yellow dwarf was most severe in fields of low fertility and with sparse stands.

Yellow dwarf of oats, caused by the barley yellow dwarf virus, was epiphytotic in some areas of Iowa in 1959. Occasional fields were severely infected throughout the State, but the areas affected most severely were in southeastern and northwestern Iowa (Fig. 1).

Several papers (4, 5, 6) have reported large yield reductions from artificially induced yellow dwarf epiphytotics on oats, but loss estimates under natural conditions are scarce (1). Three locations (Seymour, Olds, and Doon) where the 1959 Iowa oat-variety tests were grown were in yellow dwarf-affected areas (Fig. 1). This paper reports data from these tests and observations in farmers' oat fields in these areas. No other oat diseases occurred in appreciable amounts in Iowa in 1959.

### DATA FROM OAT-VARIETY TESTS

The oat varieties grown in the Seymour, Olds and Doon yield trials reacted differently to the yellow dwarf disease as evidenced by yellow dwarf ratings, yields, and test weights (Table 1). The Seymour nursery was not harvested because of poor stands. Data from another nursery, located at Sutherland, were included in Table 1 as a yellow dwarf-free check.

Yellow dwarf was rated on a scale of 1 to 5 (5 being most severe) at each location. Since yellow dwarf ratings were relative for varieties at a given location, the same numerical rating in different tests does not necessarily indicate the same severity of yellow dwarf. While yellow dwarf differed in severity from one location to another, the relative ratings for varieties were similar among tests. This observation is indicated by the highly significant correlations (Table 2) ranging from +0.63 to +0.78 for yellow dwarf ratings among locations. Putnam and Newton gave the lowest yellow dwarf ratings in all tests, whereas Fayette, Clintland, Clintland 60, and Sauk were most severely affected (Figs. 2 and 3). Putnam and Fayette are early-maturing varieties, Newton, Clintland, and Clintland 60 are midseason, and Sauk is a late-maturing variety (Table 1).

The correlations between yellow dwarf ratings and yields at Doon and Olds were both negative and significant, indicating that yields were depressed by the yellow dwarf disease. The correlation coefficient between yellow dwarf ratings and test weights at Olds was -0.46. A similar correlation could not be calculated for the Doon location since some varieties did not produce enough seed for test weight measurements.

Another method of showing the effect of yellow dwarf on oat yields would be to compare the yield of each variety subjected to infection in 1959 with the respective yields from a test where the disease was not present. Such a comparison is presented in Table 3 where all yields are expressed as percentages of the respective test means. Since both years were excellent for oat production, and diseases other than yellow dwarf in 1959 were not prevalent in either year, the differences that a variety expressed in percentage yield from one year to the next would be a measure of resistance to yellow dwarf.

<sup>1</sup> Journal paper No. J-3752 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1176. In cooperation with the Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

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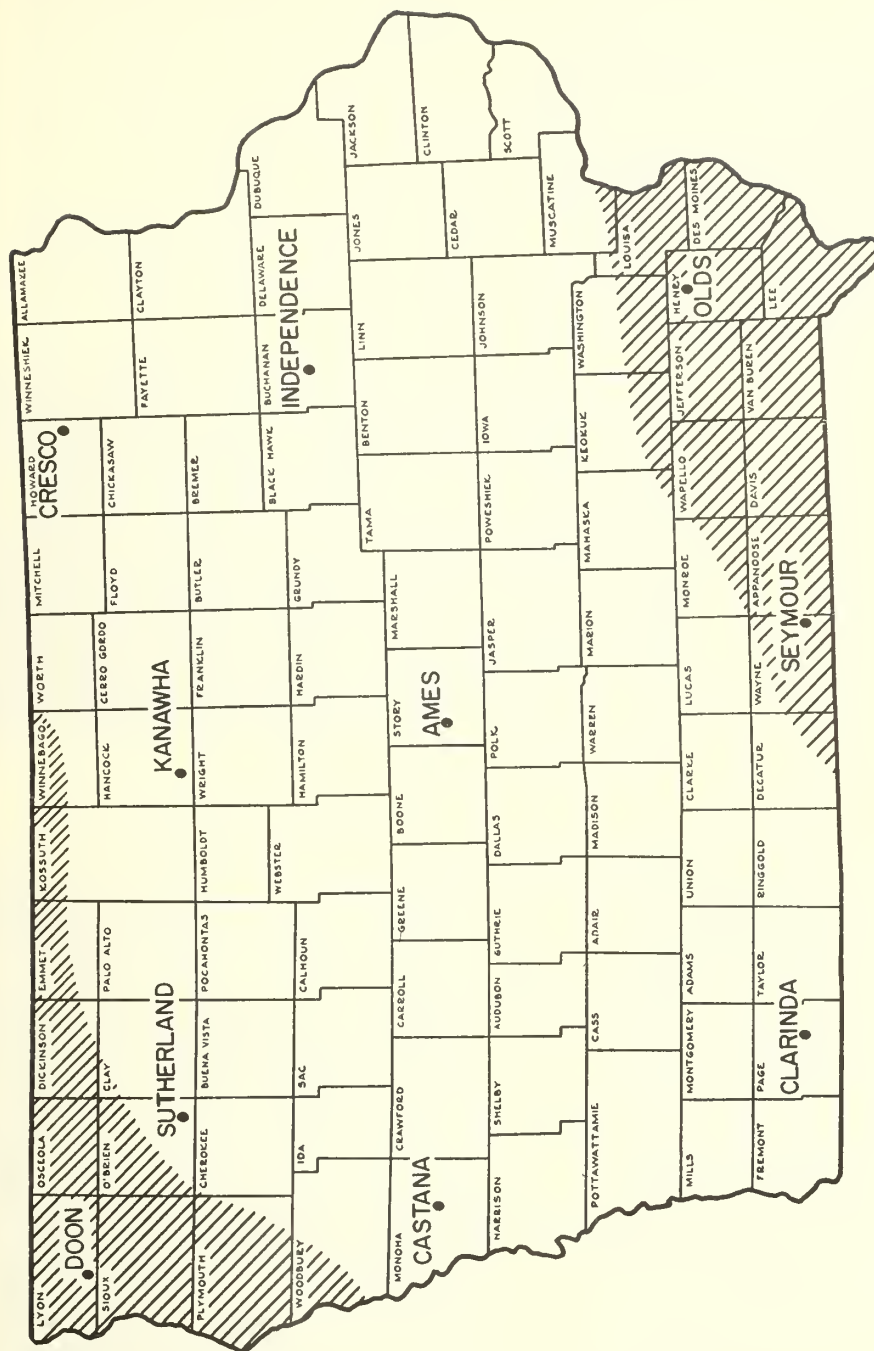


FIGURE 1. Iowa small grain-testing stations and approximate areas of Iowa where oats were affected severely with yellow dwarf in 1959.



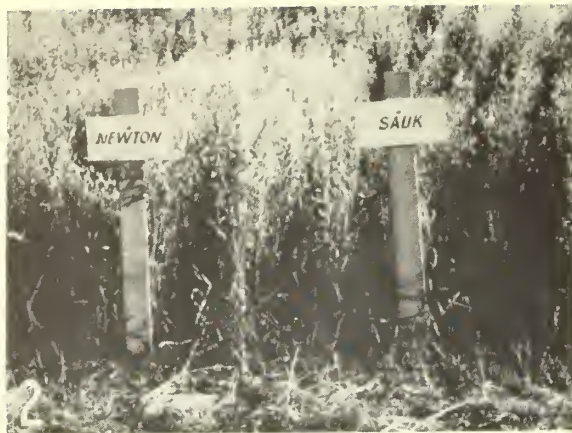


FIGURE 2. Effect of severe yellow dwarf on Newton and Sauk oats in 3-row plots at Doon, Iowa in 1959.



FIGURE 3. Effect of severe yellow dwarf on Putnam, Fayette, Minhafer, and Clintland oats in 3-row plots at Doon, Iowa in 1959.



FIGURE 4. Two fields of oats in the same locality of Plymouth County, Iowa in 1959. A -- Yellow dwarf in oats on Ida-Monona type soil. B -- Yellow dwarf-free oats on Galva-Primghar type soil.

Table 1. Yellow dwarf ratings, yields, and test weights of entries in the 1959 Iowa oat variety test<sup>a</sup>.

Variety	C.I. No.	Maturity class <sup>b</sup>	Yellow dwarf ratings <sup>c</sup>			Grain yields in bushels per acre			Test weights		
			Seymour	Olds	Doon	Av.	Olds	Doon	Sutherland	Doon	Sutherland
Newton	6642	M	2.0	1.3	1.0	1.4	91	59	95	34.5	31.2
Putnam	6927	E	1.7	1.0	1.7	1.5	86	57	79	35.7	32.6
Minhafer	6913	E	2.0	3.0	1.3	2.1	77	37	100	32.0	29.7
Beedee	6752	M	3.3	2.0	2.7	2.7	85	40	99	35.2	35.7
Macon	6625	E	3.7	2.3	2.0	2.7	82	36	90	35.0	29.6
Nemaha	4301	E	2.7	2.7	3.0	2.8	83	24	82	34.0	24.8
Cherokee	5444	E	4.0	2.3	3.0	3.1	87	36	84	34.1	27.6
---	7154	E	4.7	2.0	2.7	3.1	97	27	100	34.6	27.5
Clarion	5647	M	3.3	3.3	3.0	3.2	84	31	99	34.0	31.2
Bonham	4676	E	3.7	3.0	3.0	3.2	80	35	91	32.7	29.5
Garry	6662	L	3.3	2.3	4.3	3.3	77	13	101	31.1	25.6
Richland	787	E	4.3	2.7	3.3	3.4	73	27	88	32.1	25.6
Nehawka	7194	E	4.3	3.0	3.7	3.7	95	28	101	33.0	28.8
Goodfield	7266	M	3.0	3.0	5.0	3.7	74	16	86	35.1	31.4
---	7272	E	3.7	3.7	4.0	3.8	82	21	86	34.7	29.0
Burnett	6537	M	4.3	3.7	4.0	4.0	94	24	104	34.9	28.6
Minton	6935	M	4.0	4.0	4.7	4.2	66	18	103	30.3	27.8
Clinton	4259	M	4.0	4.0	4.7	4.2	67	10	84	32.2	--
Clintonland 60	7234	M	4.7	4.0	4.7	4.5	76	11	81	33.5	--
Sauk	5946	L	5.0	3.7	5.0	4.6	82	6	103	31.7	--
Clintonland	6701	M	4.7	4.0	5.0	4.6	71	5	75	33.4	--
Fayette	6916	E	4.7	4.0	5.0	4.6	72	11	76	32.9	23.0
Mean							81	26	91		80

<sup>a</sup> All data are means of three replications at each location.<sup>b</sup> E = Early, M = Midseason, L = Late.<sup>c</sup> Severity of response to yellow dwarf rated from 1 to 5, with 5 most severe.

Table 2. Correlation coefficients between yellow dwarf ratings, grain yields, and test weights for oat variety tests grown at Seymour, Olds, and Doon, Iowa, 1959.

Items correlated	Correlation coefficient	Degrees of freedom
Yellow dwarf at Doon and Olds	+.78**	20
Yellow dwarf at Doon and Seymour	+.70**	20
Yellow dwarf at Seymour and Olds	+.63**	20
Yellow dwarf and yield at Doon	-.92**	20
Yellow dwarf and yield at Olds	-.54**	20
Yellow dwarf and test weight at Olds	-.46*	20
Yellow dwarf and test weight at Doon	-.44	16

\*\* Significant at the 1 percent level.

\* Significant at the 5 percent level.

Table 3. Variety yields in percentage of means of experiments at Olds, Doon, and Sutherland, Iowa in 1958 and 1959.

Variety	Olds		Doon		Sutherland	
	1959	1958	1959	1958	1959	1958
Putnam	106	96	204	79	87	93
Newton	112	110	211	105	104	103
Cherokee	107	90	129	93	92	96
Beedee	105	103	143	108	109	107
Bonham	99	103	125	87	100	96
Minhafer	95	104	132	97	110	98
Clarion	104	102	111	109	109	100
Nemaha	102	91	86	90	90	97
Richland	90	93	96	96	97	98
Burnett	116	109	86	110	114	106
Fayette	89	84	39	92	84	91
Garry	95	114	46	135	111	98
Clinton	83	104	36	88	92	104
Clintland	88	84	18	100	82	103
Sauk	101	119	21	121	113	109
Means (bushels per acre)	81	96	28	92	91	112

In the Doon test, Putnam yielded 79 percent of the mean in 1958 and 204 percent in 1959. Newton percentages were 105 and 211 for 1958 and 1959, respectively. In contrast, Clintland yielded 100 percent of the mean in 1958, but only 18 percent in 1959, and Sauk yielded 121 percent and 21 percent for the 2 years, respectively. The varieties most widely grown in Iowa, Cherokee, Bonham and Nemaha, all early-maturing varieties, averaged a somewhat higher percentage yield in 1959 than in 1958. The percentage yield data indicated that Putnam and Newton were resistant to yellow dwarf, but they do not imply that these varieties were unaffected by the disease. These percentages simply mean that, relative to other varieties, Putnam and Newton were resistant. In terms of actual yields, Putnam and Newton produced 25 percent less grain in 1959 than in 1958 at the Doon location. In contrast, Clintland and Sauk produced 95 percent less in 1959.

The relative yields at Olds tend to corroborate the conclusions drawn from data obtained at Doon, but they are much less extreme. At Sutherland the 1958 and 1959 relative yields of the respective varieties were associated well, which was to be expected since neither yellow dwarf nor any other disease was severe at this location in either year.



Varieties fell into three distinct groups for response to yellow dwarf. The most susceptible varieties were Fayette, Clinton, Clintland, Clintland 60, Sauk, and Garry, and C.I. 7272, Goodfield, and Minton were slightly less susceptible. Richland, Bonham, Cherokee, Nemaha, Minhafer, Clarion, Burnett, Beedee, C.I. 7154, Macon, and Nehawka were intermediate in reaction, and Newton and Putnam were resistant.

The reduction in Iowa oat yields due to yellow dwarf in 1959 was estimated at 12 percent. Yellow dwarf was less severe than in 1949, the only previous epiphytotic year, when it was more evenly distributed over the State and caused an estimated reduction in yield of 15 percent. In 1959, however, yellow dwarf was more devastating in individual fields than it was in 1949. In fact, it was more devastating in certain fields than either Victoria blight or crown rust in years when these "major" oat diseases were epiphytotic<sup>3</sup>.

### OBSERVATIONS FROM FARMERS' FIELDS

In previous years, when yellow dwarf was present in Iowa, it first appeared on barley and then spread to oats. Symptoms of yellow dwarf have been observed repeatedly to develop progressively from south to north in oats immediately north of barley. This sequence of development is apparently correlated with the wind-movement of the vector, as prevailing winds in the summer in Iowa are from the south. However, in 1959 yellow dwarf hardly affected barley, even when the two crops were grown side-by-side.

Yellow dwarf was more severe in fields with sparse stands, as Slykhuis et al. (5) observed in Ontario. Invariably the most severe yellow dwarf in the breeding nursery at Ames, Iowa is in the space-planted rows. In space-planted nurseries there is more opportunity for the aphid vectors to be blown from plant to plant than there is in a solid stand. A sparse stand in a farmer's field would be somewhat comparable to a space-planted nursery. In contrast, a full stand of oats presents a formidable barrier to wind and also to aphid movement. When yellow dwarf has been observed to move into oats from perennial grasses in the fence row, plants well into, if not throughout, a sparse field have shown yellow dwarf symptoms. However, in a full stand only a few plants in the peripheral few feet may show symptoms.

Yellow dwarf was more serious in fields low in fertility. Fertility level may manifest its effects through the plant, the disease, the vector, or the interaction among them. Aphids have been reported (2, 3) more numerous but less damaging on small grains supplied with nitrogen, but the effect of fertility on the disease is not known.

Yellow dwarf in Iowa in 1959 was more severe on oats following corn than on those following soybeans. This could be related to nitrogen in the soil. Oats growing on Ida-Monona soil (Fig. 4A) had considerable yellow dwarf whereas those on Galva-Primghar soil (Fig. 4B) in the same locality were essentially free of yellow dwarf. This could also be related to the fertility level of the two soil types. The influence of fertility level on yellow dwarf incidence is complex, but undoubtedly low fertility is related to sparse stands.

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<sup>3</sup> Personal communication from H. C. Murphy.

BARLEY YELLOW DWARF IN KANSAS OATS AND BARLEY IN 1959<sup>1</sup>

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The most severe outbreak of barley yellow dwarf virus on record occurred in Kansas spring oats and spring barley during 1959. The disease occurred also in winter barley but was much less damaging and, in general, the percentage of infected plants was much lower than in the spring-planted fields. This disease has been seen previously in Kansas (4) but usually has not been severe.

Several aphids have been shown to transmit this virus (2). Aphid populations, particularly greenbugs, *Toxoptera graminum* Rond., were very high in eastern Kansas in both the fall of 1958 and the spring of 1959. Peak greenbug populations occurred during the last week of April and the first week of May and were considerably higher than normal during the entire spring. Greenbug feeding damage also was severe in the eastern half of the State during the spring and it was difficult at times to distinguish between this injury and virus symptoms and damage. Most observers consulted believed, however, that the virus damage in 1959 was greater than the greenbug injury.

Disease symptoms on both oats and barley were typical of those previously described in detail (1, 2, 3, 5, 6).

Varietal reactions to barley yellow dwarf in oats (red leaf) were recorded in the nurseries at Manhattan in Riley County and Powhattan in Brown County. The distribution of greenbug and red leaf was variable at Manhattan but appeared to be uniform at Powhattan. Kanota, Kanota derivatives, and Richland x Fulghum lines were outstanding in their lack of evident red leaf symptoms and in performance. Ratings on severity of red leaf were made on the following basis: slight (1, 2, or 3); average (4, 5, or 6); and severe (7, 8, or 9). Red leaf ratings, yield in pounds per acre, and test weight in pounds per bushel of named varieties are given in Table 1.

Table 1. Red leaf ratings, yield, and test weight of spring oat varieties grown in replicated performance trials at Manhattan and Powhattan, Kansas in 1959.

Variety	C. I. number	Manhattan			Powhattan		
		R. L. rating	Yield (lbs./acre)	Test weight (lbs./bushel)	R. L. rating	Yield (lbs./acre)	Test weight (lbs./bushel)
Kanota	639	1.0	2040	29.9	2.0	2024	34.1
Columbia	2820	4.0	1801	30.3	3.5	1393	31.5
Osage	3991	3.2	1623	28.0	4.2	1493	33.1
Mo. 0-205	4988	4.0	1633	30.8	4.0	1269	33.8
Andrew	4170	4.2	1324	28.2	3.2	1438	32.0
Putnam	6927	4.7	1120	32.1	2.0	1449	34.1
Macon	6625	5.7	1166	31.1	3.5	1329	34.0
Nehawka	7194	7.5	993	30.0	4.7	893	32.1
Minhafer	6913	8.0	596	28.0	4.0	1073	29.4
Clinton 59	4259	7.0	945	29.7	8.0	526	32.5

The ratings are averages of four readings at each location. The varieties are listed in order from highest to lowest average yield at both locations. In general, the higher the red leaf rating the lower was the yield. There was good agreement in disease response readings between the two locations except with Putnam and Minhafer. In general the tillers that produced grain appeared normal. The damage done was primarily one of reduced number of panicle-bearing tillers. There was also considerable early loss of leaves in susceptible vari-

<sup>1</sup> Contribution No. 556, Department of Botany and Plant Pathology, and No. 665, Department of Agronomy, Agricultural Experiment Station, Manhattan.

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<sup>2</sup> Respectively: Associate Plant Pathologist, Agricultural Experiment Station; Extension Plant Pathologist; and Professor of Agronomy, Agricultural Experiment Station, Manhattan.

CHEYENE	RAWLINS	DECATUR	NORTON	PHILLIPS	SMITH	JEWELL	REPUBLIC	WASHINGTON	MARSHALL	NEJAHNA	BROWN	ATKINSON	DOUGLASS
			5,000			10,000	6,000	8,000	5,000	13,000	2,000	4,000	13,000
			3,000			200,000	30,000	100,000	12,000	275,000	120,000	25,000	160,000
SHERMAN	THOMAS	SHERMAN	GRAHAM	ROOKS	OSBORNE	MITCHELL	CLOUD	CLAY	RILEY	POTTER	JACKSON	JEFFERSON	JEFFERSON
					9,000		2,000	5,000	60,000	5,000	35,000	5,000	170,000
					12,000		25,000	100,000	100,000	50,000	40,000	100,000	170,000
WALLACE	LOGAN	GOVE	TRIBB	ELLIS	RUSSELL	LINCOLN	OTTAWA	DOUGLASS	SEAR	WABAR	SWANEE	WABAR	WABAR
						--		10,000	3,000	10,000	7,000	13,000	14,000
						25,000	SALINE	10,000	35,000	250,000	60,000	13,000	75,000
GREELY	WORTH	SCOTT	LANE	RUSH	BARTON	ELLSWORTH	4,000	300,000	105,000	10,000	8,000	FRANKLIN	FRANKLIN
					--		100,000	10,000	10,000	10,000	130,000	8,000	15,000
					25,000	RICE	MC PHERSON	MARION	CHASE	LYON	COTTEY	ANDERSON	ANDERSON
HAMILTON	HEARBY	FINNEY	HODGEMAN	FINNEY	STAFFORD		3,000	3,000	6,000	10,000	80,000	15,000	15,000
						8,000	200,000	330,000	10,000	10,000	10,000	50,000	50,000
STANTON	GRANT	HASKELL	FORD	EDWARDS	PRATT	RENO	SEDGWICK	BUTLER	10,000	WOODSON	ALLEY	BOURDON	BOURDON
						300,000	15,000	25,000	60,000	2,000	30,000	12,000	12,000
							160,000	200,000		WILSON	NEEDS	CHAMBERS	CHAMBERS
										15,500	10,000	8,000	8,000
MORTON	STEVENS	SEWARD	CLARK	COMANCHE	BARBER	HARTER	SUMNER	COWLEY	ELIA	100,000	100,000	50,000	50,000
							24,000	25,000	100,000	22,000	13,000	9,000	9,000
							150,000	125,000	CHAUTAUQUE	60,000	40,000	45,000	45,000

FIGURE 1. Estimated county losses due to barley yellow dwarf in oats and barley in Kansas: 1959 crop.  
 Top number in each county is the bushel loss in oats. Bottom number is the bushel loss in  
 oats. Total -- 5,923,000.



eties. Other factors also influenced yield, especially the drouthy conditions at Manhattan, and, of course, greenbug damage. General observations throughout the State also indicated that the oat varieties Cherokee and Nemaha were quite susceptible, while Kanota appeared to be very resistant and Mo. 0-205 and Andrew moderately resistant.

Estimates of losses caused by barley yellow dwarf in Kansas in 1959 were made by the writers in cooperation with county agricultural agents in affected counties. Losses in some oat fields were estimated as high as 50 percent or more and often were 25 to 40 percent. Infection of individual plants, based upon field counts of red leaf plants, frequently was 50 to 75 percent and occasionally was higher. Late planted fields usually had a higher percentage of diseased plants. Losses estimated for oats in each county are presented in Figure 1 and represent the most accurate loss estimates available from all sources. The total State loss, occurring mostly in eastern counties, was estimated at 5,923,000 bushels on 481,000 acres, or approximately 25 percent of the 1959 oat crop.

Heavy greenbug infestation occurred in winter barley in the fall of 1958 in the Manhattan field plots in northeastern Kansas and spread to the nearby winter wheat. Barley yields in these plots were much lower than expected under the prevailing conditions. The higher yielding varieties were those known to have some resistance to greenbug. Hence, there was undoubtedly considerable loss from greenbug damage and an unknown but probably significant loss resulting from barley yellow dwarf.

In general losses in winter barley, particularly in northwest counties, were not severe, owing probably to the time of planting and harvesting and to smaller aphid populations. Only three winter barley fields with more than 10 percent infected plants were seen.

In spring barley six fields were seen in eastern Kansas which were a total loss and all late planted fields seen were very badly damaged. As shown in Figure 1, approximately 35,800 acres of barley, largely in the eastern half of the State, were diseased. Total loss estimates were 562,000 bushels or 2.3 percent of the 1959 State crop.

Although there is no direct evidence of barley yellow dwarf virus infection of winter wheat in Kansas in 1959, considerable indirect evidence indicates that this may have occurred, particularly in eastern counties where the disease was common in oats. Wheat yields in these eastern counties, especially in early planted winter wheat, were considerably below pre-harvest expectations. Losses from wheat streak mosaic virus and soil-borne wheat mosaic virus were known to be slight in eastern Kansas. Leaf rust of wheat, several head blights, and foot rots, including take-all, caused considerable damage but, according to the best information available, not enough to account for all the yield loss. Hence, some unknown factor or factors, possibly barley yellow dwarf virus, plus greenbug damage, appears to have caused considerable loss.

At Manhattan the winter wheat nursery was planted on two different dates because of a wet period in October. The early planted nursery had heavy greenbug infestation in the fall and in the spring appeared to be infected by barley yellow dwarf, as measured by yellowing of the plants and reduced yield. The later planted portion did not have heavy greenbug infestation or show these symptoms and the yield was much greater. This was also true of a Pawnee wheat field near Manhattan, a portion of which was planted early and the remainder later after October rains. There were reductions in yield and more shriveled kernels in the early planted portion, as well as plant yellowing in the spring. No loss estimates for wheat were made owing to lack of certain knowledge concerning the causal factors.

A puzzling malady of early planted winter wheat, which also may be barley yellow dwarf, appeared in small patches in several eastern counties during the spring of 1959. Infected plants became very chlorotic and did not elongate normally. In addition to extreme stunting, there was also considerable bud proliferation. Most of the infected plants eventually died. Those that lived usually produced only a few weak culms.

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# BARLEY YELLOW DWARF VIRUS ON OATS IN MAINE

Clinton R. Blackmon

Barley yellow dwarf virus on oats, with its typical red leaf symptoms, has caused concern since its recognition in the experiment station nurseries and on farms during 1955. From 1956-1959 the disease was widespread in Maine and appeared on all varieties in the Uniform North-eastern Oat Variety Tests. Severe infection resulted in blasting.

During 1959, a survey of oats throughout Maine was made to determine the extent of damage. The results are summarized as follows:

1. The English grain aphid (Macrosiphum granarium, Kirby) and the apple grain aphid (Rhopalosiphum fitchii, Fitch) were common in infected fields.

2. All of the oat fields surveyed were adjacent to, or partly surrounded by, forage, especially timothy and clover. This probably furnished a source of early virus infection. In most cases potato fields were also adjacent but did not seem to cause any more or less noticeable red leaf symptoms. Most of the oat crop was grown after potatoes in the rotation.

3. Losses from BYDV are shown in Table 1.

Infection estimates were based on averages of infected versus non-infected plants in several areas of each field. Distribution of diseased plants was spotty, and some areas were almost completely infected while other areas exhibited few disease symptoms. This was probably due to the early flight pattern of the aphids. The early planted oats (May 10-20) undoubtedly escaped serious infection, since they headed about July 10-15, while the peak of aphid infection was not reached until late July.

4. Infected plants matured earlier than non-infected plants. Some were severely stunted and died.

5. Aphid flights into the oat fields began in late June, and the maximum build-up of aphid populations occurred sometime after July 20th and before August 1st.

Table 1. Estimated BYDV infection losses on two oat varieties, 1959.

Variety	Date planted	Percent plants with BYDV symptoms	Percent yield loss
Clinton 59	May 10-20	5	2
	20-30	30	8
	June 1-10	55	15
Garry	May 10-20	5	2
	20-30	40	10
	June 1-10	50	10

The Maine Agricultural Experiment Station has a project underway to determine the sources of spring infection, vectors responsible, and varietal resistance to BYDV. An extensive testing program was begun in 1959 to inoculate oat varieties and selections with the virus and transplant both inoculated and uninoculated plants to the field to compare performance. There was considerable variability between varieties in symptoms and performance. Results will be published later.

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# YELLOW DWARF IN MICHIGAN IN 1959<sup>1</sup>

Richard L. Kiesling

Yellow dwarf of oats was coextensive with oat culture in Michigan in 1959. Yellow dwarf has been present to some degree in both spring barley and oat fields in many areas of Michigan every year since 1955. In most of these areas the severity of the disease outbreak was directly related to the area of grass sod fence rows adjacent to oat fields and to the time and amount of movement of the aphid vectors from these sods into the small grain fields.

A check with the station entomologists reveals no reported collections of the greenbug in Michigan in the 1959 growing season. Winged adults of several other aphid species were found in small grain fields from about May 1 through May 24. During this period, there were days with temperatures above 80° F followed by cool nights and several days of cool, wet weather. These conditions favored early flight of aphids into grain fields and rapid colonization of the field occurred after the winged forms arrived. High daytime temperatures occurred on May 2-6, 19-21 and 26-31. The high temperature period from May 26-31 was accompanied by increasing drought. This hot, dry period checked further aphid spread and few aphids were found in fields of oats in Cass County on June 11.

High temperatures and low rainfall in May and June caused oats to mature prematurely and to develop pigments which were difficult to distinguish from the red color caused by yellow dwarf virus. Examination of affected plants for blasting and stunting aided in the confirmation of yellow dwarf damage. Garry oats developed less discoloration, blasting, and stunting than did Clintland, Clintland 60 or Jackson (Table 1). In a demonstration of fertilizer practices in Kent County, Garry oats top-dressed with 20 pounds of nitrogen per acre developed fewer seriously affected plants than did areas of the field not top-dressed.

Table 1. Varietal reaction to the yellow dwarf virus epiphytotic in the rod row oat nursery, Cass County, Michigan, 1959.

Variety	Average percent <sup>a</sup> yellow dwarf damage	Average yield <sup>b</sup> (bushels per acre)
Clintland 60	42	72.0
Jackson	42	78.0
Rodney	25	79.0
Clintland	42	80.0
Simcoe	29	86.0
Eaton	50	86.0
Garry	17	93.0

<sup>a</sup>Average of three randomized replications.

<sup>b</sup>Average of four replications.

The variety of oats grown, date of sowing, level of soil fertility, and availability of soil moisture were important factors in determining the severity of the damage to stands of oats by yellow dwarf virus in Michigan in the 1959 season. Early sown fields of Garry oats which had developed thick stands showed little yellow dwarf damage. Two fields of an unidentified oat variety which were destroyed by yellow dwarf virus in Cass County were planted after the first of May in soils of low fertility. Several other fields of oats which were severely damaged by yellow dwarf in Cass County exhibited thin stands and were planted on soils having a poor fertilizer history.

No significant benefit was demonstrable from treating seed with systemic insecticides prior to sowing. However, both the incidence and the severity of yellow dwarf infection was increased by planting late, and by wide spacing of the grain plants. Under conditions of thin stands and late seeding, losses were as high as 100 percent in Michigan in the 1959 season. However, under conditions of early seeding, good fertility and thicker stands, only trace amounts of damage occurred in the same general farming areas where total losses occurred on late sown fields.

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OCCURRENCE OF BARLEY YELLOW DWARF ON OATS  
IN MISSISSIPPI, 1959<sup>1</sup>

P. G. Rothman, Donald H. Bowman, and S. S. Ivanoff<sup>2</sup>

Barley yellow dwarf was more widespread and destructive on oats in Mississippi during the last growing season than it has ever been in the past. Estimated losses in grain yields were as high as 30 to 40 percent. No oat field observed was entirely free of the disease, but great variations in the amount of damage were evident. No commercial oat variety appeared to possess resistance, but the severity of the damage was more pronounced on a few varieties. Related differences in resistance of the early, mid-season, and late-maturing oat varieties were not observed. Delair, an early-maturing oat, was badly damaged by the barley yellow dwarf virus, but perhaps not as much as the late-maturing Red Rustproof-type oats. To a large extent, total damage was determined by the vegetative state of the plants at the time of first symptom expression. Yellow dwarf symptoms appeared in the oat nursery at Stoneville in early March. At this time the early-season oat strains had begun to joint, while the late-season ones were still "tillering out." It is probable that this growth differential may be responsible for the smaller reduction in total yields of the earlier varieties than of the later Red Rustproofs. It was unusual to find a completely blasted panicle of an early oat variety, but it was not uncommon to find them readily among the late oat varieties. Not all plants were killed or made unproductive by the virus. Many plants of all oat varieties showed symptoms but matured with no apparent impairments.

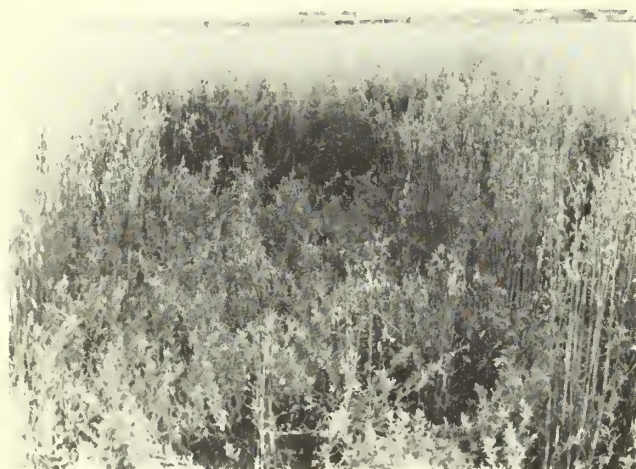


FIGURE 1. A progeny block of space-planted  $F_2$  material heavily damaged by yellow dwarf virus, flanked by progenies showing relatively little injury.

Symptom colorations varied among some oat plants, but these were not reflected in any differences in the expression of the disease. In the Stoneville space-planted  $F_2$  nursery, which was heavily damaged by yellow dwarf (Fig. 1), certain progenies exhibited bright-blue to purple coloration in their leaves. More common, however, was the brilliant-red pigmentation which most progenies exhibited. These two colors were completely absent in some infected strains also in this nursery. On affected plants with this third type of symptom the leaves turned straw color, much like those of a matured plant. Specimens with the three types of symptoms were checked by W. F. Rochow, and the yellow dwarf virus was recovered from all three groups. The different color expressions may well be an interaction of inherent plant characteristics and temperature.

Early in March, plants in the  $F_2$  nursery showing yellow dwarf symptoms were tagged and paired with healthy plants exhibiting similar agronomic characteristics, in an attempt to measure yellow dwarf damage. The unpredictable spread of infection was soon apparent because

<sup>1</sup> Cooperative investigations, Crops Research Division, Agricultural Research Service, United States Department of Agriculture and Mississippi Agricultural Experiment Station. Journal Paper (New Series) No. 808.

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there were no centers of infection. Symptoms appeared almost haphazardly on the space-planted material. Many plants tagged early as resistant became infected as the season advanced. Within the F<sub>2</sub> space-planted nursery, entire progenies were completely eliminated by the virus. Other progenies heavily infected with yellow dwarf contained one or more plants completely free of symptoms. A few progenies were relatively free of the disease except for an occasional plant. While it is possible these plants escaped infection because of the distribution of the vectors, progenies scattered about the nursery which were highly susceptible to the virus had one or more common parents (See list following).

Varieties and Selections Highly Susceptible to Yellow Dwarf at Stoneville, Mississippi, 1959

Arlington: C.I. 4653  
 Arlington x C.I. 6666: Delta 55158-26  
 Carolina Red x Clinton<sup>2</sup>-Santa Fe: C.I. 7231  
 [C.I. 3717 (RRPVR) x (Lee-Victoria x Fulwin)] x Clinton<sup>2</sup>-Santa Fe: C.I. 7226  
 C.I. 3720 - Wintok x Santa Fe: Delta 5142-7  
 C.I. 6936 (LMHJA) x C.I. 7152 (HJLVFBAL): Delta 214  
 C.I. 6936 (LMHJA) x Mid-South: Delta 5608  
 C.I. 6936 (LMHJA) x New Nortex-Landhafer: Delta 212  
 C.I. 7083 (LMHJA) x Delta Red 88: Delta 220  
 C.I. 7083 (LMHJA) x Delair: Delta X56010  
 Delair: C.I. 4653  
 Delair x [(Bonda x Hajira-Joanette) x Santa Fe]: Beltsv. 154  
 Delta Red 88: C.I. 4220  
 Fulgrain 55311-5 x C.I. 7145 (LMHJA): Delta X5728  
 [Haj-Joan x (Lee-Victoria x Fulwin)-(Bond-Anthony)] x Landh: C.I. 7152  
 Letoria x Clinton<sup>2</sup>-Santa Fe (HVR 167): C.I. 7422  
 (Lee-Victoria x Fulgrain) x (Clinton<sup>2</sup>-Santa Fe): Delta 5104-10  
 Mid-South: C.I. 6977  
 New Nortex x Landhafer: C.I. 6998  
 Nortex 107: C.I. 5872  
 Suregrain: C.I. 7155  
 Victorgrain 48-93: C.I. 5355  
 Victorgrain 48-93 x [(Bond-Anthony x Hajira-Joanette) x Santa Fe]: Beltsv. 157  
 Victorgrain 55284-2 x C.I. 6936 (LMHJA): Delta x 5719

Table 1. Reduction in yields attributed to yellow dwarf virus within the replicated plots of the same entries in the Delta preliminary oat strain tests.

Pedigree	:	: Average yield of plots		:	
		: (in grams)			: Yield loss
		: Local or	: with		
	: C.I. no.	: yellow dwarf	: less	:	
(L-V x Fulwin) CI <sup>2</sup> -SF	5104-10	775	990	14	
(L-V x Fulwin) CI <sup>2</sup> -SF	CI7237	426	596	29	
(CI3717 x CI4316:C18)CI <sup>2</sup> -SF	5312-10	978	1199	18	
(CI3717 x CI4316:C18)CI <sup>2</sup> -SF	5105-8-1	423	525	19	
(CI3717 x CI4316:C18)CI <sup>2</sup> -SF	5105-8-3	267	498	46	
(CI3720 x Wintok:CI4665)SF	5142-7	344	420	18	
Victorgrain x Landhafer	5021-6-14	805	1005	20	
Delta Red 88	CI4220	331	451	27	
Victorgrain (B-A x HJ x SF)	Md. 157	731	990	26	
Delair (Minn. Sel:BA x HJ x SF)	Md. 331	292	448	35	
Delair (Bonda x HJ-SF)	AB 2647	286	394	27	
Delair (Bonda x HJ-SF)	54128-1	433	620	30	
Delair (Bonda x HJ-SF)	54128-2	208	361	42	
Delair (Bonda x HJ-SF)	54128-3	486	601	19	
LMHJA:CI7083 x Delta Red 88	220	717	1001	28	
LMHJA:CI6936 x [HJ(LVF)(BA) Land: CI7152]	214	384	502	24	
LMHJA:CI6936 x New Nortex-Land CI6994	213	391	602	35	
LMHJA:CI6936 x New Nortex-Land CI6994	212	281	473	41	



Other widely scattered progenies within the F<sub>2</sub> nursery which showed only an occasional diseased plant in the various areas of the field had either one of two parental lines in common. These lines, X5610: (Unknown x Anderson Selection: C.I. 4837) and 5X567: (Binder: P.I. 173231 x Hein II: C.I. 4837), merit screening as possible sources of resistance.

Low oat yields and test weights reflected the loss caused by yellow dwarf. An attempt was made to measure the loss in yields which could be attributed to yellow dwarf in two oat experiments. In these replicated experiments a record was made of the plots that were infected with yellow dwarf and those that were free of symptoms. Within each entry the average yields of the infected plots were compared with the average yields of the symptomless plots. Percent of reduction was regarded as the loss in yields attributed to the virus. Reductions in yields of 14 to 46 percent were found (Table 1).

The Uniform Winter Barley Nursery and the Mississippi State Barley Test growing contiguous to the oat nursery remained free of visible yellow dwarf symptoms at Stoneville. This was difficult to understand, since aphid infestation was as heavy in the barley plots as in the oat plots. Possibly the particular strain of yellow dwarf virus in this area does not go to barley, or there may have been a different species of aphid on the barley plants. The oat and the barley nurseries were handled in an identical manner and the two barley tests averaged 61.5 bushels per acre, which is unusually high.

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IN COOPERATION WITH THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION

THE BARLEY YELLOW DWARF VIRUS-BACTERIAL BLIGHT COMPLEX  
ON OATS IN MISSOURI IN 1959<sup>1</sup>

Dale T. Sechler, J. M. Poehlman, M. D. Whitehead, and O. H. Calvert<sup>2</sup>

Summary

Barley yellow dwarf virus, accompanied by a bacterial blight, damaged oats extensively in Missouri in 1959. The disease followed widespread distribution of greenbugs earlier in the spring. Estimates of leaf area damaged range from 15 to 90 percent with yields ranging from 48 to 9 bushels in different varieties. Correlations of leaf damage to yield, stand, maturity, and test weight are reported.

The barley yellow dwarf virus disease attracted major attention in Missouri for the first time in 1959.

Symptoms of the barley yellow dwarf disease had been observed previously in barley and oats in several different years. Such occurrences of the disease, however, had been sporadic and limited to small widely scattered areas over nursery plots and farmers' fields. Except for 1949, damage to cereal grains from yellow dwarf in other years was seldom severe enough to be readily identified in mature plants, and very little was reported for the State. In 1949 a heavy "red leaf" infection was observed in oat variety plots on the Southwest Missouri Experiment Field near Pierce City; this was the only occasion, prior to 1959, that the disease was observed in sufficient intensity to record varietal reactions.

During the first few days of May in 1959 a heavy build-up of aphids was observed in the oat nurseries at Columbia. Survey entomologists had been reporting heavy greenbug infestations across southern Missouri during the previous 2-week period<sup>3</sup>. By May 5 visible damage, which appeared at first to be from aphid feeding, could be seen on the oat plants. This was followed by the appearance of yellow-green and yellow-orange to red coloration of the leaf blades, which gradually spread to the leaf sheaths. At this time the oat plants were beginning to joint. Examination of leaf tissue also revealed the presence of a bacterial exudate on the infected leaves (Fig. 1). Since the bacterial infection was general, no comparison could be made with bacteria-free plantings, which complicated any effort to determine the damage incited by either the virus or bacteria alone. Leaf-tip tissue was destroyed to a greater degree than would have been expected from virus alone.

Oats headed at Columbia largely between May 30 and June 5. By this time differences in varietal reaction to the disease could be readily observed. Varieties most severely damaged showed almost complete discoloration -- with many leaves or portions of the leaves dead, a marked reduction in tillering, dwarfing of secondary tillers and even the main tiller in severely affected varieties, and partial to almost complete blasting of spikelets. Differences in varietal reaction were observed as differences in the proportion of discolored leaves, the number and degree of dwarfing of the tillers, and the proportion of blasted spikelets. The gross appearance of the plots left no doubt that yield differences between the more resistant and the more susceptible varieties would be large. The disease did not appear in small spots -- as was frequently reported and observed here in other years, but was spread uniformly over all of the experiment field on which oats were planted. Varietal differences were consistent from block to block and between drill and nursery plots. Spaced plants and plots with thin stands were more severely damaged than thickly seeded plots. This appears to be a function of the aphid feeding, that is, aphids were present in greater numbers on plants in thinly spaced planting.

Visual estimates of leaf damage and yields of varieties and strains grown in drill plots are shown in Table 1. Leaf damage was estimated as percentage of leaf area killed or discolored. The data are from 1/40-acre unreplicated plots, but leaf damage and yield were quite similar in plots of standard varieties grown at each end of the block. Correlation coefficients

<sup>1</sup> Approved by the Director of the Missouri Agricultural Experiment Station as Journal Article No. 2083.

<sup>2</sup> Instructor, Professor, Associate Professor, and Assistant Professor in Field Crops, respectively.

<sup>3</sup> See the following article by Thomas and Munson on "The occurrence of aphids on small grains in Missouri during the spring of 1959."

Table 1. Leaf damage and yield of oat varieties grown in drill plots at Columbia in 1959.

Variety	Leaf area damaged (percent)	Yield (bushel/acre)
CI 7448 [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)] x Mo. 0-205 <sup>2</sup>	15	48.4
CI 7129 Early Clinton (Okla. sel.)	15	33.8
Newton	30	33.8
CI 7396 Fulton-Clinton x Mo. 0-205	35	38.3
CI 7447 [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)] x Mo. 0-205 <sup>2</sup>	35	33.8
CI 7267 Clintland x (Gary x Hawkeye-Victoria)	35	37.1
Andrew	40	25.9
Mo. 0-205	45	30.4
CI 7394 Early Clinton (Mo. sel.) x Mo. 0-205	45	36.0
CI 7154 Markton-Rainbow x D69-Bond	45	28.1
Burnett	50	24.8
CI 7395 Early Clinton (Mo. sel.) x Mo. 0-205	50	30.4
CI 7379 Osage x [(Bonda x Hajira-Joanette) x Sante Fe]	50	28.1
Goodfield	55	15.8
Macon	60	28.1
Minhafer	60	13.5
CI 7272 Macon x [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)]	65	18.0
Nehawka	75	20.3
Clintland	90	10.1
Clintland 60	90	9.0
CI 7235 Rodney x Landhafer-Forvic	90	12.4
Correlation coefficient (Leaf damage versus yield) $r = -.871 + .087$		
Regression coefficient (Yield on leaf damage) $b = -.438$		

Table 2. A -- Correlation coefficients(r) for percent of leaf area damaged versus yield, percent stand, date of maturity, and test weight in four oat tests at Columbia, Missouri in 1959.

		Percent leaf damage versus:			
Test number	Number of strains	yield	percent stand	time of maturity	test weight
1	31	$-.741 + .124$	$-.328 + .176$	$+.724 + .128$	$-.608 + .148$
2	30	$-.897 + .083$	$-.652 + .143$	$+.575 + .154$	$+.316 + .179$
3	28	$-.635 + .151$	$-.209 + .192$	$+.629 + .152$	$+.436 + .177$
5	38	$-.891 + .075$	$-.218 + .162$	$+.276 + .155$	$+.157 + .164$

Level of significance (5%): 31 entries=.349, 30 entries=.355, 28 entries=.367, 38 entries=.325.

B -- Regression coefficients (b) for percent of leaf area damaged on yield, percent stand, date of maturity, and test weight in four oat tests at Columbia, Missouri in 1959.

		Percent leaf damage on:			
Test number		yield	percent stand	time of maturity	test weight
1		$-.986$	$-.481$	$+.133$	$-.061$
2		$-1.017$	$-1.125$	$+.097$	$+.018$
3		$-.213$	$-.609$	$+.211$	$+.320$
5		$-1.015$	$-.455$	$+.065$	$-.017$



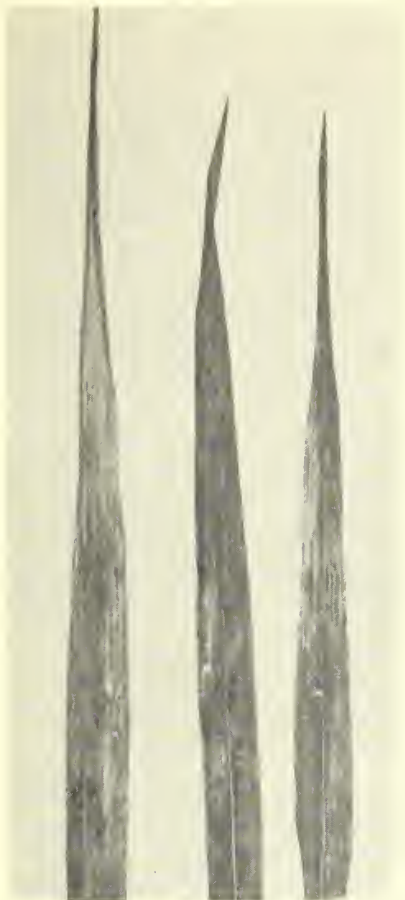


FIGURE 1. Oat leaves damaged by the virus-bacterial complex. A reddish brown leaf streaking developed, accompanied by a bacterial exudate which may be observed as white areas in the photograph.



FIGURE 2. Representative plants from oats varieties grown in drill plots at Columbia in 1959. The varieties and the percent leaf damage are (from left to right): Clintland 60, 90%; CI 7192, Early Clinton (Okla.) 15%; Mo. 0-205, 45%; Mo. 04796, 15%; CI 7235, Rodney-Landhafer-Forvic, 90%.

for leaf damage versus yield for 34 strains within the block was  $-.871$ . The regression of yield on intensity of leaf damage was  $-.483$ . Rust and other diseases were not apparent. Typical plants from five varieties are shown in Figure 2.

Leaf damage was estimated also on 127 varieties and strains grown in four replicated yield tests. Correlation coefficients and regression coefficients were calculated for leaf damage versus yield, stand, maturity, and test weight (Table 2). Highly significant negative correlations were obtained for leaf damage and yield in each test. Correlations for leaf damage and percent stands were calculated because poor stands had been obtained with some varieties in each test and observations indicated greater aphid feeding on thinly spaced plants. However, a significant negative correlation was obtained in only one of the four tests. Published reports indicate that early maturity is important to escape the disease. For this reason, correlations of leaf damage versus maturity were calculated and significant positive correlations were obtained in three tests. A significant negative correlation was obtained for leaf damage versus test weight in one test and a significant positive correlation in one test. Close inspection of the data indicates that considerable variation in test weight between varieties occurs irrespective of their reaction to yellow dwarf.

Damage in oat fields over the State was extensive. The State loss was estimated at 37 percent, with estimates ranging from 2 to 70 percent in different areas.

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THE OCCURRENCE OF APHIDS ON SMALL GRAINS IN MISSOURI  
DURING THE SPRING OF 1959

George W. Thomas<sup>1</sup> and Ralph E. Munson<sup>2</sup>

The greenbug, Toxoptera graminum (Rondani), outbreak on small grains and orchard grass attracted much attention chiefly through its dissemination of the barley yellow dwarf disease of barley and oats.

Species of aphids taken from small grains during the spring of 1959 were as follows:

<u>Aphid species</u>	<u>Host</u>
Greenbug, <u>Toxoptera graminum</u> (Rondani)	Barley, wheat, oats, orchard grass, and rye
English grain aphid, <u>Macrosiphum granarium</u> (Kirby)	Wheat, barley, and rye
Apple grain aphid, <u>Rhopalosiphum fitchii</u> (Sanderson)	Wheat and barley

The only species of aphid taken from oats was the greenbug, Toxoptera graminum.

A brief history of the greenbug build-up and spread through the State in 1959 follows.

The first record of greenbug occurrence was taken from barley and wheat in the extreme southwest area during the first week of April. Counts ranged from 0 to 2 per linear foot of drillrow.

By April 18, there had been a slight increase in greenbug numbers on barley and wheat and moderate to heavy numbers were present on orchard grass as far north and east as Greene and Lawrence counties.

By April 25, populations had rapidly increased in the southwest area. Counts ranged from 2 to 150 per linear foot of wheat drillrow and 20 to 300 per foot of barley drillrow. Spots within orchard grass fields were being destroyed and some spraying operations had begun. Winged adult aphids averaged 1 per square yard of wheat in the central area (Boone County).

By May 2, the heavy north, northeast migration was well underway. Counts in the southwest area ranged from 500 to 1000 per square foot of orchard grass and 15 to 250 per foot of barley drillrow. The majority of these populations were developing wings. Although there are no data to confirm this, the authors believe that this was the week in which spring oats in the northern third of the State became uniformly infested with winged adults.

By May 9, populations had declined rapidly in the southwest area and were increasing rapidly in the northern half of the State on oats and late seeded wheat.

By May 16, very heavy populations and damage were occurring on oats and late seeded wheat in the northeast, north-central and the northern half of the central area and were increasing in the northwest area. Counts ranged from 100 to 5000 per foot of oat drillrow, 50 to 1000 per foot of barley drillrow and 40 to 800 per foot of wheat drillrow.

By May 22, populations in oats ranged from 6 to 1000 per foot of oat drillrow in the northwest area. Populations over the remainder of the State had declined rapidly, due to predators, parasites and diseases.

By June 6, greenbug populations were practically non-existent throughout the State. Very heavy incidence of barley yellow dwarf was occurring throughout most of the counties north of the Missouri River.

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YELLOW DWARF VIRUS IN MONTANA IN 1959

E. L. Sharp

In 1959 yellow dwarf virus was most prevalent on barley, but was also found on oats in localized areas.

Barley in several counties of the State was infected with the disease, but most damage was probably caused in Gallatin, Park, Broadwater and Jefferson counties. Many barley fields were attacked quite late in the season, so losses were not extensive. A few later planted fields were observed that suffered a 50 percent loss as a result of the disease. The vector was identified by the State Entomologist as the corn aphid. This aphid preferred feeding on barley as compared with wheat and oats. Adjoining fields of wheat and oats were often non-infested and apparently non-affected.

The yellow dwarf virus on oats was observed in Ravalli, Missoula, and Teton counties. Losses were generally not extensive, but some fields were heavily damaged. As high as 50 percent losses were estimated in Ravalli County. In the Fairfield bench area of Teton County yields ranged from 35 to 50 bushels per acre. Ordinarily some fields in this area yield around 100 bushels per acre.

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DIFFERENTIAL TRANSMISSION OF BARLEY YELLOW DWARF VIRUS  
FROM FIELD SAMPLES BY FOUR APHID SPECIES<sup>1</sup>

W. F. Rochow<sup>2</sup>

Summary

Barley yellow dwarf virus (BYDV) was recovered from 109 of 137 oat samples (from 13 States) and from 18 of 23 barley samples (from 5 States) tested for suspected infection by the virus. Comparative transmission tests from each sample were made by means of apple grain, English grain, and corn leaf aphids, and greenbugs. BYDV was recovered from 68 samples by English grain aphids only, from 14 by apple grain aphids only, and from 25 by both apple grain and English grain aphids. It was recovered from 12 samples by corn leaf aphids only and by corn leaf aphids from 7 samples from which other species also transmitted virus. BYDV was transmitted by greenbugs from 2 samples, one of which also was positive with corn leaf aphids. Recovery of virus by the different aphids frequently varied with the area in which the samples had been collected. Predominant transmission from samples from Mississippi, Texas, Pennsylvania, and New York was by English grain aphids only. Apple grain aphids were most effective in transmission from samples from California and Illinois, whereas corn leaf aphids were most effective only for samples from Gainesville, Florida.

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Direct comparative tests on transmission of barley yellow dwarf virus (BYDV) by apple grain (AG) and by English grain (EG) aphids have been made in Washington and in New York. In Washington virus was generally recovered by both aphids (2, 8), but in New York the virus was usually recovered only by EG aphids (4, 5). Since the AG aphid has been used effectively for transmission of this virus in other areas of the United States (1, 3, 7), it appeared that strains of BYDV in New York might be different from those common in other areas. Current ideas on vector specificity of strains of BYDV (5, 6, 8) emphasize the importance of knowledge about occurrence of strains of this virus. One purpose of the present study was to determine whether the EG-transmitted strain of virus is common only in one section of the United States, as available data indicate.

Virus had been recovered by AG or EG aphids from all but 5 of the 80 New York samples tested previously in this laboratory (4, 5). One possible explanation for failure to recover virus from these 5 samples is that they were infected with vector-specific strains of BYDV that would have been transmitted only by aphids different from the two used (5). A second purpose of the present study was to compare the action of two additional aphid vectors with that of the two species used previously in the transmission of BYDV from field samples.

#### MATERIALS AND METHODS

The four aphid species used in this work have been shown by Oswald and Houston (3) to be vectors of BYDV. They were as follows: 1) apple grain (AG) aphids (Rhopalosiphum fitchii (Sand.)), these aphids have been identified as R. fitchii by several entomologists but one worker has identified them as R. padi L.); 2) English grain (EG) aphids (Macrosiphum granarium (Kirby)); 3) corn leaf (CL) aphids (Rhopalosiphum maidis (Fitch)); and 4) greenbugs (Toxoptera graminum (Rond.)). AG and EG aphids were those used previously (4, 5). CL aphids were collected in Ithaca, New York, in the fall of 1958. Greenbugs were supplied by H. H. Luke and A. N. Tissot from Gainesville, Florida in February 1959. Virus-free stock colonies of all four species were started weekly from newly emerged nymphs and maintained

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<sup>1</sup>Cooperative investigation of Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Cornell University Agricultural Experiment Station; supported in part by a PHS research grant, E-2540, from the National Institutes of Health.

<sup>2</sup>Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Assistant Professor, Cornell University. Grateful acknowledgment is made to Reidar Haavie, Anna Greenmun, Maureen Quinn, and Glenn Benjamin for part-time assistance and to the cooperators listed separately who collected most of the samples.

according to precautions described previously (4, 5). Although all aphid colonies have remained virus free, some aphids from each colony used always were tested as nonviruliferous controls.

Samples tested were either collected by the writer (for New York) or sent between moist blotters by one of the following: H. H. Luke (Florida), D. D. Morey (Georgia), T. T. Hebert (North Carolina), P. G. Rothman (Mississippi), H. C. Murphy and M. C. Futrell (Texas), H. C. Murphy and C. A. Suneson (California), H. C. Murphy and J. M. Poehlman (Missouri), Henry Jedlinski (Illinois), J. A. Browning (Iowa), K. D. Fezer (Minnesota), D. C. Arny (Wisconsin), and B. F. Coon and R. D. Schein (Pennsylvania). Samples received from H. C. Murphy from South Dakota and from J. T. Slykhuis from Ontario had deteriorated in the mail and were not tested. Tests were made on 137 oat samples and on 23 barley samples.

Each sample consisted of a single leaf collected in the field from a plant believed to be infected by BYDV. Since only one leaf was collected from a plant, each test represents a different field plant. Each leaf that was still turgid when received was cut into four longitudinal sections. Each section was placed in a separate dish containing moistened filter paper and infested with AG, EG, or CL aphids, or greenbugs (except for some Florida samples) as described previously (4) except for use of plastic dishes with tight-fitting covers instead of Petri dishes. The leaf sections were incubated at 15° C for an acquisition feeding period of 24 to 48 hours. A comparable group of aphids from each colony used was placed in a separate dish on healthy seedlings to serve as a nonviruliferous aphid control.

At the end of the acquisition feeding period the dishes were taken to the greenhouse, where aphids from each dish were transferred to three seedlings of California Red oats (C.I. 1026) in groups of about 10 aphids per seedling. The test seedlings had been grown in steam-sterilized soil in 4-inch pots. Most of the aphids used were mature apterous females, but often other forms were included in each group. Test seedlings were caged by means of pot cages during a 3-day inoculation test feeding period. Then all aphids were killed by fumigation with lindane in a closed chamber. Plants were next placed on a greenhouse bench under supplemental illumination and were observed at intervals for at least 4 weeks. The reactions of all three plants in each pot generally were the same, but results were considered positive if any one of the three plants developed symptoms of infection by BYDV.

## RESULTS AND CONCLUSIONS

BYDV was recovered from 109 of the 137 oat samples tested (Table 1). The virus was transmitted by EG aphids only from 36 New York samples and from 27 other samples from nine different States. Virus was recovered by EG aphids from 24 additional samples from which one or more other aphid species also transmitted. That is, EG aphids transmitted BYDV from a total of 87 of the 109 oat samples from which the virus was recovered. BYDV was transmitted by AG aphids, either alone or in addition to other aphid species, from 33 samples. It was transmitted by CL aphids from 16 oat samples. In only two cases was the virus recovered by greenbugs.

When BYDV was transmitted from a leaf by more than one aphid species, the relative severity of disease caused by the isolate transmitted by each aphid species was generally the same. There was some variation among isolates in severity of disease caused, but this variation was not related to the aphid species which had transmitted.

Although very few samples were tested from many areas, it is clear that samples from New York were not the only ones from which predominant transmission was by EG aphids only (Table 1). Most of the transmissions from samples from Mississippi, Texas, Pennsylvania, and New York were by EG aphids only. Four of these EG-isolates from States other than New York were tested in an additional transfer by means of the four aphids. Since all four virus isolates again were transmitted only by EG aphids, they appear to be similar to the EG-specific strain obtained from New York in 1957 (4, 5).

This EG-transmission was in contrast to that from samples collected in California and Illinois, from which all recoveries were by AG aphids, either alone or in addition to other species (Table 1). Samples from Florida were still different. Thirteen samples from Gainesville, Florida were tested with CL aphids; virus was recovered from 9 of them. Only occasional recoveries by CL aphids were obtained from samples from other areas (Table 1). Moreover, samples from Quincy, Florida appeared to be different from those from Gainesville, since virus was recovered from all three Quincy samples by EG aphids only.

Transmissions by CL aphids were of special interest since some of them support the idea that other vector-specific strains of BYDV exist. Virus was recovered by CL aphids from 10

Table 1. Comparisons of action of apple grain (AG), English grain (EG), and corn leaf (CL) aphids, and greenbugs (GB) in virus transmission from field samples of oats with symptoms of infection by barley yellow dwarf virus (BYDV).

Source of sample	:	Number of leaves from which BYDV was transmitted, over number of leaves tested	:	Grouping of BYDV-positive leaves according to transmission (+) or nontransmission (-) by each of the four aphid species				
				Number of leaves in group	: Transmission pattern			
					AG	EG	CL	GB
Florida <sup>a</sup>		13/23		7	-	-	+	-
				1	-	-	-	+
				1	-	-	+	+
				1	+	+	+	-
				3 <sup>b</sup>	-	+	-	-
Georgia		2/2		2	-	+	-	-
North Carolina		2/2		1	-	+	-	-
				1	+	+	-	-
Mississippi		8/12		5	-	+	-	-
				3	+	+	-	-
Texas		6/8		5	-	+	-	-
				1	+	+	-	-
California		13/17		7	+	-	-	-
				5	+	+	-	-
				1	+	+	+	-
Missouri		1/3		1	-	+	-	-
Illinois		4/5		2	+	+	+	-
				1	+	+	-	-
				1	+	-	-	-
				1	+	+	-	-
Iowa		3/4		1	-	-	+	-
				1	-	+	-	-
				1	+	+	-	-
Minnesota		4/4		2	+	+	-	-
				1	-	+	+	-
				1	-	+	-	-
Wisconsin		1/4		1	-	-	+	-
Pennsylvania		10/10		8	-	+	-	-
				1	+	-	-	-
				1	+	+	-	-
New York		42/43		36	-	+	-	-
				4	+	+	-	-
				1	+	-	-	-
				1	-	-	+	-

<sup>a</sup>All Florida samples were tested with EG aphids and greenbugs. Only 18 samples were tested with AG and only 16 with CL aphids.

<sup>b</sup>These three samples were from Quincy; the others were from Gainesville, Florida.

oat samples that were negative on the basis of tests with the other aphids (Table 1). Seven of these samples were from Gainesville, Florida and one each was from Iowa, Wisconsin, and New York. In 1958 the writer had tested 13 samples sent from Gainesville by H. H. Luke; all were negative, but the tests had been made only with AG and EG aphids. Preliminary tests with some of the CL-transmitted isolates suggest that a degree of vector-specificity exists for these isolates, as it does for some AG- and EG-transmitted ones (5).

Results from the barley samples (Table 2) were similar to those from oats. BYDV was recovered from 18 of the 23 samples tested. All transmissions from California samples were by AG aphids. EG aphids were most effective for New York samples. In two cases virus was recovered only by CL aphids.



Table 2. Comparisons of action of apple grain (AG), English grain (EG), and corn leaf (CL) aphids, and greenbugs (GB) in virus transmission from field samples of barley with symptoms of infection by barley yellow dwarf virus (BYDV).

Source of sample	:	:	Grouping of BYDV-positive leaves according to transmission (+) or nontransmission (-) by each of the four aphid species					
	:	:	Number of		Transmission pattern			
	:	:	leaves in group	AG	EG	CL	GB	
Texas	1/2	1	+	-	-	-		
California	4/6	3	+	+	-	-		
		1	+	-	-	-		
Pennsylvania	1/2	1	+	-	-	-		
New York	7/8	5	-	+	-	-		
		1	+	+	-	-		
		1	-	-	+	-		
Wisconsin	5/5	2	+	+	-	-		
		1	+	+	+	-		
		1	+	-	-	-		
		1	-	-	+	-		

In all tests plants infested with aphids as nonviruliferous controls remained healthy.

It should be emphasized that these are data only on recovery of BYDV from detached-leaf field samples and that they do not necessarily have any bearing on the relative importance of the different aphids as vectors of the virus in nature. The results do suggest, however, that the important aphid vector of one area may be different from that of another area, and the results reported here may be of value as a guide to field studies on the relative importance of different aphids as vectors of BYDV in nature. These results also emphasize the problems involved in interpreting results of negative transmission tests when only one or two aphid species are used.

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BARLEY YELLOW DWARF VIRUS DISEASE OF OATS IN NEW YORK IN 1959<sup>1</sup>W. F. Rochow and E. D. Jones<sup>2</sup>

This was not an unusual year in New York for infection of oats by barley yellow dwarf virus. As in previous years, infected plants were found in all oat fields examined during the season. Infection was present only in trace amounts in most fields early in the season. The amount of infection increased during the season; the majority of infections occurred late and had less effect on yield than did the early ones.

In the Ithaca area infected oat plants were first observed late in May. English grain aphids were commonly observed in oat fields; they were particularly abundant during the middle of June. Other aphid species were not found, but no serious attempts were made to find them. For the second year, progeny of some Cornell oat crosses (Craig x Alamo) showed resistance to natural infection.

Perhaps the most significant observation from this area is that in 4 years not a single field of oats beyond the seedling stage has been found to be free of this disease.

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<sup>1</sup> Cooperative investigation of Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Cornell University Agricultural Experiment Station.

<sup>2</sup> Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture; and Assistant Professor of Plant Pathology, Cornell University, respectively.

## YELLOW DWARF OF CEREALS IN NORTH CAROLINA IN 1959

T. T. Hebert, D. M. Kline, and R. W. Toler<sup>1</sup>

Yellow dwarf was widespread on small grains in North Carolina in 1959. It was observed in all parts of the State, but was more prevalent in the Coastal Plains and Piedmont than in the Mountains. In some fields only a few scattered infected plants were observed, while in other fields infection approached 100 percent. Symptoms on oats were much more pronounced than on wheat or barley. A reddening of the leaves was the principal symptom on oats. Only a small percentage of wheat and barley plants showed yellowing of the leaf tips even in nurseries where a high percentage of oat plants had red leaves.

### APHID VECTORS

Since the yellow dwarf virus is transmitted by aphids, a limited survey was made to determine the relative prevalence of aphid species on small grains in North Carolina. In fall collections the greenbug, Toxoptera graminum (Rondani)<sup>2</sup>, was the predominant species. This aphid was found in practically every field visited and was causing considerable damage in a number of fields. Rhopalosiphum padi (Linn.) (Kaltenbach) was present in about 10 percent of the fields visited and was collected from wheat, oats, barley, and rye. The corn leaf aphid, Rhopalosiphum maidis (Fitch), was found in about 20 percent of the barley fields, but this aphid was not found on wheat, oats, or rye. The apple grain aphid, Rhopalosiphum fitchii (Sanderson), was observed in only one field. During the winter the aphid population decreased to a very low level. However, by late February and early March aphids were more numerous. Collections made in March, April, and May were predominantly the English grain aphid, Macrosiphum granarium (Kirby). Although this aphid was found in practically all fields visited, usually only a small percentage of the plants were infested. The prevalence of R. padi and the corn leaf aphid was about the same in the spring as in the fall. The greenbug was found in only two fields in the spring. No other known vector of the barley yellow dwarf virus was found.

### TRANSMISSION TESTS

Although no yellow dwarf symptoms were apparent in November, aphids were collected in fields and tested in the greenhouse to determine if they were viruliferous. Fourteen collections of greenbugs, two collections each of corn leaf aphids and R. padi, and one collection of apple grain aphids were tested and found to be non-infective.

Ten to twenty seedlings on which aphids were feeding were collected in the fall in each of ten fields, transplanted to the greenhouse, and observed for symptoms of yellow dwarf. Only a single plant developed symptoms of yellow dwarf. Greenbugs were feeding on this plant at the time it was collected; however, other aphids may have fed on it previously. These limited tests indicate that only a small percentage of the plants in fields were infected with yellow dwarf in the fall.

In the spring aphids were collected in fields in which plants were showing symptoms of yellow dwarf. These aphids were allowed to feed on apparently diseased plants collected from the same field and then on test plants. In a few cases virus-free aphids were used to check for the presence of the yellow dwarf virus. The barley yellow dwarf virus was transmitted from plants from 8 of 10 locations with the English grain aphid, from 4 of 5 locations with R. padi, and from 1 of 3 locations with the corn leaf aphid. A single test with the greenbug failed to transmit the virus.

### VARIETAL REACTIONS TO YELLOW DWARF

A rather uniform infection of yellow dwarf occurred in a planting of the Uniform Central Area Oat Nursery at Clayton, North Carolina, and a somewhat less uniform infection occurred

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<sup>2</sup>Grateful acknowledgment is made to Mr. A. T. Olive, Department of Entomology, North Carolina State College for identification of the aphids.



Table 1. Reaction of oat varieties and selections to yellow dwarf in the field.

C. I. number <sup>a</sup>	Variety or selection	Disease rating <sup>b</sup>	
		Clayton	Salisbury
		April 29,	May 13,
		1959	1959
7175	Victorgrain 48-93	3.0	1.5
6977	Midsouth	2.9	1.5
7239	Vict. x (Bonda x H. J. x S.F.)		
	Md. 116	2.1	2.0
7403	Coker's 58-7	2.1	2.0
1815	Appler	3.0	3.5
7421	Coker's 57-20	1.5	1.5
7418	Luke's H. V. Res. Vict.		
	Fla. 284-2	2.5	1.5
7415	Luke's H. V. Res. Vict.		
	Fla. 303-9	2.5	2.0
7229	Moregrain	2.0	2.5
7294	Coker's 57-11	2.6	3.0
3531	Fultex	2.1	2.5
7304	(Vict. x Coker's 52-22) x 6671	1.8	2.0
7225	(L-V x Fulwin) x Bonda	1.9	1.5
6994	Tennex x (Victoria-H. B.)	2.6	2.0
7143	Tennex x (Victoria-H. B.)	2.8	2.5
Check	Lee	1.4	1.0
7231	C. Red x (Cl <sup>2</sup> x S.F.)	2.1	3.5
6571	Bronco	1.9	1.5
4660	Mustang	2.1	4.0
7136	(L-V x F) x (F-A) x Land.	2.1	3.0
7307	(Atl. x (Cl <sup>2</sup> -S.F.)) x Imp.		
	Garry Md. 370	1.5	1.0
7308	Win. x (Cl <sup>2</sup> -S.F.) x Imp.		
	Garry Md. 2950	1.3	1.0
7309	Win. x (Cl <sup>2</sup> -S.F.) x Imp.		
	Garry Md. 2725	1.4	1.5
4657	Arlington	1.3	1.0
7311	Arl. x ((B-H. J.) x S.F.)		
	Md. 333	1.4	2.0
1815	Appler	3.9	4.0
7220	Arl. (Win. x (Cl <sup>2</sup> -S.F.))		
	Md. 310	1.3	1.0
7413	Arl. (Win. x (Cl <sup>2</sup> -S.F.))		
	Md. 232	1.5	2.0
7416	Arl. (Win. x (Cl <sup>2</sup> -S.F.))		
	Md. 222	1.3	1.5
7417	Arl. (Win. x (Cl <sup>2</sup> -S.F.))		
	Md. 251	1.9	1.5

<sup>a</sup> C. I. refers to the accession number of the Cereal Crops Research Branch, Crops Research Division.

<sup>b</sup> Relative degree of leaf reddening; 1 = little or no reddening, 4 = maximum reddening. Averages of four replications at Clayton and two replications at Salisbury.

Table 2. Reaction of winter barley varieties and selections to inoculation with the barley yellow dwarf virus.

C. I. number	Variety or selection	Reaction to yellow dwarf <sup>a</sup>	
		Test 1	Test 2
		February 17, 1959	April 13, 1959
6728	Wong	7	9
8067	Hudson	7	9
8062	Colonial 2	5	5
9170	Davie	10	10
7576	Cordova	8	5
9564	Tex. 10-47-84	9	9
9565	Tex. 10-47-136	8	9
7524	Harbine	9	9
9174	Rogers	9	10
9566	Pace	5	5
9569	Oma	4	4
9570	Kenate	5	8
7574	Kenbar	6	8
8107	Marconee	9	9
8065	Calhoun M450-4	10	10
10298	N. C. 954	10	10
9517	Dayton	6	9

<sup>a</sup> Based on stunting; 1 = no apparent stunting; 10 = very severe stunting.

in this group of varieties at Salisbury, North Carolina. Ratings were made on the relative amount of reddening of the varieties at each location (Table 1). Appler appeared to be the most susceptible variety of this group. Arlington and Lee showed a relatively small amount of leaf discoloration. Several experimental lines also appeared to have considerable tolerance.

Barley varieties from the Uniform Winter Barley Nursery of Semihardy Varieties were inoculated in the three-leaf stage in the greenhouse by allowing viruliferous *R. padi* aphids to feed on them for 3 days. The aphids were then killed, and the plants were grown in the greenhouse for observation. The most conspicuous symptom was stunting as compared with uninoculated plants of the same variety and only a small amount of yellowing developed. The varieties were rated for degree of stunting about 6 weeks after inoculation (Table 2). Oma, Pace, and Colonial 2 appeared to have some tolerance to yellow dwarf in these tests, whereas Davie, Calhoun M450-4 and N. C. 954 appeared to be very susceptible. In the field, however, Davie appeared to be only slightly more susceptible than Colonial, although neither variety was very severely affected by yellow dwarf.

Field observations indicated that there was little difference in reaction to yellow dwarf among the wheat varieties commonly grown in North Carolina. None of the varieties appeared to be greatly affected in 1959. When inoculated in the seedling stage in the greenhouse, Anderson showed somewhat more leaf yellowing than did Atlas 66, Atlas 50, Taylor 49, Knox, Seneca, and Thorne. Although moderate stunting was observed, these varieties differed little in stunting.

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BARLEY YELLOW DWARF ON OATS IN OHIODale A. Ray<sup>1</sup>

Symptoms of barley yellow dwarf have been observed on oats in farmers' fields in central and southern Ohio and in the experimental-plot nurseries at Columbus for several years. The leaves on oat plants in localized areas in fields showed varying degrees of chlorosis, from a water-soaked colorless condition through shades of yellow to deep red. On early inspection, nutrient deficiencies were suspected. The apparent damage in reduction of crop yield was not usually significant, owing to the limited areas of attack in the fields.

The first indication of the potential for serious damage to the oat crop by a high incidence of the disease was provided in a study at Columbus in 1958 on the influence of date of seeding on oat yields. Over 100 entries of spring oats were seeded in single five-foot rows on April 4 and May 8. Little infection was observed on any entries in the early planting, but the entire seeding in May was severely damaged with yellow dwarf and very little seed was harvested on maturity. The effect of the disease appeared to be most critical in direct relation with the relative maturity ratings of the entries. Computation of reduction in yield due to barley yellow dwarf was not possible since infection was confounded with date of seeding and no entries could be used as checks since all were damaged.

The incidence of yellow dwarf on oats was more widespread in occurrence in 1959. The reduction in yield was indirectly related to the stage of plant development when the symptoms first occurred. Local areas in fields or entire fields in central Ohio which were attacked early in the growing season and several fields of late-maturing varieties, such as Rodney and Garry, gave only limited production. Estimates of 0 to 75 percent reduction in yield of oats from yellow dwarf infection were reported from specific fields. Areas of infection in fields appeared to spread in a circular pattern from a localized center of initial attack.

Observational data on the extent of damage by the disease were recorded for all rod-row nursery plots at Columbus. Incidence of yellow dwarf was very general and no entry appeared immune. Local areas showed severe stunting of growth but there did not appear to be any relation between spread of the disease and the degree of susceptibility of the entries.

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# BARLEY YELLOW DWARF ON OATS IN OREGON<sup>1</sup>

W. B. Raymer and Wilson H. Foote<sup>2</sup>

Cereal yellow dwarf, first identified in Oregon in 1954, did not cause serious losses until 1957. Initially the virus appeared to be limited to the Willamette Valley of western Oregon, but in 1958 it was present in all of the counties along the Columbia River east of the Cascade Range and in the northeastern section of the State as far as the Idaho border. Although some losses to late-seeded spring grains occurred in the eastern part of the State in 1958, major damage has been confined to western Oregon. Losses in small grains due to yellow dwarf have increased yearly until 1959, when an estimated 20 to 25 percent of the total cereal crop in the Willamette Valley was destroyed.

Three circumstances certainly contribute to the continued seriousness of yellow dwarf in Oregon: 1) Large acreages of both cultivated and native grasses in western Oregon are susceptible to the yellow dwarf virus and act as reservoirs for the disease.

2) Rainfall in the Willamette Valley ranges between 40 and 50 inches annually, with appreciable amounts in the spring months. In most years, when the soil has dried sufficiently for spring planting, aphids are already plentiful and active. These aphids carry the virus from perennial grasses into the grain fields and infect the young plants in the 2- to 3-leaf stage or earlier. This early infection stunts both the foliage and root systems. The stunted root systems cause infected plants to suffer severe damage when moisture becomes scarce during the warm dry period in late spring and early summer.

3) The usually mild winters in the Willamette Valley appear to permit larger numbers of aphids to survive than is the case east of the Cascade Range where winter temperatures are much lower.

Loss estimates were first obtained in 1957 through a series of surveys made by the senior author. In 1958 and 1959 county agents were asked to conduct surveys in each of the 10 Willamette Valley counties. Farmers, warehousemen, field men and others in the grain trade were consulted on these surveys and the results adjusted by the county agents on the basis of their knowledge of farming practices and other conditions which affected the crop. A definite attempt was made to eliminate loss factors not directly connected with yellow dwarf.

By 1959 fairly accurate yield data were available for the 1957 and 1958 crops from the crop reporting service of Oregon State College and the United States Department of Agriculture. Preliminary estimates were available for the 1959 crop. Yield data for oats were available only as a figure representing the entire State. Since about 70 percent of the oat crop in the State (or about 200,000 acres) is grown in the Willamette Valley, the total yield for the State should reflect the losses to yellow dwarf in western Oregon. A "normal yield per acre" for the State was computed by averaging the yield per acre for the years 1954-56 as reported in commodity data sheets by the Oregon Crop and Livestock Reporting Service. A total potential yield for the State was then determined for each year by multiplying the acreage by the "normal yield per acre." The decrease in yield due to yellow dwarf as determined by the surveys was then computed as a percentage of the total potential yield. To compensate for the fact that the Willamette Valley represented only 70 percent of the total oat crop, the estimates were multiplied by a factor of 0.70. For example, the 1958 loss was computed as follows:

Total potential yield --

311,000 acres x 0.601 tons ("normal yield per acre") = 186,911 tons

Loss in the Willamette Valley estimated at 10 percent --

$0.10 \times 0.7 \times 186,911 = 13,083$  ton loss

$13,083 \times \$41.90$  (average seasonal price) = \$556,976

This procedure was employed in making the yield loss estimates from the survey material, as shown in Table 1.

To check the estimates from surveys, the total loss in oat production in the State was computed from the commodity data sheets. These losses were again based on a "normal yield per acre" equal to the average for 1954-56. These figures represented the total loss to the State without breakdown according to area or to cause. There was no attempt to separate the causes of this total decrease in yield, and such factors as a moderate outbreak of stem rust in the Klamath Falls area in 1958 were ignored. Losses from yellow dwarf should always be less than the total losses for the State. A comparison of these two types of estimates is presented in Table 1.

<sup>1</sup> Technical Paper No. 1276, Oregon Agricultural Experiment Station.

<sup>2</sup> Respectively, Assistant Professor, Department of Botany and Plant Pathology, and Professor, Department of Farm Crops, Oregon State College.

Table 1. Comparison of losses due to yellow dwarf of oats in the Willamette Valley with total losses in Oregon.

Year	Percent loss		Loss in tons		Loss in dollars	
	WV <sup>a</sup>	TL <sup>b</sup>	WV	TL	WV	TL
1957	5	4.1	6,289	7,475	\$263,509	\$313,202
1958	10	9.5	13,293	17,727	556,976	742,761
1959 <sup>c</sup>	32	14.8	34,732	23,066	1,562,940	1,037,970

<sup>a</sup>Losses due to yellow dwarf in the Willamette Valley computed from survey.

<sup>b</sup>Losses from all causes for the State as a whole computed from crop reports.

<sup>c</sup>All yield data for 1959 are preliminary estimates by the crop reporting service.

In 1959 the total decrease in yield computed from the preliminary crop reports is less than the loss estimated for yellow dwarf in the Willamette Valley alone. This discrepancy may be accounted for in three possible ways: 1) The loss estimates for yellow dwarf are too high. 2) The yield estimates of the crop reporting service are too high. 3) The crop reports are based on acres actually harvested. Several oat fields in almost all of the 10 counties surveyed were not harvested, owing to severity of damage to the crop by the yellow dwarf virus. At the present time it appears that the preliminary estimates of the crop reporting service may be too optimistic.

This 1959 season was notable in several respects. Aphids were extremely abundant even when medium-early planted grain was just emerging from the soil. In most areas there were no "escaped" healthy plants by the time they were in the "boot" stage. Losses ranged from 6 to 50 percent for individual counties in 1959.

The impact of this disease on farmers and the general economy of western Oregon has not yet been fully appreciated. Almost half of about one million acres cultivated in this region is devoted to grain crops. The prospect of continued heavy losses with no immediate solution in sight places these farmers in a difficult position. There is need for intensive research on this problem.

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YELLOW DWARF OF OATS IN TEXAS IN 1959I. M. Atkins and M. C. Futrell<sup>1</sup>

Yellow dwarf of oats was observed in a number of fields of oats in Texas in 1959. Yellow dwarf virus was positively identified in six of seven leaf samples sent to W. F. Rochow, Department of Plant Pathology, Cornell University, Ithaca, New York. The disease usually occurred in small areas a few feet to several yards across where plants were stunted and badly discolored. The forage value of oats was reduced in these areas, and no doubt grain production also was reduced. Because of the spotted nature of infection and its confusion with nutritional and other problems, estimates of damage were very difficult. Several species of aphids were prevalent throughout the winter and spring over large areas in Texas. These included the greenbug, corn leaf aphid, and apple grain aphid.

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<sup>1</sup> Agronomist and pathologist, respectively, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

OBSERVATIONS ON CEREAL YELLOW DWARF OF OATS IN WASHINGTON IN 1959<sup>1</sup>G. W. Bruehl and V. D. Damsteegt<sup>2</sup>

Cereal yellow dwarf is considered an endemic disease of small grains in western Washington and a potential epidemic disease of those hosts in the State east of the Cascade Mountains. The areas differ mainly because of differences in climate on the two sides of that partial barrier to the maritime Pacific air masses and the influence of the Japanese Current (1). As in most seasons, in 1959 yellow dwarf was widespread west of the Cascades in oats, wheat, and barley, and of little or no consequence in eastern Washington. Observations of yellow dwarf in western Washington were concentrated at the Southwest Washington Experiment Station, Vancouver. Some observations made there are reported below.

The aphids responsible for the spread of yellow dwarf in that area in 1959 were primarily of local origin. Nymphs and adults (parthenogenetic females) were observed in winter cereals at weekly or bi-weekly intervals all through the winter of 1958-1959, and in the very early spring. The egg stage was not necessary for the overwintering of the apple grain (Rhopalosiphum fitchii Sand.), English grain (Macrosiphum granarium Kirby), or the rose grass aphid (Macrosiphum dirhodum Walker) in this winter season, and the aphids overwintered in such numbers as to multiply quickly in the early spring.

Yellow dwarf in western Washington usually develops relatively evenly in entire fields, with little or no border effect along grassy roadsides or fence rows or spots to indicate foci of infection. This is taken as evidence of invasion by large flights of winged aphids, with the aphids distributing themselves among the young grain with uncanny uniformity. This uniformity of aphid distribution is most noted in relatively level fields. In the cool early spring the aphids tend to congregate and multiply on the warmer, sunnier exposures of hilly fields.

Aphid populations in spring oats fluctuated markedly in early spring, then seemed to stabilize at low to moderate levels for the remainder of the cereal growth period. Early seeded (April 6-9) spring oats were most heavily invaded. The aphid population reached a peak about May 1 to May 10, and then dropped abruptly. Oats seeded about May 1 emerged late enough to miss the greatest aphid invasion and they fared a little better, but such fields became completely infected by the yellow dwarf virus by the tillering stage. This greater invasion of early-seeded oats is at variance with experience in most regions and seasons.

In areas with frigid winters, spring seeding is delayed until the soil is thawed and then dried enough for seeding. The low temperatures of late winter and early spring prevent aphid multiplication so that these early-seeded fields escape early infestation, barring a migration of aphids from a warmer area. In contrast, western Washington soil is thawed in early spring and could be seeded except for an excess of moisture. Overwintered aphids multiply slowly during the prolonged period in which the moderately cool but damp soil becomes dry enough to permit tillage and seeding. Under these circumstances aphids of local origin are sufficiently abundant to infest even the earliest seedings of spring oats. In all probability seeding date cannot be used effectively as a means of control west of the Cascades in Washington.

An attempt to measure the loss from yellow dwarf in a field of Shasta oats by placing aphid-tight nylon mesh screen cages over the seeded oats prior to emergence was only partially successful. The caged oats remained aphid-free and developed no symptoms of yellow dwarf and were taller than uncaged oats, but they were somewhat pale and failed to tiller. Caged oats outyielded the uncaged oats by only 5 bushels per acre. A comparable shade was placed over some oats at 10 inches of height after they were showing symptoms of yellow dwarf and after two to three tillers per plant had developed. This shading resulted in taller plants but a yield reduction due to shading of 5 bushels per acre. As the shading by the cage decreased the yield of oats by at least 5 bushels, and the caging preventing infection increased the yield over the uncaged area by 5 bushels, the yellow dwarf loss was estimated at 10 bushels per acre. This 10 bushels per acre is believed to be an underestimation.

The active world spring oat collection of the United States Department of Agriculture was seeded in short rows for screening for yellow dwarf resistance. Albion, C.I. 729, the most

<sup>1</sup>Scientific paper No. 1915, Washington Experiment Stations, Pullman. Work conducted under Project No. 1280, in cooperation with the Agricultural Research Service, Farm Crops Division.

<sup>2</sup>The authors wish to acknowledge the assistance of the personnel of Southwest Washington Experiment Station, Vancouver. Joseph C. Craddock of the United States Department of Agriculture furnished seed of over 3500 oat varieties for testing. R. M. Endo and D. C. Arny also kindly gave the authors seeds of some promising oats.

resistant common oat (*A. sativa*) found by Endo (2), in his study in Illinois, and Saia, C.I. 4639 (an *A. strigosa* selection) were seeded in every eleventh and twelfth row as standards. In this nursery of 3587 entries, 306 oats were judged equal to Albion and 139 superior to it. Saia was more tolerant than Albion. Victory, a variety commonly grown in this area, appeared equal or superior to Albion. It is apparent that selection must be made against local strains. Further testing is needed before a reliable rating of the 445 oats judged equal or superior to Albion in this preliminary screening is possible. *Avena strigosa* x *A. sativa* hybrid selections were not promising, as none of the resistance of the *A. strigosa* parent had been retained.

In a limited trial of winter oats, Ballard Selection (C.I. 6980) and Fulwin (C.I. 3168) were more resistant than Gray Winter oats, the local standard winter oats.

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YIELD OF CERTAIN OAT VARIETIES UNDER NATURAL EPIDEMIC CONDITIONS  
OF YELLOW DWARF (RED LEAF) VIRUS IN WISCONSIN, 1959<sup>1</sup>

H. L. Shands and L. G. Cruger

Summary

Commercial oat varieties grown in Wisconsin in 1959 showed different degrees of susceptibility, or perhaps tolerance, to the yellow dwarf virus. Estimated yield damage of 32 varieties at the Marshfield Branch Experiment Station where there was a natural epidemic gave a high negative correlation (-.90) with actual yield. Ajax, Beedee, Burnett, Fundy, Garry and Newton had less damage than some other commercial varieties. Some unnamed selections had about as much tolerance as the above varieties.

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Ever since recognition of the viral nature of red leaf of oats there has been interest in obtaining varieties resistant to the disease. Several workers have published observations concerning reaction of a limited number of varieties. However, in 1957 Endo (3) summarized a 3-year study of the reaction of 4000 varieties of *Avena sativa* and other species to a moderately virulent strain of barley yellow dwarf virus. He inoculated in the three-leaf stage and found no immune or even highly resistant plants. He classified oat varieties in six reaction groups: extremely susceptible, very highly susceptible, highly susceptible, moderately susceptible, slightly resistant, and moderately resistant. In the last group he placed Saia (*Avena strigosa*, C.I. 7010), while Albion, C.I. 4918, and Fulghum were slightly resistant. Since he found so few resistant varieties, most workers are pessimistic concerning the value of this means of disease control.

Observations in Wisconsin in 1959 indicate the possibility of a practical type of tolerance to the yellow dwarf virus in certain commercial varieties. Evidence for this is the fact that farmers retained a good impression of the Beedee variety in 1959, even though the disease was seen in many oat fields.

## LITERATURE REVIEW

### Variety Reaction

Manns (5) in 1909 observed that oat varieties responded differently to blade blight. Although he believed that the blight was caused by bacteria, Manns made frequent reference to aphids and other insects. His descriptions suggest that he was working with yellow dwarf. In field plots Primus barley yielded only 9 bushels per acre while Oderbrucker produced 37.8. Wideawake oats yielded 55.2 bushels per acre compared with 73.5 for the Improved American variety. Two years earlier, Sixty Day oats yielded 57.0 bushels per acre, or 22.2 bushels more than the average of all varieties in the Ohio test plots.

In 1948 Rosen (7) described the red spot mosaic of oats in Arkansas. It is not known whether this was related to yellow dwarf. He noted that Traveler 15 oats was mixed in reaction and selected progenies from it that proved resistant. DeSoto and Victorgrain oats had no red spot. Rosen classified Lee, Custis, and Winter Turf as highly resistant. Several Red Rustproof strains showed only mild symptoms.

In 1952 Rosen (8) (after Oswald and Houston had clearly defined the barley yellow dwarf virus problem) found severe chlorosis in Nortex oats. Arkwin, Fulghum 708, Fulwin and an unnamed selection appeared highly resistant. Traveler 15-8, DeSoto, Victorgrain and Red Rustproof strains were susceptible. In 1953 Oswald and Houston (6) in California listed the reactions of a limited number of oat varieties. The tolerant varieties were Kanota and Bond. Those intermediate in reaction were Westdale, Ventura, Palestine, Custis, Lee, Richland and Victory. Others were highly susceptible, while California Red and Coast Black were stated to be extremely susceptible.

In 1955 Bruehl and Toko (2) stated that Bannock was the most tolerant variety available in their tests in Washington. Ajax, Andrew, Rodney and Roxton were fairly tolerant. Several highly susceptible varieties were Garry, Marida, Overland, Simcoe and Shelby. They used a

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<sup>1</sup>Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

Washington strain of the yellow dwarf virus and made comparisons with the findings of the 1953 work of Oswald and Houston (6). There was fair agreement with the barley tests, but not for some of the oat tests. Sill et al. (9) noted that Missouri 0-205 and Kanota were less susceptible to blue dwarf and red leaf than were Clinton, Nemaha and Cherokee. Working with aphid transmission of barley yellow dwarf virus of cereals in Ontario, Slykhuus et al. (11) used four oat varieties as test plants and found all highly susceptible. Clintland was more susceptible than Garry, Rodney or Winter Turf.

### Yield Reductions

In 1957 Suneson and Ramage (10) in California found yellow dwarf yield reductions in California Red oats up to 88 percent, of which 60 percent could be accounted for in fewer seeds and 25 percent in less weight per seed. Thirteen oat varieties had an average of 26 percent yield reduction. California Red had significantly less yield in 2 years of a 6-year period than Kanota, which they considered tolerant to the disease. Bruehl et al. (1) compared yields of oats, barley and wheat grown for 4 years at three stations in western Washington. They noted that after a very severe freeze in the fall of 1955, aphids were scarce the following spring. Thus, in 1956, oats, barley and wheat all yielded much above the average at the three locations of Mt. Vernon, Puyallup and Vancouver. The mild winter of 1957-58 may have favored overwintering of aphids, and oats yielded only 16 bushels per acre at Puyallup in 1958 in contrast to 133 bushels per acre in the good year of 1956. Endo and Brown (4) inoculated Fayette, Clintland and Rodney varieties with yellow dwarf in the three-leaf and boot stages. In the three-leaf stage the varieties had yield damages of 92.5, 94.4, and 75.8 percent, respectively. However, when the plants were inoculated in the boot stage, Fayette suffered only 10.4 percent yield reduction, Clintland 21.8, and Rodney 15.0, and they averaged near 76 bushels per acre.

Thus, the virus can be very damaging to oats, and there appears to be some confusion in regard to varietal reaction. The general opinion prevails that nearly all common oat varieties are susceptible, but with a few exceptions.

### OBSERVATIONS IN WISCONSIN

On July 13, 1959, when the writers were observing the Wisconsin State Uniform Oat Yield Nursery of 32 varieties at the Marshfield Station<sup>2</sup>, yellow dwarf was much in evidence. There appeared to be a definite differential response of varieties and notes were taken on the basis of estimated yield reduction caused by the disease. The four-replication average of estimated reduction ranged from 18.8 to 52.5 percent. After the grain was threshed weights were determined, and it was found that the average yield for the nursery was 35.8 bushels per acre. The average estimate of yield reduction by the virus was 35.1 percent. A correlation coefficient was calculated between the actual yield in bushels per acre and the estimated yield reduction in percent. The correlation was  $-.90$  with a regression of  $-.87$  bushels for each estimated percent damage in yield (Fig. 1). Based on an extension of the regression line and comparative nursery yields of non-constant entries of barley and oat selections for the previous 10-year period, oat yields may have been reduced approximately 25 bushels per acre. One hybrid selection yielded only 18.8 bushels per acre. Fayette, Clintland and Clintland 60 were also low in yield. Clinton outyielded Clintland and Clintland 60 at both Marshfield and Ashland.

The varieties Ajax, Beedee, Fundy, Garry and Newton appeared to have definitely less damage than others. Two unnamed selections, C.I. 7372 (Vicland<sup>2</sup>x Andrew-Landhafer sel.) and C.I. 7107 (Ajax x Hawkeye-Victoria), seemed to have less damage than average. C.I. 7372 is early and may have escaped for this reason. Beedee showed good production when serving as a "filler" for the nursery field.

Figure 2 illustrates guard rows of Clintland and Beedee oats. The amount of straw and grain of Clintland appeared to be definitely less than that of Beedee; Beedee produced 48.6 bushels per acre and Clintland 22.1. Figure 3 shows several consecutive plants taken from a Clintland guard row. The plants varied from only a few inches in height, for those with severe yellow dwarf damage, to tall plants with apparently little damage.

Somewhat similar observations were made at the Ashland Branch Station where the same varieties were included in the State Uniform Nursery. Instead of having a great deal of reddening of leaves and stunting of plants, Clintland and Clintland 60 had plants that appeared to be

<sup>2</sup>The cooperation of Russell Johannes in growing this nursery is acknowledged.

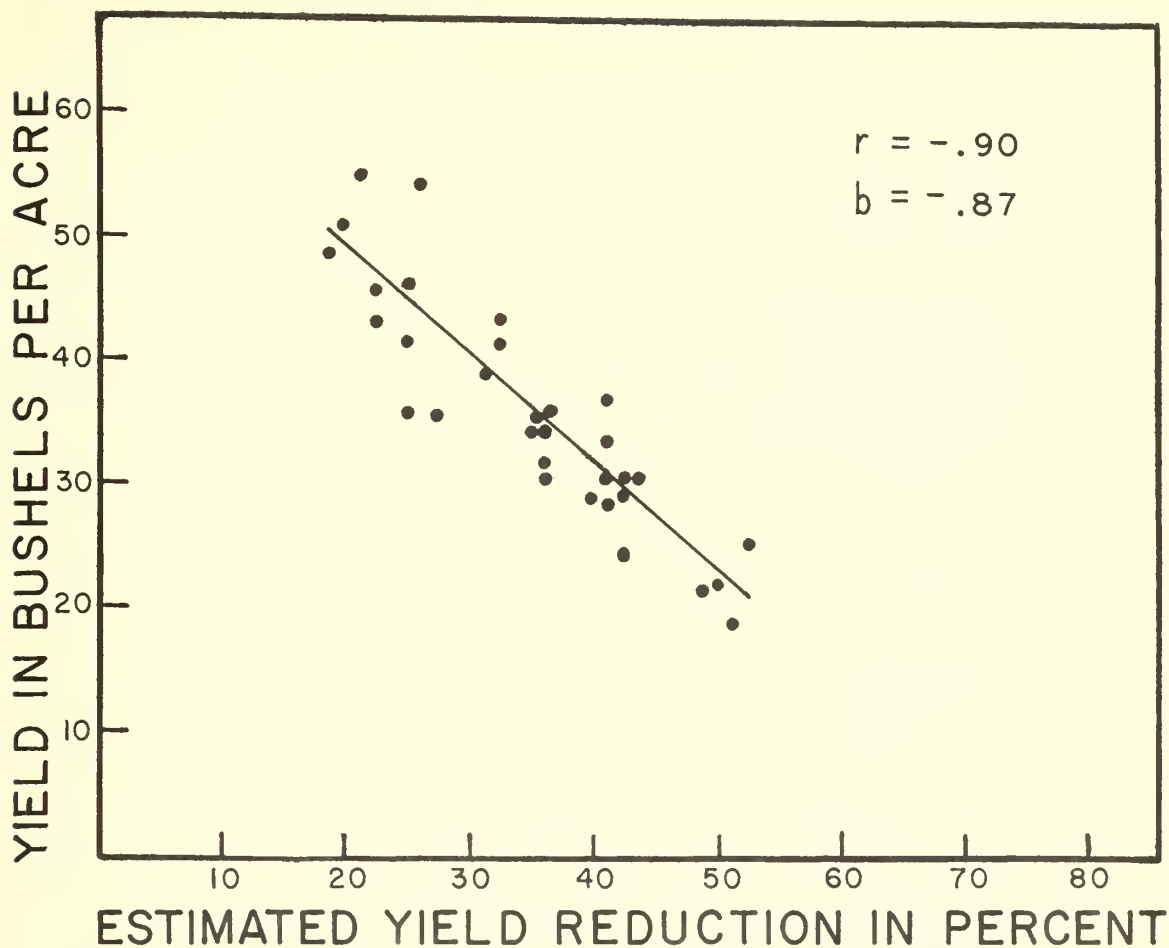


FIGURE 1. Yields of 32 oat varieties and their estimated percentage yield reductions during a natural epidemic of yellow dwarf at Marshfield, Wisconsin, 1959.



FIGURE 2. Guard rows of Clintland (left) and Beedee (right) at Marshfield, Wisconsin, where yellow dwarf was present, 1959.



FIGURE 3. Plants of Clintland with different severities of yellow dwarf infection, Marshfield, Wisconsin, 1959.



sprawled at the base and not as tall as in other tests. Furthermore, the plants seemed to have less seed per panicle, as well as an unproductive manner. This was verified also by the yield tests.

At the Ashland Station, X481-3, a selection from Arkansas 674 x C.I. 4629 (a Clinton type) growing in a Septoria test of L. S. Wood, appeared to be relatively free of red leaf. This observation will need further verification. In addition to those varieties found by Endo to be resistant, C. I. 1012 and C.I. 1050 from D. C. Arny appear to have resistance under field conditions. Albion, now in use as a resistance source, was grown on a million and a half acres in the North Central States in 1919. The selection and purification of the variety at Iowa was probably done during the "blade blight" years described by Manns. This suggests that red leaf may have helped separate adapted sorts a half century ago.

While it is realized that there may be many strains of the virus and that varieties may respond differently in different years, there seems to be a certain amount of tolerance in at least a portion of the commercial varieties now in use. It appears likely that some artificial tests for varietal reaction have been too severe, thus obscuring the responses of those varieties that may actually have enough low-grade resistance, or perhaps tolerance, to withstand modest virus infection in the field. This does not minimize the need for a good grade of resistance.

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OBSERVATIONS ON VECTORS OF BARLEY YELLOW DWARF VIRUS  
IN WISCONSIN

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Observations on the populations of aphids which can carry barley yellow dwarf virus are of interest in connection with the widespread occurrence of the red leaf disease of oats in 1959, although direct evidence of virus transmission was obtained in relatively few cases. Certain grain aphids are endemic and appear in about the same numbers each year. These are, the English grain aphid (Macrosiphum granarium (Kirby)), the apple grain aphid (Rhopalosiphum fitchii (Sand.))<sup>2</sup>, and the corn leaf aphid (R. maidis (Fitch)). The winged forms of these species usually appear during April, and for the apple grain aphid there is evidence that the earlier migrants are blown in from areas to the south. These aphids do not usually develop large populations, although the corn leaf aphid may build-up on barley and frequently does build-up on corn later in the season. Two other species, M. dirhodum (Wlk.) and R. poae (Gill.), are also vectors, but appear to be of little importance in the epidemiology of the disease.

The greenbug, Toxoptera graminum (Rond.), might be called an epidemic vector as it is rare in Wisconsin in most years but sometimes occurs in great numbers. In early May of 1959 winged migrants were carried into the State. In localized areas over the State the greenbug populations developed to high levels on the young oat plants and considerable feeding damage resulted. Increased incidence of red leaf of oats in 1959 has been largely attributed to the widespread occurrence of the greenbug, although in severe cases it was difficult to distinguish between damage caused by the virus, by aphids, and by drought.

An attempt was made to follow the development of aphid populations over a larger area of the country in the spring of 1959. In western and southwestern Arkansas<sup>3</sup> apterous R. fitchii and T. graminum were found on small grains from March 11-13 and alates were collected during early April. At Columbia, Missouri<sup>4</sup> peak numbers of greenbugs were obtained by sweeping on April 25 and in yellow pan traps during April 27-30. At Manhattan, Kansas<sup>5</sup> the peak collections of greenbugs in yellow pan traps were on April 29 and May 3. Large numbers of alate greenbugs appeared at Madison, Wisconsin from May 2-6. Since this period was characterized by strong southerly winds, these aphids were undoubtedly transported from areas considerably south of Wisconsin, where the aphid had already built up large populations. It has been reported that the greenbugs were blown into Minnesota from southwestern States between May 1 and 5<sup>6</sup>. Schafer et al.<sup>7</sup> reported an outbreak of greenbugs at Lafayette, Indiana during the second week of May.

If such cooperative aphid observations can be broadened, a much better understanding of aphid migrations will be obtained. The observations may also help to prevent damage from epidemics, both from the aphids themselves and from the barley yellow dwarf which they can introduce.

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<sup>2</sup>A very similar species, R. padi (L.), is also known to be a vector.

<sup>3</sup>Through the cooperation of G. E. Templeton, Department of Plant Pathology, University of Arkansas, Fayetteville, Arkansas.

<sup>4</sup>Through the cooperation of D. C. Peters, formerly Department of Entomology, University of Missouri, Columbia, and now at Iowa State University, Ames.

<sup>5</sup>Through the cooperation of R. H. Painter, Department of Entomology, Kansas State College, Manhattan.

<sup>6</sup>Anonymous. 1959. Scientists study greenbug and virus problems. Cargill Crop Bull. 34: 18.

<sup>7</sup>Schafer, John F., Ralph M. Caldwell, W. B. Cartwright, and R. L. Gallun. 1959. Prediction of oat yellow dwarf epidemics. Plant Disease Repr. 43: 1052.

OAT YELLOW DWARF OR RED LEAF IN WISCONSIN IN 1959

D. C. Arny and H. L. Shands

Red leaf symptoms in oats, as observed by the writers, were more impressive in 1959 than in any time within the last quarter century in Wisconsin. The situation appeared to result, in large part, from the presence of the barley yellow dwarf virus, which is transmitted by several aphid species.

In the southern part of the State, except in the extreme southeast, the disease appeared late enough so that the crop was not severely damaged. In the central and northern regions symptoms were complicated by drought conditions and/or by greenbug (Toxoptera graminum (Rond.)) damage. Contiguous areas 5 to 10 miles in diameter seemed to have markedly different symptom expression, suggesting that yields or yield reductions were probably quite variable.

In spite of the rather poor appearance of the crop in many areas of the State, the Federal-State Crop Reporting Service's September estimate of yield of oats was 48.0 bushels per acre for 1959, as compared with 46.1 bushels for the previous 10-year average. Since the growing season was considered neither highly favorable nor unfavorable, the average damage from BYDV was probably near 5 percent for the State.

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## YELLOW DWARF BIBLIOGRAPHY

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