PEACH BROWN ROT STUDIES IN BERRIEN COUNTY, MICHIGAN IN 1949

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Donald Harry Petersen

1949

This is to certify that the

thesis entitled

Peach brown rot studies in
Berrien county, Michigan
in 1949

presented by

Donald Harry Petersen

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Plant Pathology

Donald Cation
Major professor

Date December 8, 1949

O-169

PEACH BROWN ROT STUDIES

IN BERRIEN COUNTY, MICHIGAN

IN 1949

By

Donald Harry Petersen

A THESIS

Submitted to the School of Graduate Studies of Michigan

State College of Agriculture and Applied Science

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

Department of Botany and Plant Pathology

Year 1949

INDEX

Acknowledgements

Introduction 1

Literature review . . . . 2 - 12

Canker studies . . . . 13 - 17

Introduction 13

Methods and materials 13

Results . . . . 14 - 17

Fungicidal control of brown rot . . . . 18 - 52

Introduction 18

Blossom sprays . . . . 18 - 31

Introduction 18

Methods and materials . . . . 19 - 24

Results . . . . 24 - 31

Post-bloom sprays . . . . 32 - 40

Methods and materials . . . . 32 - 38

Results . . . . 39 - 40

Pre-harvest sprays . . . . 41 - 52

Methods and materials 41

Results . . . . 42 - 52

Fungicidal applications under conditions of heavy inoculum . . . . 52 - 54

Dipping tests . . . . 54 - 57

Methods and materials . . . . 54 - 55

Results . . . . 55 - 57

Observations . . . . 58 - 59

Conclusions . . . . 60 - 61

Literature cited

Conclusions . . . . 60 - 61

Literature cited

Acknowledgements

The writer wishes to express his appreciation for the opportunity of the counsel and guidance of Mr. Donald Cation, Associate Professor (Research). Without his initiative and assistance in planning, the field and laboratory studies would have been most difficult. And to the Standard Oil Company (Indiana), particularly Dr. C. R. Cleveland, Chief Entomologist, and Mr. George Day, for making possible the extended field studies, my sincere gratitude.

Introduction

The following work discusses various aspects of peach brown rot studied during 1949. Laboratory studies and field observations were made to determine the importance of over-wintered twig cankers as a possible source of primary inoculum. Field studies involved the relationship of humidity to the timing of blossom sprays, the testing of certain fungicides in the peach spray program, and testing various chemicals as post-harvest fruit dips in an attempt to prevent brown rot in storage and transit.

Literature Review

The common brown rot of peach encountered in Berrien County is caused by the fungus Monilinia fructicola (Wint) Honey (1). The generic name is of rather recent acceptance, the former being Sclerotinia. A group of species of Sclerotinia having a monilioid conidial stage were elevated to generic rank with M. fructicola as the type. The organism produces its conidial stage on infected parts of susceptible hosts and its apothecial stage on over-wintered mummies partially buried in the soil.

The primary infection of M. fructicola is largely restricted to the blossom blight phase of the disease. The rot of ripening, and in some cases, green fruit, may also be caused by conidia from over-wintered mummies hanging on the tree (21) and possibly conidia from over-wintered cankers.

The possible sources of inoculum for the primary infection are: ascospores from over-wintered mummies on the ground, conidia from mummies on the tree, and conidia from twig cankers.

A remarkable phenomenon is the production and maturation of ascospores from over-wintered mummies on the ground coincident with the opening of the peach blossoms. At one time it was thought that mummies had to be buried for two years in the soil before apothecia would be produced. However, many workers have demonstrated that first-year mummies are the most productive under favorable conditions. Roberts and Dunegan (21) in experimental trials maintained mummies

which produced apothecia for 6 succeeding years though in diminishing numbers from the abundant production of the first year.

The most favorable position for the mummy in respect to apothecial production is about half-buried in the soil. If they are completely buried the apothecia tend to produce imperfect ascospores. Those resting on top of the soil seldom get sufficient moisture to produce apothecia (12).

Peach mummies buried to a depth of 2 or 3 inches and more disintegrate rapidly. In fact, Ezekiel (12) found, with one exception, complete disintegration of mummies buried at 3, 8, and 18 inches at the end of 14 months. An entire mummy is not essential for apothecial production. Roberts and Dunegan (21) have observed a fragment of sclerotim 1 cm by 2 mm produce 3 average-sized apothecia.

While it has been felt by many investigators that ascospores are the most important source of primary inoculum, this has not been satisfactorily proven in all cases. In 1947 and 1948 Cation (7) observed extremely high percentages of blossom blight (up to 85%) in orchards that had no apparent source of primary inoculum, i.e. apothecia on the tree or over-wintered mummies on the trees.

Evidence of the over-wintering of the brown rot fungus can be seen readily after the first spring rains. The surface of the over-wintered mummies hanging on the trees becomes a mass of conidial tufts or sporodochia. The ability of the fungus to withstand the adverse conditions of cold and desiccation is due to the formation of a sclerotial

mat investing the outer tissues of the fruit. Though the majority of the rotted fruit and subsequent mummies fall to the ground before spring, some remain on the tree at least until blossoming time. Roberts and Dunegan (21) state that by late spring they become dry, cease to produce conidia, and fall to the ground. Several investigators have shown that conidia produced by these over-wintered mummies on the tree often cause blossom blight (2, 8, 20).

Conidial production may also occur in the fall of the year on newly formed mummies. It has been demonstrated that conidia formed at this time can survive the winter (22). Bartram (4) demonstrated the viability of conidia that had passed through winter temperatures as low as -32°C.

Active over-wintered twig cankers may represent a third possible source of spores for initiation of the primary infection.McClintock, in Georgia, (11) has reported observing conidia on twig cankers formed during the previous season. However, he later reported failure to find conidia on blossom blight cankers in their second year (18). Roberts and Dunegan (21) after 6 years experience in Georgia failed to find conidia on over-wintered cankers with but one exception. Smith (22) states that he occasionally saw conidial tufts on branches of the previous season's growth. Cook (9) in 1919 observed the production of conidia from cankers of the previous year and considered them important in the production of blossom blight. Berkeley (5), at St. Catherines, Ontario, reports in the spring of 1926 many cankers active and producing conidia. He found active 2-year old cankers and concluded that possibly cankers were sources of infection for the

blossoms.

It was once believed that the brown rot fungus after penetrating through a blighted blossom or rotted fruit to a twig, continued growing into the larger limbs where it expressed itself as a perennial peach canker (16). However, Willison points out that 97.8% of the twig cankers caused by blossom blight healed over during the summer they were formed and only 6.2% of those caused by rotted fruit increased in size during the winter. He found that none eventually resulted in the formation of Valsatype peach cankers. It was apparent that the brown rot fungus, in spite of its ability to attack wood and bark, was not a serious factor in the canker complex. However, as these lesions are open to invasion by other canker-producing organisms, these cankers may assume considerable importance indirectly (25).

In later studies, Willison (26) noted that brown rot cankers are usually delimited within a period of 3 weeks which corresponds to the time necessary for the host to lay down wood periderm and a wound-fum barrier. Still further studies by the same author (27) showed that out of 100 cankers caused by brown rot blossom blight, 80% were either healed or inactive the following year. 12 of the remaining 20 had caused twig blight and the twigs had died back nearly to the parent branch. The few typical cankers that developed were due to secondary infections of canker-producing fungi (Valsa Cincta and V. leucostoma). These studies are in agreement with those made by Hildebrand (13).

Blossom Blight Phase

Conidia from over-wintered mummies on the tree and possibly conidia from holdover twig cankers are distributed by the wind and rain. They may lodge on the floral parts, germinate, and penetrate the suscept tissues. The ascospores are violently discharged from the apothecium at maturity to be carried by the air currents. Some of these ascospores may settle on the blossom.

Either conidia from mummies or cankers, or the ascospores are capable of causing blossom infection and this has been demonstrated many times (15, 9, 17, 18, 20). However, the phenological factors of humidity and temperature may be of great significance during germination and incubation of these spores. Amos (1) showed conidial germination at 1°C, though growth of the germ tube was very slow. Ezekiel (11) was unable to observe any difference for the various strains of the fungus at the cardinal temperatures: minimum 3°C, optimum 25°C, and maximum 33°C. Weaver (23) found the time required for germination on peach petals floated on a 4% sucrose solution varied with the temperature, from 11 to 12 hours at 5°C and increasingly shorter periods for intermediate temperatures reaching a minimum of 2½ to 3 hours at 20°C. Higher temperatures resulted in longer periods for germination with no germination at 35°C.

Conidia require precipitated moisture for germination on glass slides. On blossoms, germination occurred only on the stigma at 80% relative humidity. 96% was required for germination on the anthers and petals, and 100% for all other floral parts.

The occurrence of severe blossom blight has most often been as-

sociated with hot, humid weather. Barss (3), however, studying brown rot in Oregon, found that the moist, cool weather of early spring was often favorable for blossom blight infection. It is probable in this case that the causal fungus may have been M. laxa. Weaver (23) noted pistil infection in 10 hours and resulting complete blossom blight in 4 days in a saturated atmosphere at 10°C. 18½ hours were required for petal infection under these conditions, and 34 hours were required for the fungus mycelium to spread from the petals to the calyx. It was found that floral parts had to be maintained in a saturated atmosphere 12 hours at 15°C to cause eventual complete blighting if the flower has been pollinated. If it remained unfertilized, only 16 hours of 100% relative humidity at 10°C were required for complete destruction. Given shorter periods in a saturated atmosphere, brown rot lesions developed in less than 10 to 16 hours but no complete blight occurred.

Weaver (23) states that at humidities of 90% and above the diseased areas of the petals did not dry out. At 80% the lesions were soon delimited and dried out. He also noted that the production of sporodochia and conidia on the diseased flower parts was dependent on high humidities. Sporodochia were present on infected stamens 48 hours after inoculation at 95% relative humidity. No sporodochia were produced on completely blighted blossoms at 70 and 80% humidities.

The first observations as to the infection courts on the blossoms were made by Woronin (38). He believed that under natural conditions the stigma was the infection court. Jehle (15) thought that infection began in the calyx and spread to the stamens and pistil. Roberts and Dunegan (20) state that any part of the blossom may be invaded, though

this is disputed by Whetzel (24). Weaver's work (23) on artificial inoculations agrees with that of Roberts and Dunegan. He states that at 90% relative humidity, 3 days after the inoculation the fungus had spread into the calyx cup from infection initiated in the petals, sepals, or stamens. After penetration of the stigma, progress down the style was comparatively slow, but the ovary and finally the entire blossom blighted. At 80% humidity only the petals and pistils became infected. At this humidity the diseased petals usually fell off, and the lesions soon became dry and papery. A few blossoms blighted completely after 6 days in this humidity, apparently from pistil infection.

Throughout Weaver's studies, the greater percentage of completely blighted blossoms was due to the spread of the fungus mycelium following stamen infection. Under most conditions the advance of the mycelium in the pistil was comparatively slow. Frequently complete blighting of all flower parts including the calyx was observed while the style was but partially brown and wrinkled. However, the first appearance of the disease was most frequently seen on the stigma.

Since all floral parts may serve as infection courts, knowledge of the percentage of infection at different stages of blossom development has practical significance. In tests conducted by Roberts and Dunegan (20) partially opened peach blossoms were not easily infected and some escaped infection entirely. Weaver (23) found that blossoms in the pink stage of development were not as readily infected as when they were open. Sepal infection was very rare in the pink stage and the progress of the fungus mycelium from petal infection to

the rest of the blossom occurred only at sustained high humidities. Large-petaled varieties of peach were less frequently blighted in the pink stage than small-petaled varieties because of the protection the petals afforded the stigmas and stamens. No blight occurred at the closed stage.

It has been noted by most investigators that the young enlarging fruit usually escapes rot by losing the diseased shuck (21).

Weaver (23) states that blighting of the entire blossom rarely occurs if inoculation takes place 5 days after pollination.

The first symptom of the disease on the blossom is a faint discoloration of the part infected. Under ideal conditions for the growth of the fungus the entire blossom soon becomes brown and shriveled. Masses of ash-grey conidia are produced over the entire blossom. The petals, style, and stamens of the blighted blossom become matted together in a gummy mass, often bending downward. These masses of gum and floral parts often remain attached to the twigs for several weeks and even up into the fall and winter months. During each rain of the season, the gummy mass softens and produces a new crop of sporodochia and conidia.

The Canker and Twig Blight Phase

A frequent sequal to complete blossom blight is the formation of twig cankers. These are the result of the fungus mycelium passing down the peduncle into the tissues of the twigs. Twig cankers may

also result from a rotted fruit; however, this more often causes a complete blighting of the twig rather than the formation of a canker.

Twig cankers resulting from penetration of the fungus from a blighted blossom appear first as small, brownish, slightly sunken areas about the base of the peduncle. Subsequent growth of the fungus extends the diseased area up and down the twig from the base of the peduncle. Growth usually ceases in a few weeks time depending on the ability of the host to delimit the invaded area. Gum pockets are formed in the cankers and in rainy periods gum collects on the surface in drops or masses. As the season advances the sunken areas of the cankers are ruptured by host callus tissue, leaving a rough, cankered area on the twig.

The fungus may girdle the twig, killing it above the canker. This happens most frequently when the fungus penetrates through the peduncle following fruit rot. However, typical cankers may result in such a case.

The cankers on the twigs resulting from blighted blossoms are known to produce conidia the first summer under conditions of high humidity thus serving as a source of secondary inoculum for the fruit rot phase of the disease.

Fruit Rot Phase

The fruit rot phase of brown rot usually results from secondary spores or conidia. Though fruit rot may result from infection by the

primary conidia of over-wintered mummies hanging on the trees, secconidia from blighted blossoms and from current-season twig cankers are probably the mostimportant sources of inoculum.

Leaves infected by the peach leaf curl fungus (Exoascus deformans) may also be a source of inoculum as they have been reported easily infected by M. fructicola (19).

The rot of fruit is most frequently a rot of ripe or maturing fruit, although the green fruit may be rotted when the fungus enters through punctures or bruises. Roberts and Dunegan (21) report observing small green fruit infected from a closely appressed diseased calyx.

The conidia of the fungus are carried over to the fruit by wind and rain. Those that land in or near a fresh wound in the fruit often bring about infection. The most common wounds are those made by the plum curculio adults and larvae and the oriental fruit moth larvae. Invasion of the ripe fruit may take place through the unbroken surface primarily through hair sockets but also through the stomata (10). Smith (22) has shown that the fungus may also enter the fruit by way of the lesions made by the peach scab fungus (Cladosporium carpophilium).

Upon arrival of the conidia on near-ripe fruit, germination is often rapid. Under favorable conditions this may take place in an hour and rot symptoms may appear in 18 to 20 hours after germination (21). Soon after the appearance of the rot, sporodochia are produced

in abundant numbers which serve as a further source of inoculum for other fruit.

Some of the fruit falls to the ground before it is completely rotted. Some remains on the tree and becomes thoroughly invested with fungus hyphae. Such completely invaded fruits may dry and may either drop or remain on the tree. Those that remain do so because the fruit stem is killed by the fungus before it produces an abcission layer. The completely rotted and shriveled fruit on the tree and on the ground are the so-called mummies and are important in initiating the disease the following spring through production of conidia or ascospores.

CANKER STUDIES

Introduction

In certain orchards where severe blossom blight occurred ascospores and conidia from over-wintered mummies, the two common sources of inoculum for blossom infection, were not present. In these instances over-wintered twig cankers were suspected of being the major source of inoculum. Therefore, laboratory studies were undertaken to determine the importance of twig cankers as a source of conidia for primary infection.

Cation and Dunegan (6) in isolation studies conducted in 1948 showed that 73% of over-wintered cankers contained _M. fructicola_. They also reported sporulation of the cankers in the laboratory in moist chambers. Laboratory studies were undertaken in 1949 to enlarge upon these observations.

Methods and Materials

During February, 1949, cankered peach branches were collected in southwestern Michigan and brought to East Lansing. On February 16, branches of Elberta peach were cut from trees near South Haven and on February 20, branches of Halehaven peach were collected near Sodus. The day after collection the cankers were subjected to treatments of varying moisture and temperature to determine conidial production under controlled conditions.

Results of Canker Studies

A group of Elberta peach branches, containing 123 cankers typical of those caused by the brown rot fungus, were subjected to 9 hours of wetting and then placed in a saturated atmosphere with a temperature of 15° to 18°C. The majority of these cankers were on 2-year old wood resulting from the invasion of the fungus through blighted blossoms of the previous year. However, there were some cankers on 3 and 4-year old wood.

Conidia were first observed on the cankers after 9 hours in a saturated atmosphere. At 14 hours, 6.5% of the cankers were producing conidia. After 48 hours, a maximum of 47.1% showed sporodochia. These data are presented in TABLE I. The sporodochia were, with but one exception, produced on the lip of the canker rather than in the center. Sporodochia were also produced in some cases on tips of old fruit peduncles and on blighted twigs. Some of the fruit peduncles showed evidence of the fungus after 5 hours in a saturated atmosphere.

TABLE I. Sporulation observations of 123 cankers in a saturated atmosphere, temperature 15 to 18°C.

Time in saturated atmosphere	Total No. of cankers producing sporodochia	% producing sporodochia. Total 123
14 hours	8	6.5%
24 "	12	9.8%
38 "	28	22.8%
48 "	58	47.1%

A study was then made to determine the percentage of cankers of different age groups that were capable of producing sporodochia under laboratory conditions. Cankered branches of Elberta peach were collected, the uncankered wood cut off just beyond the visible limits of the cankers, and the cankers placed in water for 9 hours. They were then removed and placed in a saturated atmosphere at a temperature of 21°C.

Results of this study showed that 1-year old cankers were the most active in producing sporodochia. At 23 hours in a saturated atmosphere, 75% of the 1-year cankers and 69% of the 2-year cankers were sporulating. None of the 3 and 4-year old cankers had produced conidia at this time, the 3-year cankers requiring over 23 hours in a saturated atmosphere and the 4-year cankers needing over 46 hours for conidial production to start. 9.5% was the maximum number of 4-year cankers to produce conidia while 22.2% of the 3-year cankers eventually produced conidia. TABLE II tabulates these data.

TABLE II. Sporulation observations of various aged *cankers in a saturated atmosphere, temperature 21°C.

Time in saturated atmosphere	1-year canker (total of 32)		2-year canker (total of 26)		3-year canker (total of 27)		4-year canker (total of 26)	
	No. active	% active	No. active	% active	No. active	% active	No. active	% active
7 hours	8	25%	2	7.7%	0	---	0	---
23 "	24	75%	18	69.2%	0	---	0	---
46 "	24	75%	18	69.2%	6	22.2%	0	---
70 "	24	75%	18	69.2%	6	22.2%	2	9.5%

* Cankers were presumed to be 1 year younger than the age of that portion of the branch on which they were borne.

In all cases the cankers were held longer than 70 hours but there was no increase in the numbers producing sporodochia. In many cases in the 3 and 4-year old groups, callus tissue formation was quite extensive. The percent difference in sporulation between the 1 and 2-year old groups was not great but there was a large drop between the 2 and 3-year old groups, 69.2% to 22.2%. As a source of conidia for the primary cycles the 3 and 4-year old cankers would seem to be of little importance. The lack of healing in such cases is usually the result of secondary fungi of the peach canker complex.

Though equipment was not available to establish a series of studies on the production of sporodochia by cankers covering a complete range of temperature and humidity, an attempt was made to determine the minimum temperature at which sporodochia might be produced in a saturated atmosphere.

In this study the cankered portions of the twigs were cut out and placed in water for 7 hours. One group was then held at 4°C and the other at 7°C, both in a saturated atmosphere.

Both groups were maintained under the above conditions for 111 hours. By the end of this time there was no visible evidence of sporodochia in either group. The temperature was then increased to 21°C. After 40 hours at 21°C evidence of sporodochia appeared on the 1-year old canker in the group originally hald at 7°C, but no sporodochia were ever produced on the 3-year old cankers. Though these cankers were held longer than 72 hours at 21°C no further sporodochial production took place on the inactive cankers. A max-

imum of 44.4% of the 1-year cankers produced conidia. These data are presented in TABLE III.

TABLE III. Observations of sporodochial production of twig cankers at 21°C after 111 hours at 7°C.

Additional time at 21°C.	36 1-year cankers		16 2-year cankers		18 3-year cankers	
	No. active	% active	No. active	% active	No. active	% active
48 hours	8	22.2%	4	25%	0	---
72 "	16	44.4%	4	25%	0	---

In the group held originally at 4°C, but 29.4% of the 1-year cankers produced sporodochia. However, 9.7% of the 3-year cankers sporulated after 74 hours at 21°C. These data are presented in TABLE IV.

TABLE IV. Observations of sporodochial production on twig cankers at 21°C after 111 hours at 4°C.

Additional time at 21°C.	34 1-year cankers		25 2-year cankers		31 3-year cankers	
	No. active	% active	No. active	% active	No. active	% active
48 hours	0	---	0	---	0	---
74 "	10	29.4%	6	24%	3	9.7%

It is apparent that at temperatures of 7°C and lower, canker-produced conidia are not significant as a source of spores for the primary cycles of brown rot.

FUNGICIDAL CONTROL OF BROWN ROT IN 1949

As it is practically impossible to destroy all sources of inoculum by orchard sanitation practices, and as completely resistant varieties of peach are not known, the control of brown rot must be supplemented by protective sprays. Thus the major objectives of the 1949 field studies were: (1) the testing of certain spray materials, (2) a study of the timing of the fungicidal applications in accordance with susceptible periods in the development of the host and weather favorable to the fungus, and (3) observations on the epidemiology of the disease under Michigan conditions.

Blossom Sprays

Examination of the facts concerning brown rot indicate that considerable emphasis in control of fruit rot should be placed on complete control of blossom blight to eliminate a major source of secondary inoculum. It is postulated that complete control of blossom blight over a 2 or 3-year period would automatically tend to eliminate two sources of inoculum: conidia from currently blighted blossoms and future conidia from the resultant cankers. With complete control of blossom blight, the protection of the ripening fruits should be accomplished readily in light of the reduced spore load. This in turn would lead to fewer mummies for the over-wintering stages of the fungus, both on the tree and on the ground

Methods and Materials

The currently recommended program (29) for blossom sprays in Michigan is based on studies by Weaver (23) and results of certain spray programs of Dunegan (30). The schedule calls for 3 applications during the interval between the pink and full bloom stages in those orchards having a recent history of brown rot and if conditions of humidity are favorable to the development of the fungus. The timings of the applications are suggested when the blossoms are in the pink stage of development, 25% open and 75% open.

Blossom blight varies year to year in severity according to climatic conditions. To be more certain of encountering blossom infection it was desirable to establish experiments in locations subject to different climatic environments.

In the area immediately adjacent to Lake Michigan there are climatic factors differing from those several miles inland. Thus 2 orchards of varied locations were selected in which to set up the experimental program. One, the Colby Orchard, was situated on the Lake shore; the other, the Handy Orchard, was 8 miles inland. In each orchard a history of both heavy blossom blight and fruit rot is known. Hold-over cankers were numerous in both situations and 3 to 5 clusters of apothecia per tree were common on the ground at blossoming time. In the orchard on the lake shore the mummies had not been removed from the trees. An attempt had been made to remove them in the Handy Orchard but the job was far from thorough.

Nine-tree plots (3 X 3) were used for each treatment with all counts being made on the center tree of each plot. This arrangement

allowed for 1 tree on each side of the count tree to act as a buffer against spray contamination. All spraying was done from the ground using a Friend Pecan gun with a No. 10 disc and a pressure of 250 pounds. The Halehaven variety of peach was used in the trials at the Colby Orchard, and Rochester at the Handy Orchard.

In an attempt to determine the effectiveness of each individual application in relation to the phenological factors of temperature and humidity, a factorial design of 4 sprays was planned. It was hoped that the results might indicate more effective timing of sprays for control of blossom blight and to eliminate unnecessary applications.

The materials used here in the factorial design were wettable sulfur, 5 pounds in 100 gallons, plus a wetting agent (B-1956) and Stanofide, a fungicide manufactured by the Standard Oil Company (Indiana) at ½ pint per 100 gallons. In addition to the two fungicides used in the complete program, a 4-spray treatment of liquid lime sulfur, 2 gallons in 100 plus a wetting agent (B-1956), and L-7752 and L-8299 at ½ pint in 100 gallons were planned. The latter two numbers designate code numbers for experimental materials furnished by the Standard Oil Company (Indiana).

Since Weaver's work (23) has shown the improbability of blossom infection during the pink stage of bloom unless the stigmas were exposed, the initial spray was planned when approximately 25% of the blossoms had their stigmas exposed. The other sequences were to be applied when the blossoms had 50%, 75%, and all their stigmas ex-

posed or at about $2\frac{1}{2}$-day intervals during a normal blossoming season. TABLE V indicates the planned applications. However, the rapid advancement of the blossoms allowed only 2 applications.

TABLE V. Factorial design of spray applications for blossom blight control.

Halehaven variety — Colby Orchard

Plot No.	Material	Sequence of Applications			
1	Stanofide	1	-	-	-
2	"	1	-	3	4
3	"	1	-	-	4
4	"	1	2	-	-
5	"	1	2	3	4
6	"	1	2	3	-
7	"	1	2	-	4
8	"	-	2	-	-
9	"	-	2	-	4
10	"	-	2	3	4
11	"	-	2	3	-
12	"	-	-	3	4
13	"	-	-	3	-
14	"	-	-	-	4
15	Wettable sulfur + B-1956	1	-	-	-
16	" " "	1	-	3	4
17	" " "	1	-	-	4
18	" " "	1	2	-	-
19	" " "	1	2	-	4

TABLE V (Cont).

Plot No.	Material	Sequence of Applications			
20	Wettable sulfur + B-1956	1	2	3	4
21	" " "	1	2	3	-
22	" " "	-	2	-	4
23	" " "	-	2	-	-
24	" " "	-	2	3	4
25	" " "	-	2	3	-
26	" " "	-	-	3	4
27	" " "	-	-	3	-
28	" " "	-	-	-	4
29	L-8299	1	2	3	4
30	L-7752	1	2	3	4
31	Non-sprayed	-	-	-	-
32	" "	-	-	-	-

Rochester variety - - Handy Orchard

Plot No.	Material	Sequence of Applications			
1	Stanofide	1	-	-	-
2	"	1	-	3	4
3	"	1	-	-	4
4	"	1	2	-	-
5	"	1	2	3	4
6	"	1	2	3	-
7	"	1	2	-	4
8	"	-	2	-	-

TABLE V (Cont).

Plot No.	Material	Sequence	of	Applications	
9	Stanofide	-	2	-	4
10	"	-	2	3	4
11	"	-	2	3	-
12	"	-	-	3	4
13	"	-	-	3	-
14	"	-	-	-	4
15	Wettable sulfur + B-1956	1	-	-	-
16	Non-sprayed	-	-	-	-
17	Wettable sulfur + B-1956	1	-	3	4
18	" " "	1	-	-	4
19	" " "	1	2	-	-
20	" " "	1	2	3	4
21	" " "	1	2	-	4
22	" " "	1	2	3	-
23	" " "	-	2	-	4
24	" " "	-	2	-	-
25	" " "	-	2	3	4
26	" " "	-	2	3	-
27	" " "	-	-	3	4
28	" " "	-	-	3	-
29	" " "	-	-	-	4
30	Liquid lime sulfur + B-1956	1	2	3	4
31	L-7752	1	2	3	4
32	L-8299	1	2	3	4

TABLE V (Cont).

Plot No.	Material	Sequence of Applications
33	Non-sprayed	- - - -
34	" "	- - - -

Coincident with the pink stage of bloom, a period of unseasonably warm weather was experienced, including warm nights. As a result the complete opening of all blossoms occurred in 4 days rather than the usual average of 10 days. Thus, it was impossible to carry out the complete program and but 2 of the 4 sequences planned were applied, these when 25% of the bloom had their stigmas exposed and at full bloom.

The first application was applied on the Handy plots on April 30. At the time the application started, 25% of the blossoms had their stigmas exposed. The following day, May 1, 0.4 inch of rain fell during intermittant showers throughout the daylight hours. On May 2 the first sprays were applied to the plots at the Colby Orchard. 28% of the stigmas were exposed. On May 3 and 4 the second sequence of applications were given to the Handy and Colby plots respectively. In both cases the trees were in full bloom. Blossom blight counts were made 10 days after the last sprays.

Results of Blossom Blight Studies

One of the most apparent differences in the results obtained is

the difference in the amount of blight in the non-sprayed plots in the 2 orchards. The average blight in 8000 blossoms counted in the Colby Orchard was 5.3% while the average in 9000 blossoms in the Handy Orchard was 1.11%. This could not be attributed to differences in the amount of inoculum and was probably concerned with differences in relative humidity at the critical periods of infection.

It is apparent from the results obtained in the Handy Orchard that the second spray might well have been omitted. The ineffectiveness of this spray is demonstrated by the fact that the incidence of of blight in 4000 blossoms each in the Stanofide and wettable sulfur plots that received 2 applications was not materially below that of the first spray. This would be anticipated if sprays are protective only since the first spray was applied the day prior to the rain. It is apparent from these results that the rain initiated the only infectious period during bloom. With the great amount of apothecia present it might well be questioned why more blight did not occur as precipitated moisture is not necessarily essential for infections of stigmas. However, the day following the precipitation the relative humidity dropped below 70% and remained there for several days. It is possible that this accounts for the little further development of blossom blight (23). Too, the combination of the low humidities and high temperatures during the opening of the blossoms (88 to 92°F) may have stopped fungus growth and delimited the lesions if infection did occur. It was not possible to determine if infection other than that which became visible did occur. Because of the high seasonal temperatures the petals dropped in a comparatively short time after the full bloom stage was reached making accurate observations impossible

for more than 72 hours after the precipitation.

In the Colby Orchard the rain had occurred before any sprays were applied. In these plots the second sequence of sprays or those applied during full bloom were the most effective, reducing blossom blight 89% where Stanofide was used and 87% where wettable sulfur was applied. It is true that the first application greatly reduced the incidence of blight, however where both applications were made there was little decrease in the amount of blight over the one full bloom spray. Indications are that the infection period occurred after the second spray; that the first spray retained its protection for those 28% of the open blossoms covered and that the second spray alone not only protected the analogous 28% but also the blossoms which had opened later.

There were some differences in control of blossom blight among the different materials used. In both orchards the greatest reduction of blossom blight was in the plots sprayed with the Standard Oil Company experimental sprays L-7752 and L-8299. In each case however, the precentage of blight was based on 1000 blossoms rather than on 3 or 4 thousand as were counted in the Stanofide and wettable sulfur plots, and the significance is questionable. In the Colby Orchard there was little difference in the fungicidal effectiveness between Stanofide and wettable sulfur while at the Handy Orchard the sulfur resulted in somewhat better control. Liquid lime sulfur resulted in better control than wettable sulfur at the Handy Orchard but the counts were based on 1000 blossoms in the case of the liquid lime sulfur and 4000 blossoms for the wettable sulfur and the superiority may be ques-

tioned. Even though the temperature was 89°F, 2 gallons of liquid lime sulfur in 100 caused no evident injury to the blossoms or fruit set. No phytotoxic reactions were noted from any of the materials applied. TABLES VI, VII, VIII, and IX show these data.

TABLE VI. Blossom blight counts.

Halehaven variety — Colby Orchard.

Plot No.	Material	Applications Applied		Amount of Blight/1000 Blossoms	% Blight
1	Stanofide	1	-	10	1.0
2	"	1	-	12	1.2
3	"	1	-	11	1.1
4	"	1	2	7	0.7
5	"	1	2	6	0.6
6	"	1	2	7	0.7
7	"	1	2	8	0.8
8	"	-	2	4	0.4
9	"	-	2	5	0.5
10	"	-	2	7	0.7
11	"	-	2	8	0.8
12	Used as check	None		55	5.5
13	" "	"		55	5.5
14	" "	"		53	5.3
15	Wettable sulfur + B-1956	1	-	12	1.2
16	" "	1	-	15	1.5
17	" "	1	-	15	1.5
18	" "	1	2	3	0.3

TABLE VI (Cont)

Plot No.	Material	Applications Applied		Amount of Blight/1000 Blossoms	% Blight
19	Wettable sulfur + B-1956	1	2	4	0.4
20	" "	1	2	5	0.5
21	" "	1	2	4	0.4
22	" "	-	2	7	0.7
23	" "	-	2	7	0.7
24	" "	-	2	6	0.6
25	" "	-	2	8	0.8
26	Used as check	None		55	5.5
27	" "	"		53	5.3
28	" "	"		54	5.4
29	L-8299	1	2	2	0.2
30	L-7752	1	2	0	0.0
31	Non-sprayed			49	4.9
32	" "			50	5.0

TABLE VII. A summary of the above table.

Material	Applications Applied		No. Blossoms Counted	% Blight	% Reduction
Stanofide	1	-	3000	1.1	79
"	-	2	4000	0.6	89
"	1	2	4000	0.7	87
Wettable sulfur	1	-	3000	1.4	74

TABLE VII (Cont)

Material	Applications Applied		No. Blossoms Counted	% Blight	% Reduction
Wettable sulfur	-	2	4000	0.7	87
" "	1	2	4000	0.4	92
L-7752	1	2	1000	0.0	100
L-8299	1	2	1000	0.2	96
Non-sprayed			8000	5.3	-

TABLE VIII. Blossom blight counts.

Rochester variety - Handy Orchard

Plot No.	Material	Applications Applied		Amount of Blight/1000 Blossoms	% Blight
1	Stanofide	1	-	0	0.0
2	"	1	-	2	0.2
3	"	1	-	1	0.1
4	"	1	2	1	0.1
5	"	1	2	2	0.2
6	"	1	2	0	0.0
7	"	1	2	0	0.0
8	"	-	2	3	0.3
9	"	-	2	1	0.1
10	"	-	2	2	0.2
11	"	-	2	0	0.0

TABLE VIII (Cont)

Plot No.	Material	Applications Applied		Amount of Blight/1000 Blossoms	% Blight
12	Used as check	None		1	0.1
13	" "	"		0	0.0
14	" "	"		0	0.0
15	Wettable sulfur + B-1956	1	-	1	0.1
16	Non-sprayed			2	0.2
17	Wettable sulfur + B-1956	/	-	0	0.0
18	" "	1	-	0	0.0
19	" "	1	2	1	0.1
20	" "	1	2	1	0.1
21	" "	1	2	0	0.0
22	" "	1	2	0	0.0
23	" "	-	2	2	0.2
24	" "	-	2	1	0.1
25	" "	-	2	3	0.3
26	" "	-	2	0	0.0
27	Used as check	None		1	0.1
28	" "	"		0	0.0
29	" "	"		2	0.2
30	Liquid lime sulfur + B-1956	1	2	1	0.1
31	L-7752	1	2	0	0.0
32	L-8299	1	2	0	0.0
33	Non-Sprayed			1	0.1
34	" "			3	0.3

TABLE IX. A summary of the above table.

Material	Applications Applied		No. Blossoms Counted	% Blight	% Reduction
Stanofide	1	-	3000	0.75	32.2
"	-	2	4000	1.5	-26.0
"	1	2	4000	0.75	32.4
Wettable sulfur	1	-	3000	0.33	70.3
" "	-	2	4000	1.5	-26.0
" "	1	2	4000	0.5	55.0
Liquid lime sulfur	1	2	1000	0.1	91.0
L-7752	1	2	1000	0.0	100.0
L-8299	1	2	1000	0.0	100.0
Non-sprayed			9000	1.11	

Post-bloom and Pre-harvest Sprays

Methods and Materials

One of the considerations during the 1949 season's study was the testing of certain new materials. One of these newer fungicides is Stanofide, the trade name of a fungicide produced by the Standard Oil Company of Indiana. Its use thus far has been confined primarily on apples as a protectant against apple scab. Since this product indicated considerable control of brown rot in small-scale tests by the Standard Oil Company workers the previous season, it seemed advisable toundertake more thorough trials using this fungicide. The Michigan State College Spray Calender (29) suggests 3 sprays shortly after bloom, Any fungicide to be of value during these sprays would need to be compatable with the insecticides used in controlling the plum curculio and with D. D. T. used in control of the oriental fruit moth, also the sucking insects responsible for "catfacing". Therefore, the post-bloom sprays were designed to test the compatabilities of the fungicides and certain insecticides as well as comparative control of diseases by the different combinations. In addition to Stanofide, L-7752, L-8299, and wettable sulfur were compared as fungicides during these trials. The fungicidal plots were so established that they would form a continuous fungicidal program from petal fall to harvest time. Additional fungicides, to be indicated later, were also used during the pre-harvest sprays.

The two orchards selected for these trials were different from those used in the blossom studies so that all plots would have had

identical treatments previous to this phase of the experiments beginning with the petal fall spray. As before the orchard locations were varied. Plots of Rochester and Elberta varieties were established on the Deaner Farms, 8 miles inland from Lake Michigan, and plots of Halehaven and Elberta varieties were set up in the Closson Orchard, $\frac{1}{2}$ mile from the lake shore. Nine-tree blocks (3 x 3) were used and where possible all counts and observations were made from the center tree in each block.

Fungicides were used in combination with insecticides in three sprays. These applications were made at petal fall, when 75% of the shucks were off, and 2 weeks after the latter (first cover).

The purpose of a fungicide in these sprays is two-fold: control of brown rot and control of peach scab. Very little data is available to show the actual value of a fungicide at this time for brown rot control. The young fruits are seldom seen rotting unless a wound has occurred. It is possible during prolonged periods of wet weather for the fungus to penetrate a young fruit from a diseased calyx. However, weather conditions are seldom encountered where such infections occur, and it is doubtful that the fungicide would be of value in such a case.

TABLE X records the various insecticide-fungicide combinations used in the above sprays. The amounts of the various materials used in this series of sprays and in the pre-harvest sprays per 100 gallons of solution is indicated in TABLE XI.

D. D. T. was included in the shuck fall and first cover sprays at the Closson Orchard, but none was used at the Deaner Farms at the request of the owner.

No effort was made to accurately determine the effectiveness of the various insecticide-fungicide combinations in regards to control of insect pests, so the study was concerned solely with the injury phase.

TABLE X - Post-bloom sprays.

Rochester variety -- Deaner Farms

Plot No.	Fungicide	Insecticide
4	Stanofide	Basic lead
5	Stanofide	BHC
6	Stanofide	Chlordane
7	Stanofide	Acid lead plus corrective
8	None	None
9	Stanofide	Acid lead
13	None	Acid lead plus corrective
14a	Wettable sulfur plus B-1956	Chlordane
15	Wettable sulfur plus B-1956	Chlordane
16	Wettable sulfur plus B-1956	Acid lead plus corrective
17	Wettable sulfur plus B-1956	Chlordane
18	Stanofide	None

Elberta variety -- Deaner Farms

Plot No.	Fungicide	Insecticide
1a,b,c	None	Chlordane
2	None	Chlordane
3	Stanofide	Parathion
4	Stanofide	Basic lead
10a	Arathane	Arathane
10b	None	None
11	L-8299	See page "39"

TABLE X (Cont)

Plot No.	Fungicide	Insecticide
12	L-7752	See page "39"
13	None	Acid lead plus corrective

Halehaven variety -- Closson Orchard

Plot No.	Fungicide	Insecticide
1	Stanofide	Acid lead plus correvtice
2	Stanofide	Chlordane
3	Stanofide	BHC
4	Stanofide	Basic lead
5	Stanofide	None
6	None	Acid lead plus corrective
7	Stanofide	Parathion
11	Wettable sulfur plus B-1956	Chlordane
13	L-7752	See page "39"
15	None	None

Elberta variety -- Closson Orchard

Plot No.	Fungicide	Insecticide
2	Stanofide	Chlordane
6	None	Acid lead plus corrective
7	Stanofide	Parathion

TABLE X (Cont)

Plot No.	Fungicide	Insecticide
8	Wettable sulfur plus B-1956	Chlordane
9	Wettable sulfur plus B-1956	Acid lead plus corrective
10	Wettable sulfur plus B-1956	Chlordane
11	Wettable sulfur plus B-1956	Chlordane
12	None	None
13	L-7752	See page "39"
14	L-8299	See page "39"

TABLE XI. Amounts of materials used in the post-bloom and pre-harvest sprays per 100 gallons.

Fungicides	Amount per 100 gallon
Acti-dione	20, 10, 5, and 2 ppm
Arathane	3/4 lb
CR 305 (Rohm and Haas experimental)	1½ lb
Liquid lime sulfur	3 qts
L-7752 (Standard Oil (Ind.) experimental)	½ pt
L-8299 (Standard Oil (Ind.) experimental)	½ pt
Stanofide	½ pt
Wettable sulfur	5 lbs
Wetting agent (B-1956)	1½ oz

TABLE XI (Cont)

Insecticides		Amount per 100 gallons
Acid lead		2 lbs
Arathane		3/4 lbs
Basic lead		3 lbs
BHC		3 lbs
Chlordane		2 lbs
Corrective:	Zinc sulphate (flake)	4 lbs
	spray lime	4 lbs
D. D. T. (50%)		1½ lbs
Parathion (15%)		1½ lbs

Spray Injury

There was no evidence to suspect incompatability or detrimental results following the use of Stanofide mixed with Parathion, BHC, and Chlordane, with or without D. D. T. added. All tank mixes were obtained without difficulty. Experience indicated, however, that the Stanofide be added to the tank when the latter is nearly full. This tends to prevent excessive foaming which may occur if the fungicide is added to a partially-filled tank.

Some difficulty was experienced in mixing certain insecticides in combination with the fungicides L-7752 and L-8299. The insecticides tried in combination with these two fungicides were Chlordane, BHC, and Parathion and D. D. T. alone and in combination with the other 3 insecticides. A good mix was finally obtained by adding the fungicide to the tank as soon as the agitators were covered and in operation. The insecticide was sifted into the tank as it neared the full point. This resulted in considerable foaming but not so much so as to impair the activity of the pump. As several combinations of insecticide-fungicides were used on each plot of L-7752 and L-8299, no insecticide is indicated in the TABLES following these two fungicides.

Severe injury resulted whenever lead arsenate was used as the insecticide. Typical arsenical injury on foliage occurred where acid lead plus a corrective of zinc sulphate and lime (2-4-4) was used without a fungicide. The injury was not enhanced by adding wettable sulfur to the insecticide. There was, however, somewhat more arsenic-

al injury when Stanofide was added to the acid lead plus the corrective. Stanofide and basic lead caused injury in the approximate severity as with acid lead and a corrective used alone or in combination with wettable sulfur. The combination of acid lead without a corrective and Stanofide caused 50% defoliation following one application.

The result of these fungicide-insecticide combinations indicate that Stanofide has no corrective action for lead arsenate and the combination should not be used on peaches.

Pre-harvest Spray Trials

Methods and Materials

Most of the plots set up in the post-bloom sprays were continued using the same fungicide throughout the pre-harvest applications. Additional plots of Acti-dione (an anti-biotic chemical, cycloheximide, produced by the Upjohn Company) and CR-305 (Rohm and Haas experimental fungicide) were applied during the pre-harvest sprays only. Plots on which these materials were used had received 3 applications of an insecticide (Chlordane), during the three post-bloom sprays. D. D. T. was added to all fungicide plots in the first two pre-harvest sprays.

Applications of fungicidal sprays were started one month before harvest taking into consideration the estimated picking dates of the varieties and their locations. 4 applications were made at approximately 10-day intervals, the last one applied the day previous to picking.

All peaches were harvested at the firm-ripe stage of maturity. A two-bushel sample was picked from each plot. One bushel was placed in cold storage (34°F) for 48 hours and then removed to common storage for 4 additional days. The other bushel was placed in common storage for 6 days. At the end of the 6 days each sample was examined to determine the extent of the infection incurred.

Discussion of Results

In the trials on the Rochester variety of peach, the wettable sulfur and liquid lime sulfur gave the best control of brown rot: 88 and 97% respectively under conditions of 2 days cold - 4 days common storage. Only with the Chlordane combination (Plot 6) did Stanofide compare with the above two fungicides giving 88% control under the same storage procedure.

Under conditions of continuous common storage, the advantage of wettable sulfur over Stanofide was indicated. However, liquid lime sulfur was not superior to Stanofide in this type storage.

On the Halehaven variety under conditions of 2 days cold - 4 days common storage, liquid lime sulfur gave the best results with 94% control. Stanofide was slightly superior in continuous common storage. Under the latter conditions, L-7752 gave but 49% control.

On Elberta variety several fungicides gave 100% control under conditions of little brown rot even on the non-sprayed plots. These materials included wettable sulfur, liquid lime sulfur, Acti-dione at 5 ppm, and Arathane. Stanofide with basic lead as the insecticide, a combination not recommended because of foliage injury, also gave 100% control. In all the above tests, the peaches were subjected to 2 days cold - 4 days common storage. The grower program of a liquid lime sulfur (2 quarts in 100 gallons) and 3 sulfur dusts, and CR-305 were not satisfactory. These data in TABLES XII, XIII, XIV, and XV.

TABLE XII. FRUIT ROT

Rochester Variety

Plot No.	Fungicide	Insecticide (applied in 3 post-bloom sprays only)	No. fruit counted
4	Stanofide	Basic lead	152
5	Stanofide	BHC	230
6	Stanofide	Chlordane	197
7	Stanofide	Acid lead plus corrective	186
8	Non-sprayed	Non-sprayed	195
9*	Stanofide	Acid lead	142
14-a**	Wettable sulfur plus B-1956		
b**	Liquid lime sulfur plus B-1956	Chlordane	157
15	Wettable sulfur plus B-1956	Chlordane	188
16	Wettable sulfur plus B-1956	Acid lead plus corrective	209
17-a**	Wettable sulfur plus B-1956	Chlordane	213
b**	Stanofide		
18	Stanofide	None	201

* 1 post-bloom spray at petal-fall; 4 pre-harvest applications of Stanofide.

** a-Spray program for the 3 post-bloom sprays.

b-Spray program for the 4 pre-harvest sprays.

Deaner Farms

% rot cold storage	No. fruit counted	% rot common storage	% rot reduction cold storage	% rot reduction common storage
36	No sample	---	60	---
19	239	26	79	73
11	236	33	88	67
41	173	45	53	54
89	190	97	---	---
59	No sample	---	33	---
11	144	55	88	43
3	198	17	97	82
3	198	8	97	92
17	189	32	80	67
43	174	69	52	29

TABLE XIII. FRUIT ROT

Halehaven variety

Plot No.	Fungicide	Insecticide (applied in 3 post-bloom sprays only)	No. fruit counted
1	Stanofide	Acid lead plus corrective	172
2	Stanofide	Chlordane	196
3	Stanofide	BHC	192
4	Stanofide	Basic lead	---
5	Stanofide	None	184
6	None	Acid lead plus corrective	205
7	Stanofide	Parathion	166
11-a***	Wettable sulfur plus B-1956		
b***	Liquid lime sulfur plus B-1956	Chlordane	196
13	L-7752****	See page "39"	229

* Percent reduction based on rot in Plot 6.

** Many, small, necrotic areas were just beginning to appear but these were not counted due to the inability to identify them as brown rot.

*** a Spray program for the 3 post-bloom sprays.

b Spray program for the 4 pre-harvest sprays.

**** Fruit heavily infected with bacterial spot.

Closson Orchards

% rot cold storage	No. fruit counted	% rot common storage	% rot reduction* cold storage	common storage
5	166	11	71	81
3	232	6	82	90
3	148	4	82	93
---	218	6	---	90
7**	165	52	59	10
17	187	58	---	---
2	224	9	88	81
1	154	7	94	89
4	194	29	76	49

TABLE XIV. FRUIT ROT

Elberta variety

Plot No.	Fungicide	Insecticide (applied in 3 post-bloom sprays only)	No. fruit counted
2	Stanofide	Chlordane	---
6	None	Acid lead plus corrective	145
7	Stanofide	Parathion	85
8-a** b**	Wettable sulfur plus B-1956 Stanofide	Chlordane	123
10	Wettable sulfur plus B-1956	Chlordane	176
11-a** b**	Wettable sulfur plus B-1956 Liquid lime sulfur plus B-1956	Chlordane	172
12	Non-sprayed	Non-sprayed	152
13	L-7752***	See page "39"	105
14	L-8299	See page "39"	128

* More rot present than in the non-sprayed plot.

** a Spray program for the 3 post-bloom sprays.

b Spray program for the 4 pre-harvest sprays.

*** Fruit heavily infected with bacterial spot.

Clossen Orchards

% rot cold storage	No. fruit counted	% rot common storage	% rot reduction cold storage	common storage
---	69	20	---	29
12	135	37	(-33)*	(-24)*
4	86	15	50	46
2	114	12	75	56
0	169	10	100	64
0	173	12	100	57
8	147	28	---	---
2	128	25	75	11
3	124	16	65	43

TABLE XV. FRUIT ROT

Elberta variety

Plot No.	Fungicide	Insecticide (applied in 3 post-bloom sprays only)	No. fruit counted
1-a*			
b*			
c*	None	Chlordane	
e*	Acti-dione (10ppm)		91
f*	Acti-dione (5ppm)		113
g*	Acti-dione (2ppm)		97
2-a**	None		
b**	CR 305	Chlordane	104
3	Stanofide	Parathion	97
4	Stanofide	Basic lead	97
10-a	Arathane	Arathane	76
b	Non-sprayed	Non-sprayed	56
11	L-8299	See page "39"	96
12	L-7752	See page "39"	102
13	None	Acid lead plus corrective	---
	Grower program***		68

* 1 a,b,c Spray program for the 3 post-bloom sprays.

1 e,f,g Spray program for the 4 pre-harvest sprays.

** 2 a Spray program for the 3 post-bloom sprays.

2 b Spray program for the 4 pre-harvest sprays.

*** Grower program: 3 post-bloom sprays of BHC and sulfur paste. Pre-harvest applications: (1) 2 qts liquid lime sulfur, (2) sulfur dust, (3 and 4) sulfur dust by plane.

**** More rot than in non-sprayed plot.

Deaner Farms

% rot cold storage	No. fruit counted	% rot common storage	% rot reduction cold storage	common storage
1	100	23	86	36
0	----	----	100	--- -
2	----	----	71	----
3	96	36	57	3
1	114	20	86	44
0	114	16	100	56
0	----	----	100	----
7	75	36	----	----
1	100	16	86	56
1	100	18	86	50
----	100	30	----	17
3	64	42	57	(-14)****

A severe phytotoxic reaction on the foliage occurred where L-7752 was used as the fungicide in the pre-harvest sprays. The injury was characterized by large, irregular, necrotic areas on the leaf which soon dropped out. Where the necrotic areas were numerous the leaf took on a very ragged appearance after the lesions had fallen. The injury was not noted on the plots after receiving the 3 post-bloom sprays, but it was common on both Halehaven and Elberta varieties during the pre-harvest sprays. A slight streaking of the color on the fruit was noted about 3 weeks prior to harvest. However, this had largely disappeared at picking time.

In all Stanofide plots on the Rochester variety, a slight scattering of small, shot-holes was seen after the first pre-harvest spray was applied. This reaction was not observed on Halehaven or Elberta varieties at any time nor was it observed on Rochester following the later sprays. Attempts to duplicate the injury on other Rochester trees failed.

Acti-dione caused severe cracking of firm-ripe Halehaven peaches and to a lesser extent Elbertas. The cracks, often ¼ inch deep and varying from 2 to 8 in number per peach, radiated in several directions. In addition, the spray mottled the fruit, seeming to actually dissolve the red coloring of the skin.

A slight amount of sulfur burn on the foliage was noted on those trees receiving liquid lime sulfur (3 quarts in 100). This was most evident on the suckers and terminal leaves of the twigs.

At harvest time there was no apparent differences in the stage of maturity in respect to the different treatments. Stanofide, L-7752, and L-8299-sprayed fruit showed slightly brighter color because of the absence of apparent residue than did the fruit sprayed with liquid lime sulfur, wettable sulfur, CR-305, and Arathane.

Fungicidal Applications Under Conditions of Heavy Inoculum

Near harvest time an orchard of Halehaven peaches with a high incidence of infection came to our attention. It had received only a haphazzard spray program after the blossom sprays because of the prospects of a small crop. Counts of the fruit on 3 random trees revealed 11.4% rotted fruit hanging in the trees at this time. Comparative sprays of fungicides mixed with 100 gallons of water, namely: wettable sulfur (5 lbs) plus B-1956, Stanofide (½ pt), and Acti-dione (20ppm), were applied the same day the grower applied a spray of liquid lime sulfur (2 pts) plus B-1956 to the remainder of the orchard. Two days later a picking was made. 2-bushel samples were harvested from each treatment and placed in cold storage for 2 days and then removed to common storage for 3 days.

2 days after the first picking another application of the same materials was made and compared with another grower-applied liquid lime sulfur spray. No second application of Acti-dione was made because of the severe cracking of the fruit. After picking, the fruit was subjected to the same storage procedure as after the first application.

The control effected by Stanofide and wettable sulfur was superior to that obtained by the grower using liquid lime sulfur while Acti-dione under these conditions showed a high rot count. The high rot count for Acti-dione might have resulted from the fruit cracking attributed to that material. TABLE XVI shows the percentage of brown

rot following the different treatments.

TABLE XVI. Fruit rot under conditions of heavy inoculum.

Material	1st application No. fruit counted	1st application % rot	2nd application No. fruit counted	2nd application % rot
Stanofide	309	71	249	55
Wettable sulfur plus B-1956	236	67	210	46
Acti-dione (20ppm)	283	84	111*	92
Liquid lime sulfur plus B-1956 (grower applied)	134	89	238	79

* Only 1 application put on because of the severe cracking of the fruit due to the chemical.

Dipping Tests

Most of the loss from fruit rot caused by the brown rot fungus occurs in storage or in transit between the grower and the consumer. Infection during this stage apparently is due to conidia lodged on the fruit at picking time and germinating later, or conidia that have germinated just prior to harvest. In an attempt to prevent rot by killing the surface-borne spores or perhaps retarding germination and infection of the fruit with a coating of fungus-inhibiting chemicals, a series of dipping tests were tried.

Methods and Materials

25-gallon mixes of various chemicals were made up in a 100-gal-

lon drum. The peaches to be dipped were put in open field boxes and placed in the solution. They were immersed for approximately 30 seconds and the solution washed thru them by raising and lowering the container. 2-bushel samples were used for each treatment. After draining for $1\frac{1}{2}$ hours they were placed in common storage for 5 days.

The peaches in this test were the Rochester variety. The samples were picked out of a grower-load and hand-sorted for bad and over-ripe fruit. These peaches had previously received a complete spray program of blossom, post-bloom, and pre-harvest sprays, both fungicides and insecticides.

The samples were from two different parts of the farm and are designated as the Lower and Upper Orchards. They received an identical spray schedule throughout the season, applications being made on the same day. However, certain horticultural practices differed. The Lower Orchard was heavily fertilized promoting lush growth that cut down air circulation allowing longer periods of wet fruit and interferred with spray penetration into the tree. The Lower Orchard had not been pruned during the previous dormant season as had the Upper Orchard. A good deal more rotted fruit was hanging in the trees at harvest time in the Lower Orchard. These factors account for, at least in part, the difference in the percentage of rotted fruit in the non-dipped samples after 5 days in storage.

None of the materials used in the dipping tests materially reduced the incidence of brown rot. Liquid lime sulfur was the most effective reducing the rot 14 and 15%. In many instances the dipping

resulted in more rot than developed in the non-dipped samples. These data are presented in TABLE XVII.

TABLE XVII. Dipping trials.

Lower Orchard

Material	No. fruit counted	% Rot	% Reduction over non-dipped
Not dipped	280	94	---
Water	258	97	(-3)
Wettable sulfur (5 lbs)	292	86	9
Wettable sulfur (5 lbs) plus B-1956	296	88	6
Liquid lime sulfur (3 qts)	272	81	14
Liquid lime sulfur (3 qts) plus B-1956	286	80	15
Acti-dione (2ppm)	286	95	(-1)
Acti-dione (5ppm)	310	84	11
Acti-dione (10ppm)	279	95	(-1)
Acti-dione (20ppm)	292	90	4
Stanofide ($\frac{1}{2}$ pt)	253	99	(-5)
B-1956 (2 oz)	250	99	(-5)
Fermate ($1\frac{1}{2}$ lbs) plus B-1956	292	96	(-2)
Dithane (D-14, 1 qt)	262	97	(-3)
Arathane ($\frac{3}{4}$ lbs)	119	95	(-2)

TABLE XVII (Cont)

Upper Orchard			
Material	No. fruit counted	% Rot	% Reduction over non-dipped
Not dipped	488	16	---
Water	411	78	(-89)
L-7752 (½ pt)	411	47	(-66)
L-8299 (½ pt)	417	51	(-69)
Sodium hypochlorite (200 cc of 5.25%)	454	47	(-66)
Craig 341 B (2¼ lbs)	388	56	(-71)
Craig 341 C (1 pt)	410	37	(-57)
CR 305 (1½ lbs)	266	54	(-70)

OBSERVATIONS

The following notes are observations on the epidemiology of brown rot made during the 1949 season by the author.

A plentiful number of apothecia was observed in many orchards. It was commonplace to find 6 or 8 clusters of apothecia under a tree. In one instance 28 clusters were counted under a single tree. The majority of these apothecia were mature during the time peaches were in bloom. Yet the average blossom blight in several orchards where many apothecia were present was less than 1%. In one case, 5.3% blight was counted on non-sprayed trees.

Usually mummies require at least partial burial before apothecia are produced. It was noted, however, that in some orchards where a heavy cover crop existed creating a local atmosphere of high moisture content, apothecia were coming from mummies on the surface of the soil. In all cases the stipes came from the underside of the mummy where it was in contact with the soil moisture.

No cankers except the ones formed as a result of blossom blight during the current season were observed to sporulate in the field during observations conducted from March to September.

An important fact must be kept in mind in attempts to control brown rot. And that fact is this: all possible sources of inoculum must be eliminated. For instance, in 1949 the importance of the present season's blossom blight and previous season's cankers as a source

of secondary spores was negligible. Yet fruit rot was serious in certain orchards, as much as 11% counted on the tree at picking time and up to 90% after 5 days in common storage. The inoculum for this rot must come from somewhere and the fact that there were occasional mummies left hanging in the trees indicated that they were important in continuing the epidemic. The writer observed these mummies clinging to the tree throughout the summer. In addition, these mummies were observed to produce conidia all season with each rain sufficient to soak the sclerotial membrane.

Another source of secondary spores was important on Red Haven and Oriole varieties during the 1949 season. These two varieties developed a considerable number of split pits when they were about half-grown. As development of these peaches continued an opening occurred at the stem end. In many of these peaches rot was iniated on the inside and soon enveloped the entire peach. This provided a tremendous amount of inoculum for the near-ripe fruit on the tree.

CONCLUSIONS

Laboratory studies were undertaken to determine the possibility of conidial production from over-wintered cankers. After an initial 9 hours wetting, 25% of the 1-year cankers were producing conidia within 7 hours in a saturated atmosphere. At the end of 24 hours 75% were active. Prolonged periods in a saturated atmosphere did not increase the number found sporulating. 69% of the 2-year cankers were active after 24 hours. Indications were that the 3 and 4-year cankers are of little importance as a source of conidia for the primary cycles of peach brown rot. No sporodochia were produced at temperatures of 4 or 7°C after 111 hours in a saturated atmosphere. TABLES II and III.

Blossom blight control experiments showed the importance of a protective spray on the exposed blossoms just prior to a rain. TABLE XI. Wettable sulfur was superior to Stanofide as a fungicide during the blossom sprays with the 2 experimental spray materials of the Standard Oil Company showing promise. Controls of 70 to 100% were obtained.

In compatability tests, Stanofide showed no corrective action for lead arsenate, basic or acid. The combination should not be used on peaches. The experimental fungicides L-7752 and L-8299 mixed with difficulty with Chlordane, BHC, Parathion, and D. D. T.

Wettable sulfur and liquid lime sulfur gave the best control of brown rot on fruit in the pre-harvest sprays where the incidence of

rot was high. Arathane and L-8299 gave promise. TABLES XIII to XVI.

L-7752 injured foliage during the pre-harvest sprays and Actidione severely cracked firm-ripe fruit.

In dipping no material tested significantly reduced the incidence of brown rot infection in harvested peaches.

Bibliography

(1) Amos, A. The temperature relations of some fungi causing storage rots. Phytopath. 5:11-19. 1915.

(2) Arthur, J. C. Rotting of cherries and plums, Oidium fructigina S. and K. New York Agr. Exp. Sta. Ann. Rpt. 4:280-285. 1886.

(3) Barss, H. P. Brown Rot and related diseases of stone fruits in Oregon. Ore. Agr. Exp. Sta. Circ. 53:1-18. 1925.

(4) Bartram, H. E. A study of the brown rot fungus in northern Vermont. Phytopath. 6:71-78. 1916.

(5) Berkeley, G. H. Brown rot. Canadian Dept. Agr. Div. Bot. Dominion Rpt. 1926:64-65. 1926.

(6) Cation, D., and Dunegan, J. C. The over-wintering of Monolinia fructicola in twig cankers under Michigan conditions. Pl. Dis. Rptr. 33:97-98. 1949.

(7) Cation, D. Unpublished notes gathered in 1946, 1947, and 1948.

(8) Chester, F. D. The rot of peach and other stone fruits. Peninsula Hort. Soc. (Delaware) Trans. 6:57-64. 1893.

(9) Cook, M. T. The blossom blight of peach. Phytopath. 11:290-294. 1921.

(10) Curtis, K. M. The morphological aspect of resistance to brown rot in stone fruit. Ann. Bot. (London). 42:39-68. 1928.

(11) Ezekiel, W. N. Fruit-rotting Sclerotinias. II. The American brown rot fungi. Md. Agr. Exp, Sta. Bul. 271:87-142. 1924

(12) ___________ Fruit-rotting Sclerotinias, III. Longevity of buried brown rot mummies. Md. Agr. Exp. Sta. Bul. 284.

1926.

(13) Hildebrand, E. M. Peach cankers and their control. Cornell Ex. Bul. 657. 1944

(14) Honey, E. E. The monilioid species of Sclerotinia. Mycologia. 20:125-157. 1928.

(15) Jehle, R. A. The brown rot canker of peach. Phytopath. 3:105-110. 1913.

(16) ____________ Peach cankers and their treatment. Cornell Agr. Exp. Sta. Cir. 26. 1914.

(17) McClintock, J. A. Peach disease control. Ga. Agr. Exp. Sta. Bul. 139:11. 1921.

(18) _______________ The brown rot situation in 1929. Am. Fr. Growers Mag. 50:11, 30. 1930.

(19) Mix, A. J. Brown rot, leaf and twig blight, following peach leaf curl. Phytopath. 20:265-266. 1930.

(20) Roberts, J. W., and Dunegan, J. C. Blossom blight of peach. Phytopath. 16:217-222. 1926.

(21) ____________________________ Peach brown rot. U.S. Dept. Agr. Tech. Bul. 328. 1932.

(22) Smith, E. F. Peach rot and peach blight. Jour. Mycol. 5:131. 1889.

(23) Weaver, L. O. Effect of temperature and relative humidity on the occurrence of blossom blight of stone fruit. Thesis (unpublished) Cornell U. 1943.

(24) Whetzel, H. H. Unpublished notes. Cornell U. 1935.

(25) Willison, R. S. Peach canker investigations. I. Sci. Agr. 14:39. 1933.

(26) ____________ Peach canker investigations. II. Canadian Jour.

Res. 14:40-41. 1936.

(27) ______________ Peach canker investigations. III. Canadian Jour. Res. 15:328. 1937.

(28) Woronin, M. Uber Sclerotinia Cinirea and S. fructigena. Mem. Acad. Sci. St. Peterbourgh. Phys. - Math. 10:1-38. 1900.

(29) Mitchell, A. E., Hutson, R., and Cation, D. The spraying calender. Mich. State College Ext. Bul. 154.

(30) Dunegan, J. C., and Goldsworthy, M. C. The control of blossom blight and its relation to brown rot of Red Bird peaches at harvest. Pl. Dis. Rptr. 32: 4: 136-137. 1948.