

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 195

FEBRUARY, 1945

THE IMPORTANT PEACH INSECTS IN TENNESSEE

By

S. MARCOVITCH AND W. W. STANLEY



An orchard in which many of the tests were conducted, at Knoxville

KNOXVILLE

SUMMARY

The most important insect pests of the peach in Tennessee are the plum curculio, oriental fruit moth, peach tree borer, and San Jose scale. Of less importance are the terrapin scale, shot-hole borer, and lesser peach tree borer.

The adult curculio passes the winter in woodlands adjoining orchards. In Tennessee, the beetles begin to appear on the trees about the first week in April, after blooming, and reach their peak of emergence about the last week in April.

As soon as the young peaches are large enough, egg deposition begins. The injured peaches drop to the ground, where first-brood beetles develop. These begin to emerge about June 20, reaching the peak about the middle of July.

Jarring of trees is recommended not only as a control measure but as a means of keeping up with the number of beetles present in the orchard.

Collection and disposal of drops is recommended as a supplementary control measure in years of heavy infestation.

Although acid lead arsenate is the standard insecticide for control of the curculio, it is limited in its usefulness by the injury it causes to leaves and bearing wood. Nitrogenous fertilizers, by inducing new growth, helped to overcome the injurious effects of lead arsenate.

Cryolite was used as a substitute for lead arsenate; it was found to be safe on peach foliage, and gave good control of the curculio.

In 1937, wet, misty weather appeared to be responsible for a "tip-end" injury to the fruit when cryolite was used. This tip-end injury is characterized also by the presence of sunken sutures and the formation of a more rounded peach.

One cryolite spray at shuck fall, followed by lead arsenate for the 10-day spray, did not cause injury to the fruit.

Satisfactory methods of control for oriental fruit moth have not yet been found. Some measure of control may be attained by the mass liberation of parasites, such as *Macrocentrus ancylivora*.

The peach tree borer and lesser peach tree borer are effectively controlled by the use of paradichlorobenzene and ethylene dichloride.

The San Jose scale and terrapin scale may be controlled by a thorough dormant spray of a lubricating-oil emulsion, 3 percent actual oil being used for the former and 4 percent for the latter.

The shot-hole borer is best kept in check by proper care of the orchard through fertilization and pruning and removal of weak trees and prunings.

THE IMPORTANT PEACH INSECTS IN TENNESSEE

By

S. MARCOVITCH AND W. W. STANLEY

INTRODUCTION

Insects attack not only the fruit but all parts of the peach tree; and unless adequate control measures are adopted, a crop cannot be grown. The insects found in the fruit are generally of most importance and represent the greatest problem. Since 1922, the peach has been attacked by the larvae of the oriental fruit moth. This pest and the plum curculio not only cause damage directly, but predispose the fruit to infection by brown rot. Of the insects that attack the trunk and branches in Tennessee, the most important are the peach tree borer, San Jose scale, terrapin scale, shot-hole borer, and lesser peach tree borer.

Starting in 1930, the Tennessee Experiment Station has conducted tests on control of the curculio, the oriental fruit moth, and other insect enemies of the peach. The studies have included related problems, such as defoliation caused by arsenicals. The object of this bulletin is to report these experiments and to suggest control measures that logically follow from the results obtained.

PLUM CURCULIO

HISTORICAL

The plum curculio, *Conotrachelus nenuphar*, is a native pest which was first found attacking wild plums. There is evidence that it was troublesome to the Indians, who stored dried plums for winter use (3). With the advent of peach growing, this small beetle discovered a new source of food that was both excellent and abundant, and it has multiplied accordingly. It attacks apples, cherries, and other stone fruits.

The plum curculio is one of the first pests that entomologists tried to control with insecticides. In 1870, G. M. Smith, of Berlin, Wisconsin, used a mixture of 1 part of paris green to 30 parts of flour (10). It was applied to the tree by means of a perforated pail fastened to a pole, but the method was very difficult to carry out. Afterward, paris green was used as a spray, at the rate of 1 pound to 160 gallons of water. This material proved to be highly toxic to foliage, besides injuring the fruit. Even when lime was used with the paris green, two or three applications usually resulted in defoliation. Lead arsenate, discovered in 1893, and later used on peaches, was found to be injurious to the foliage after several applications (4). Thus, the problem of insect control became interwoven with that of foliage injury.

LIFE HISTORY

The curculio passes the winter as a beetle (fig. 1) in leaves, grass, briar thickets, fence rows, or similar places adjoining orchards. When

warm weather comes, the beetles leave their hibernating quarters and go to the orchard. Jarring records show that they may appear as early as March 23, although the usual emergence, in the vicinity of Knoxville, is from April 4 to April 11.

When the fruit is about the size of a cherry, the females begin laying eggs in the tiny peaches. The characteristic egg-laying punctures are not noticeable on peaches because of the fuzz, but are very conspicuous on smooth-skinned fruit. These crescent-shaped punctures have given this pest the nickname of "the little Turk."

The milky-white eggs hatch within 7 to 12 days. The small grub eats its way into the young peach and finally reaches the pit, which it often consumes (fig. 2). Most of the infested peaches fall to the ground, where the growth of the worm is completed if conditions are favorable.

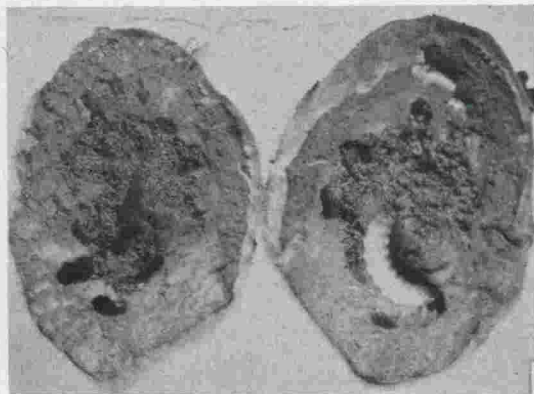


Fig. 2—Peach drop cut open to show the curculio larva

numbers of adults emerging even from a wet soil were greatly reduced when the soil was allowed to dry out naturally. In a dry soil the mortality seems to take place largely after transformation to the beetle stage.

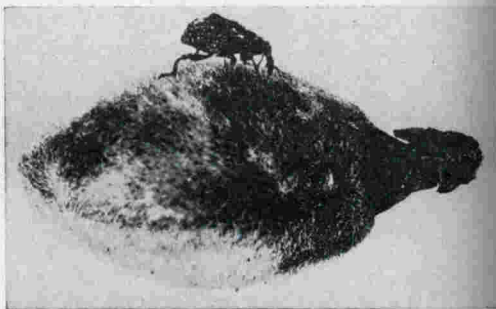


Fig. 1—Plum curculio beetle feeding on a young peach.

During hot, dry summers there has been a decided scarcity of beetles. Adequate soil moisture is necessary for their successful transformation and emergence (10). This may be the principal reason that the insect is not a pest in the dry western states.

Experimental work by Quaintance and Jenne (10) with wet and dry soils showed that no adults emerged from a dry soil. The

SEASONAL HISTORY

In order to time spraying operations most effectively, it is necessary to know when the beetles emerge from hibernation. Beginning in 1930, the emergence of curculio adults from hibernation was determined for several years by the jarring of plum and peach trees. Jarring is accomplished by striking the larger limbs sharply with a padded club. The shock

causes the beetles to lose hold and fall to the ground. A large white canvas or sheet under the tree will retain the insects for several minutes. If it is warm, the beetles will quickly fly away; hence, jarring is best done in the early morning. In 1930, nine trees were marked and jarred throughout the season. The beetles that fell were destroyed. The records show that beetles move about from tree to tree, and that jarring the same tree repeatedly will not influence counts. Observations in the years 1930-1934 and 1936 showed that the first beetles emerged from hibernation between April 4 and April 13. Complete seasonal records of the presence of adults in orchards were made only during the three years 1930, 1931, and 1932. From figure 3 it is seen that the beetles may be found from early in April to about the middle of

October. The chart shows also that the beetles which hibernated reached the peak of emergence during the last of April and first of May. By the middle of June, only a very few are present. About June 20, they begin to increase in numbers as the adults from the first brood appear. This first brood reaches its peak about July 15, then gradually decreases in numbers until the last of August or first of September, when no beetles are found. It is this brood that causes the wormy fruit in later-maturing peaches. These beetles are believed to go into hibernation during the summer months.

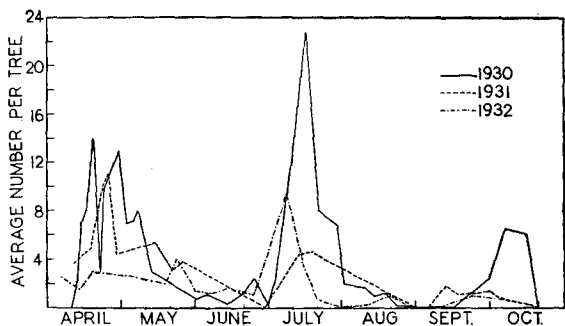


Fig. 3—Jarring records of plum curculio, showing the average number of beetles caught per tree, Knoxville, 1930-32.

In September, a small second brood appears, reaching a peak late in that month. They have been found in orchards as late as October 20. This brood develops in the very late peaches.

In 1930, the first egg laying in plums was observed on April 16; in 1931, the first egg was not found until April 26, although adults had been out of hibernation since April 11. In that month the length of egg stage was found to be about 6 days.

The larvae in 1931 stayed in the fruit from 18 to 20 days. After leaving the fruit, they prepared small cells in the ground 1 or 2 inches deep and remained there for about 2 weeks. About 8 to 10 days before emergence, the larva changes to a soft white pupa of much the same shape as the adult beetle. Mature larvae that entered the ground August 2 and 3 emerged as adults September 15 to 29.

DROPPING OF FRUIT

In May, many immature peaches fall. This shedding of the small fruit is called the "May drop." It results from causes not fully understood, as well as from the presence of larvae in the fruit. One may achieve some degree of control by picking up the drops and destroying

them to kill the worms; but this is not always easy to do, as the peaches fall throughout a long period of time. During the years 1930, 1931, 1935, and 1937, drops were collected for a study of the life history of the insect, and as a means of obtaining data on control measures. The records show that dropping began as early as May 5 and continued into June. The drops were placed on screen trays, so that as the larvae left the fruit they would fall onto a cloth tray, where they could be counted. Emergence of larvae began as early as May 10 and continued into late June. The peak seemed to be during the last week of May.

Temperature Studies of Immature Stages.—The rates of growth and development of the various stages of the plum curculio were obtained by observation of the immature stages reared in cabinets kept at constant temperatures. The temperatures used were 59°, 68°, 77°, and 86° F. Eggs were laid by caged females on small plums, which were placed in small salve boxes and observed daily. The data in table 1 show that the length of the egg stage was shortest, 2.5 days, at 86°, and longest, 11.7 days, at 59°. The larval stage was about 12 days at 86°, 77°, and 68°, but was more than doubled at 59°. The prepupal stage was shortest at 77° and more than twice as long at 59°. The length of the pupal stage was 5.9 days at 86° and about five times as long at 59°. The most favorable temperature was 77°; at that point the insect completed its growth in about 36 days. At 59° it took 114 days. A few eggs failed to hatch in 28 days at 53°, but when removed to a temperature of 68° they hatched in 3 days. Larvae did not develop at 53° even when kept as long as 156 days.

TABLE 1—*Relation of temperature to length of immature stages of the plum curculio.*

Temperature	Stage				
	Egg	Larval	Prepupal	Pupal	Total
°F	Days	Days	Days	Days	Days
59	11.7	28.9	37.7	30.0	114.3
68	5.1	12.4	20.5	13.3	51.3
77	3.5	11.9	14.8	5.9	36.1
86	2.5	12.0	16.8	6.8	38.1

EXPERIMENTAL FLUORINE COMPOUNDS

Early work with cryolite and barium fluosilicate (6, 7) showed that these materials were promising insecticides, since they were toxic to a number of insects and did not cause foliage injury, and consequently were good substitutes for arsenicals. The usefulness of lead arsenate is limited because of its injury to foliage. Preliminary tests showed that 6 weekly applications of cryolite and barium fluosilicate, at the rate of 1 pound to 50 gallons of water, caused no foliage injury. It appeared that these two fluorine compounds offered excellent chances of being successful on peach, as they were toxic to insects and apparently not harmful to foliage. They have been tested, therefore, in experiments beginning in 1930 and continuing to the present time.

In 1930, tests were made in two orchards. The crops were reduced by late frosts. In the University orchard, at Knoxville, a fair crop survived, but at Kingston, in a block of mature Elberta trees, the tests were valuable only for studies on foliage injury.

Tests with sprays in the University orchard indicated that cryolite, barium fluosilicate, and lead arsenate were of equal value, as the amount of wormy fruit ranged only from 7 to 14 percent. On the basis of infestation of drops, barium fluosilicate and natural cryolite gave much better control than synthetic cryolite (Bowker) or lead arsenate. Tests with dusts showed that 50 percent barium fluosilicate was decidedly better than 5 percent lead arsenate, 5 or 10 percent barium fluosilicate, 50 percent sodium fluosilicate, or 10 percent natural cryolite. The drops showed the smallest infestation from the use of 50 percent barium fluosilicate. The check plot showed an infestation of 68 percent in the ripe fruit and 53 percent in the drops. The data were gathered from plots containing only three trees each. The observations on foliage injury showed that barium fluosilicate, synthetic cryolite, and sodium fluosilicate caused foliage injury.

At Kingston, barium fluosilicate used as a spray was injurious to the foliage, but when used as a 5-percent dust it caused no apparent injury. Synthetic cryolite (Jungman) showed no injury. The greatest amount of injury to foliage came from the use of lead arsenate. At harvest time, July 29, trees that had been sprayed 4 times with lead arsenate 1-50, lime 8-50, and sulfur 6-50 were about 75 percent defoliated. Trees sprayed only 3 times with the same formula held their leaves until jarred for curculio; then the leaves fell in large numbers. On October 2, 1930, the trees that had received 4 lead arsenate sprays had a fresh growth of leaves



Fig. 4—Left, Peach trees defoliated by four lead arsenate sprays. Right, Trees sprayed four times with cryolite show no injury. Kingston, 1930.

on the twigs (fig. 4), and several of the trees produced blossoms. The trees that received 4 dust treatments, containing 5 percent lead arsenate, 15 percent lime, and 80 percent sulfur, were in somewhat better condition than those sprayed 3 times. It was noted that trees at the edge of the orchard, along a fence row, lost few if any leaves, while trees that received the same treatment within the orchard were badly defoliated.

In 1931, because of the favorable results from the use of fluorine compounds, the work was expanded. Sixteen different tests were carried out in four counties—Knox, Blount, Anderson, and Roane. Over 1000 trees were sprayed or dusted, and more than 400 bushels of peaches were sliced for records. The curculio infestation in 1931 was small; unsprayed trees averaged less than 10-percent damage in ripe fruit. The results of the 16 treatments were not significantly different; all generally showed satisfactory control for curculio.

A heavy infestation of oriental fruit moth was found in a small orchard in Bradley County on June 3, 1932. A spraying test was completed, consisting of 3 applications, on June 20, July 12, and July 19, to determine the value of 1 percent Verdol (summer oil) with barium fluosilicate and cryolite. The fruit picked on July 28 (check) showed 12.7 percent curculio in trees sprayed during the entire season by the owner, and 3.9 to 6.5 percent on trees treated with fluorine. The tests showed no difference in the sprays with or without summer oil. The oriental fruit moth infestation ranged from 58.7 to 64.7 percent in all plots, thus indicating no control. Brown rot infestation was severe in this orchard, and the data obtained show that the oriental fruit moth larvae were an important factor in the spread of the disease, as 30.7 percent of the ripe fruit was infested with the larvae and infected with the fungus. Brown rot infection alone was 12.6 percent, while only 1.9 percent of the fruit contained curculio larvae and brown rot.

After our work in 1930 showed that cryolite and barium fluosilicate were satisfactory substitutes for lead arsenate on the peach, and caused no injury to the foliage or fruit, many growers expressed a desire to use these materials. Trials in Georgia in 1935, however, revealed injury to the fruit which became known as "tip-end" injury. Later, Steiner (12) reported injury in Pennsylvania.

Such injury had not been observed up to that time. The season of 1936 was devoted to observations to determine whether this type of injury

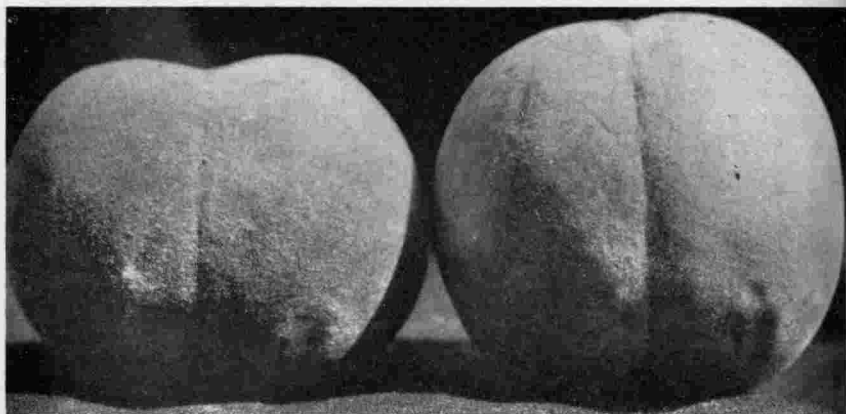


Fig. 5—Comparative effects of cryolite and lead arsenate sprays on Mikado peach, 1937.

Left, Fruit sprayed four times with cryolite, 1¼-50. Note that the tip end has become concave. Right, Normal fruit, sprayed with lead arsenate.

was present. But the season was dry, and no fruit injury was observed. The barium fluosilicate, however, produced some foliage injury on the Georgia Belle and Elberta, indicating that it is not as safe as cryolite.

Injury to the fruit from fluorine sprays was observed for the first time in Tennessee in 1937. The injury began to appear as the fruit ripened. Dutox (1 $\frac{1}{4}$ -50) gave severe injury from 3 applications. Injury from cryolite was less pronounced. The damage caused by Dutox was largely skin burn and cracking along the suture. The tip end was often affected, showing a rather dark sunken area, which indicated that the tissue just under the skin had been injured. The most noticeable injury by cryolite was malformation of the fruit (figs. 5 and 6), the tip end being concave instead of convex. The fruit was somewhat smaller on trees treated with cryolite than on those treated with lead arsenate. Occasionally, small sunken areas would appear and the skin would crack. The cracking of the skin usually was followed by severe brown rot infection.

The injury from both Dutox and cryolite was most pronounced on trees fertilized with superphosphate; less so on trees not fertilized; and still less on trees fertilized with sodium nitrate. Lead arsenate caused no injury to the fruit.

In 1940, only a few trees were available for spraying. These were of Vainqueur and Mikado varieties. As other work indicated that safening agents would not prevent fruit injury, the next question selected for study was the number of cryolite sprays that could be applied without injury to the fruit. Results showed that cryolite gave no noticeable injury when used in only one spray, either shuck-fall or 10-day.

Work was continued in 1941 with aluminum oxide and calcium phosphate as safening agents that might reduce the fruit injury. The insecticides used were Alorco cryolite, natural cryolite, and lead arsenate. The injury was not as bad as in previous years, especially on the Mikado variety. Both types of cryolite, however, produced injury, with premature ripening. Again it was noted that cryolite reduced the size of the fruit. None of the safening materials were of value. Increasing the number of sprays increased the amount of injury, which generally became apparent only as the fruit began to ripen. It appears that one cryolite spray can be used without causing injury.

In Virginia, Hurt (5) also found that one cryolite spray, 4 lbs.-100 gals., caused no fruit injury when applied in the petal-fall stage. At the

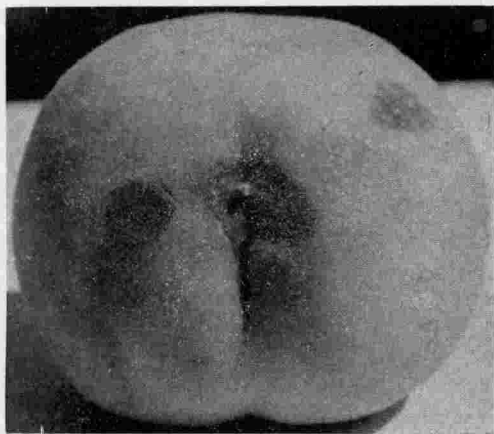


Fig. 6—Cryolite injury on Mikado peach.

Note the burned area around the tip, and the crack appearing in the suture; also the darkened areas at the left and upper right.

rate of 1 pound to 100 gallons of water, cryolite gave good control and did not cause injury when applied on June 25 and July 8 for the second brood.

The causes of fluorine injury to the fruit are obscure, but there is no doubt that misty, rainy weather accentuated the injury. No injury to fruit or foliage has been noted from a 50-percent cryolite dust against the peach twig borer in the semi-arid interior valleys of California (1).

EFFECT OF FERTILIZERS ON ARSENICAL INJURY

During the season of 1930, observations on peach foliage sprayed with arsenate of lead showed that soil fertility and moisture were the important factors involved in the defoliation. As part of the experimental control of insects, peach trees were treated with 5 different fertilizers to determine any possible relation between fertilizers and defoliation.

This test was made at Kingston, in a block of Elberta trees that had been used in tests the previous year. Table 2 shows the fertilizers used.

TABLE 2—*Fertilizers used at Kingston, Tennessee, on Elberta peaches, season of 1931.*

Fertilizer	Rate per application per tree	Number of applications	Dates of applications
	Pounds		
Ammonium sulfate	1.21	3	Dec. 19, 1930; Mar. 23 and April 23, 1931
Calcium nitrate	1.0		
Ammonium sulfate	2.0	3	do
Sodium nitrate	2.5	3	do
Sodium nitrate	2.5	3	do
Acid phosphate	5.0		
Potash (K_2SO_4)	1.6		
Manure	62.5	2	Dec 19, 1930; Mar. 23, 1931
Check (sodium nitrate)	1.0	1	Feb. 16, 1931

The sprays used with each of the fertilizer treatments are as follows: Lead arsenate 1-50, lime 3-50, and flotation sulfur 5-50, 4 applications; cryolite (Jungman) 1-50 and flotation sulfur 5-50, 6 applications.

Examination on May 25, after the application of 2 sprays, showed no foliage injury; but the fertilized trees were greener than those not fertilized. Trees sprayed with lead arsenate, flotation sulfur, and lime began to show injury on July 8. At that time, the fertilized trees were holding their leaves somewhat better than the unfertilized. By July 28, the difference in foliage injury was more noticeable, and by August 12 it was conspicuous. The fertilized trees were vigorous-looking, with the foliage and fruit green, while the unfertilized trees were almost completely defoliated and the fruit was ripe and ready to pick. Yet the two lots each received the same number of lead arsenate sprays, 4 in all. The lack of foliage in the unfertilized plots caused considerable sunscald on the prematurely ripened fruit. An examination of the trees was made again August 28. The difference between the fertilized and unfertilized was not as striking on that date as on August 12, for a new crop of leaves had begun to appear on the unfertilized trees. Nevertheless, the injury to the trees may have been greater, for the production of a new crop of leaves at that season is always detrimental to

the following crop of fruit. Late in the season, some burning and defoliation were observed on the fertilized trees, but the total effect did not appear serious because of the continual production of twig growth and new leaves (fig. 7).

One of the interesting things noted in the fertilizer treatments is that no difference could be observed from the various applications. Apparently, nitrogen is the only element needed to give a good growth response. This is in accord with the experience of the practical growers who use nitrogenous fertilizers only.

A survey of the literature on arsenical injury of peach indicates that the states of New Jersey and Georgia are most concerned. The soils of these states where peaches are grown are predominantly sandy. Sandy uplands usually are poor in nitrogen and other nutrients necessary for growth and vigor. Although commercial fertilizers are used in these areas, a tree grown on a sandy soil seldom has the appearance of one grown on a rich soil with an abundance of nitrogen. The soils at Kingston, where spray burn has been encountered, are known to be low in fertility.

In 1930, Paden and Albert (9) noted that the sandy soils in South Carolina become unproductive when preceded by cotton crops that have been dusted with calcium arsenate for the control of the boll weevil. The addition of calcium hydroxide to the "arsenic-sick" soils aided in overcoming the trouble, probably because the lime decreased the solubility of the arsenic in the soil. An experiment to determine just what effect the addition of an adequate supply of nitrogen to these unproductive soils would have might be interesting. It is not to be inferred that the use of nitrogen, by increasing growth, will overcome all types of arsenical injury. Yet the evidence points to the conclusion that if the water-soluble arsenic is reduced to the minimum—other factors being equal—increased vigor and growth will help a tree to overcome arsenical injury when otherwise it might succumb. The natural antidote for arsenical injury is the presence in the leaf tissues of an abundance of SH groups such as are found in glutathione, thioglucose, and cysteine, which are more plentiful in growing leaves (8).



Fig. 7—Effect of fertilizer on trees sprayed with lead arsenate.

Left, Twig from unfertilized tree, showing dead buds and new growth. Right, Twig from fertilized tree, showing partial defoliation but no new growth. Oct. 9, 1931.

CONTROL MEASURES

Jarring.—This was one of the earliest methods of control practiced against the curculio. Before the advent of spraying, it was the only one. The beetles have the habit of sulking, or "playing possum," when disturbed, and if the tree is jarred they will drop to the ground. In order to make use of this peculiar habit, a sheet of canvas is placed under the tree to catch the beetles, then the main limbs are given two or three blows with a padded club. For large orchards, an improved jarring sheet may be desirable (11).

The best time to jar a tree is the early morning. The beetles then are not active and can easily be caught and killed. In the warmer part of the day they become active and fly away. Jarring should begin soon after blossoming and continue at intervals of 4 days, especially in the rows next to a woodland where the beetles enter the orchard. Systematic jarring will give an idea of the number of beetles entering the orchard. It will also reduce the number of insects and thus keep them away from the fruit.

Collection of Drops.—Where spraying does not give adequate control in a heavily infested orchard, the collection and disposal of drops is a supplementary control measure that may be practiced with benefit. After the small infested peaches drop to the ground, the larvae continue to develop within them. If they are left, the grubs will enter the ground and complete their growth. The drops therefore should be collected soon after they fall. In Tennessee, the time for making these collections begins about the second week in May, or as soon as drops become evident under the trees. Where the infestation is heavy, several collections, at weekly intervals, will be necessary. If weeds are kept down it will be easier to find the drops.

It is important to dispose of the drops properly; otherwise, the larvae may emerge and nullify the work that has been done. A good method is to keep them under water for 3 weeks. It will not do merely to pour the drops in water, as many of the grubs will float and remain alive. Experiments have shown that the drops must be completely submerged for 3 weeks or longer.

Cultivation.—Since the larvae spend considerable time in the ground before they reappear as beetles, shallow cultivation will destroy many of them.

Spraying.—The most dependable method of control is the application of insecticides by spraying or dusting. Lead arsenate, in spite of its drawbacks, is still the best insecticide, and when combined with safening agents, and properly used, it gives satisfactory results.

The spray program, on page 22, shows the sprays that are considered best at the present time.

The third spray of the season—but the first against the curculio—is applied when the shucks, or dried floral parts, split open and fall off. Brown rot and scab also must be controlled at this time. Four different materials are used to make up this spray (see spray schedule). Hydrated lime and zinc sulfate are first mixed, a little time being allowed for these to react; then the sulfur and lead arsenate are added. The timing of this spray is important, and is best judged by jarring.

Frequently the curculio in coming out of hibernation enters the peach orchard on one side only. When this happens it is possible to kill many adults by jarring the outer three or four rows daily, and it may be practicable to omit lead arsenate from the shuck-fall spray. Trees farther in the orchard should be watched carefully for beetles that may have infiltrated.

The fourth spray, called the first-cover spray, is applied about 2 weeks after the shuck-fall. The same materials are used.

The fifth spray, or second-cover, should be applied early in June. It consists only of sulfur to control diseases.

The sixth spray, or third-cover, comes early in July, and aims to control the new generation of curculios, as well as brown rot. The same four materials that are used for the shuck-fall spray are used again in the same manner.

Peaches may be grown without strict adherence to this schedule. In dry seasons the fungicides may be omitted, while in wet years an extra sulfur spray may be needed. Over a period of years, however, adherence to the schedule will be beneficial.

PEACH DUST SCHEDULE

In many peach orchards in East Tennessee, spraying is rather difficult because of steep ground or lack of water. Under those conditions, or when economy of time and labor is of greatest importance, all of the sprays outlined in the schedule, beginning with "shuck stage" and continuing to the end of the season, may be replaced to advantage by dusting.

For the shuck and first- and third-cover stages, the following dust mixture is advised:

5 pounds lead arsenate
15 pounds hydrated lime
80 pounds fine dusting sulfur.

In second-cover and pre-harvest stages, only a sulfur dust need be used.

To insure the success of dusting, the foliage should be wet with dew, and the air quiet, as in the late afternoon, or in the early morning before the dew dries.

ORIENTAL FRUIT MOTH

In 1915, the oriental fruit moth, *Grapholitha molesta* (fig. 8), was discovered near Washington, D. C. The insect spread rapidly, and by about 1922 had reached Tennessee. Several years elapsed before it was reported as doing excessive damage to peaches in this State. Now it is known to occur in all sections of the United States, with the possible exception of the Pacific Northwest.

This insect has the unusual habit of causing injury to the tree as well as to the fruit. The larvae bore out the tip end of tender twigs, causing them to die back; and later attack the fruit, after it has nearly reached full size. The twig injury (fig. 9) occurs in the spring, seriously affecting the growth of young trees and giving them a stunted, bushy appearance. The injury to the fruit resembles somewhat



Fig. 8.—Larvae and adults of the oriental fruit moth.

that caused by the plum curculio larvae. Oriental fruit moth larvae tunnel or bore through the fruit rather aimlessly, and do not make a cavity as large as that made by curculio larvae. On immature fruit (fig. 10), damage is indicated by a clear waxy substance exuded by the green peach. At harvest time the fruit may show no outward signs of larvae. The inability to grade out infested fruit thus results in serious loss to the consumer. In 1932, 45 percent of the peaches in a bushel sample from an orchard near Knoxville had no visible injury.

The larva is of pinkish color and is very much like the codling moth larva. When it attacks apples, it is distinguishable from the other only by a comb-shaped plate on the last segment of its body. This plate is not readily visible, and slight pressure must be applied to force it out into view. Besides peaches and apples, this pest attacks plum, pear, quince, and other fruits.



Fig. 9—Work of oriental fruit moth larvae on peach twigs.

As a result of the injury, each twig will be stunted.

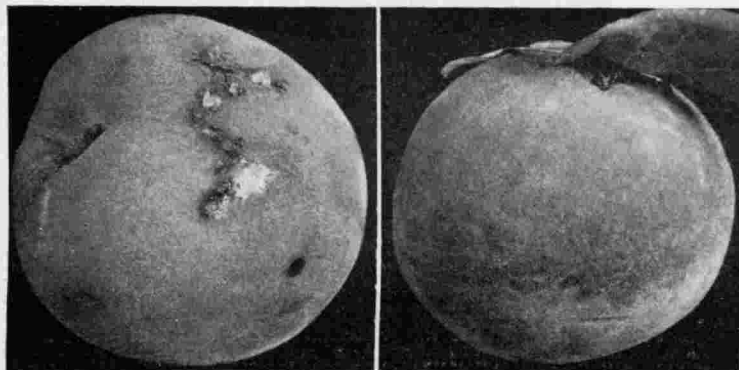


Fig. 10—Immature peaches injured by the oriental fruit moth larvae. Left, Note the waxy secretion. Right, Typical injury, with leaf sticking to the wax.

The eggs are laid singly on twigs and leaves by a moth about $\frac{1}{4}$ inch long, of grayish color, with dark-brown markings on the wings. The larvae,

upon hatching, crawl about until they find a suitable place to feed, then start boring in.

In 1932, bait traps were employed to determine seasonal abundance of moths. The traps were suspended on stakes about 10 feet high in the centers of 35 mature trees on the University Farm. The bait was made of fermenting molasses and ethyl cinnamate. The traps were placed in the orchard on May 10 and removed on August 31. Figure 11 shows the total number of adults removed from the 36 traps on the date indicated during the season.

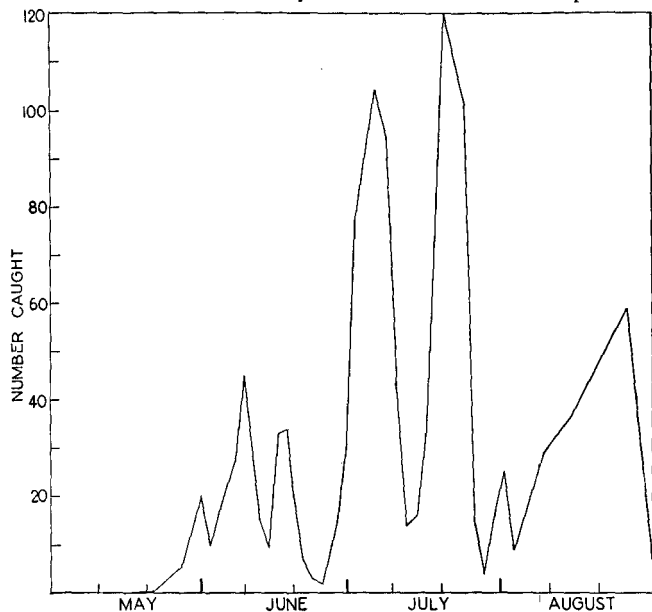


Fig. 11—Seasonal abundance of the oriental fruit moth durrig 1932.

The usual stomach poisons do not control the oriental fruit moth larvae because the first few mouthfuls taken are discarded. Owing to the inability of the present insecticides to control this pest, a study has been made of its various parasites by the United States Department of Agriculture. The most important one found is a native insect, *Macrocentrus ancylivorus* Roh. The same parasite attacks larvae of the strawberry leaf-roller and other larvae boring in weeds surrounding peach orchards. The populations of both the parasite and the oriental fruit moth in Tennessee fluctuate with weather conditions. In 1934, the peach orchard used for the tests was bordered on two sides by strawberry fields, and at harvest time oriental fruit moth larvae infestation ranged only from 4.2 to 7.3 percent. Wild blackberries also are an important host for the strawberry leaf-roller and may be of some value in this connection. According to Brunson and Allen (2), the mass liberation of *M. ancylivorus*—330 females per acre—in peach orchards increased the parasitization of second-brood oriental fruit moth larvae and reduced fruit injury by about 50 percent.

The early experiments on the control of this pest by dusts and sprays appeared to be promising, but a continuation of the work showed no definite results. It was observed also that oriental fruit moth larvae were responsible to a much greater extent than curculio for brown rot infection in the ripe fruit (fig. 10).

In Illinois, oil dusts have given some measure of control. Generally, 4 applications are recommended, the first starting 3 weeks before harvest

and the last ending within 3 days before harvest. About $\frac{1}{2}$ to 1 pound of dust is used for each mature tree. The oil dust is made up as follows:

Sulfur	60	pounds
Talc	35	"
Lubricating oil (80-110 vis.).....	5	"

These materials are thoroughly mixed in a dust mixer and applied with a power duster.

PEACH TREE BORER

The peach tree borer, *Sanninoidea exitiosa* (fig. 12), is known to all peach growers. If treatments for it are not given every year, the trees will soon be killed or become weakened and then will be attacked by other insects, such as the shot-hole borer.

The larvae of the peach tree borer is a white worm with a brown head. It is found in tree trunks at about ground level (fig. 13), where it overwinters, completing its growth and developing into the moth by late summer. The eggs are placed on the trunk near the ground and in soil cracks close to the tree during the late summer.

Fortunately, there are several effective control measures. The most common is the use of crystals of paradichlorobenzene (PDB). This material volatilizes into a heavy gas and kills the borers by penetrating into the burrows and cracks where they are feeding. PDB must be used carefully so

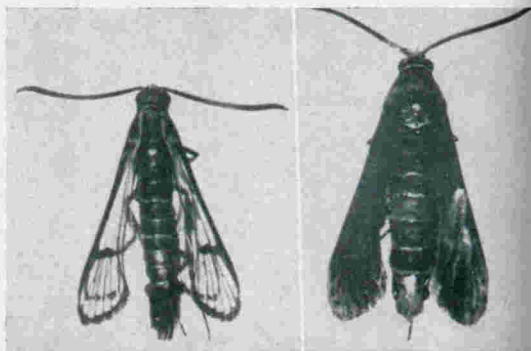


Fig. 12—Peach tree borer moths.
Left, male; right female.



Fig. 13—Peach tree borer.

The whitish worms are usually found boring in the trunk under a mass of wax. The moths come from the brown pupa case (right).

Tree ready for PDB treatment. The soil is made smooth for about a foot from the trunk with the back of a shovel before the crystals are placed in a circle. Do not remove soil from the trunk. The soil should be mounded slightly if the borers are working above the soil level as indicated by gum, which should be removed.

PDB properly applied and ready to be covered. Note that the crystals form a band about the trunk but do not touch the bark. PDB will kill the tree if placed against the bark or too close to it. Make the band about $1\frac{1}{2}$ inches from the trunk. Trees 1 to 3 years old need only $\frac{1}{2}$ ounce per tree. For trees 3 to 6 years old, use $\frac{3}{4}$ ounce, and for older trees, 1 to $1\frac{1}{2}$ ounces.

PDB properly covered. The soil is mounded up around the tree to a height of about 6 inches and packed rather firmly with the back of a shovel. The soil used should be free of stones and trash. The mounds should be removed from young trees in 2 weeks, or after 4 weeks from trees 4-6 years old and 6 weeks from trees over 6 years old.

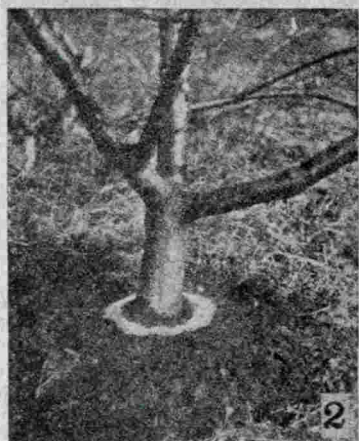


Fig. 14—Steps in the application of PDB for control of the peach tree borer.

as not to injure trees. The amount required will vary with the age of the tree, as follows; For trees under 3 years, $\frac{1}{2}$ ounce per tree; for trees 3 to 6 years, $\frac{3}{4}$ ounce; for trees older than 6 years, 1 to $1\frac{1}{2}$ ounces. The soil temperature must be above 60° F. for the crystals to volatilize, and the material must be applied late enough in the season for the borers to be in the trunk. In Tennessee, on an average, the first week in October is the best time to apply PDB.

In preparation for the applications, the ground is cleared of weeds and trash for a distance of 12 to 15 inches from the trunk. The crystals then are placed in a uniform ring around the trunk, not closer to the bark than 1 inch, nor farther away than 3 inches (fig. 14). Several shovelfuls of fine soil, not very wet, are used to cover the crystals. The dirt is mounded up around the trunk and lightly packed. The mound on trees 1 to 3 years old should be removed after two weeks, and on older trees, early in the following season.

PDB can be applied more easily and quickly in emulsion form than in crystals, as less soil preparation is required, and it can be used later in the season. Trees must be mounded after treatment. Commercially prepared oil emulsions containing PDB are available under various trade names, such as "Boretex" and "Para-scalecide." The manufacturers' directions should be followed for these materials.

Recently, ethylene dichloride has been found to be very effective against the borer. This chemical can be applied in the late fall, during warm spells in the winter, and in early spring. The material is on the market in emulsified form with directions for its use. The directions that follow are given for the benefit of growers who wish to make their own emulsion: Pour 9 quarts of ethylene dichloride into 1 quart of a good grade of liquid potash fish-oil soap, and mix well. Add 8 quarts of water while stirring to prepare a good emulsion. These proportions will give a stock emulsion containing 50 percent ethylene dichloride. For use on the trees the emulsion must be diluted further, as shown in table 3.

Mixing should be done outdoors or in a well-ventilated room. The soil at the base of the tree should be scratched loose on the surface and the cracks filled. Pour the solution carefully 2 or 3 inches away from the trunk, and cover lightly with a little dirt (fig. 15). Keep stirring to prevent the ethylene dichloride from floating on top. Wet soil will prevent diffusion, and may result in damage to trees.



Fig. 15—One way to apply ethylene dichloride emulsion.

TABLE 3—Ethylene dichloride dilution for peach trees of given ages.

Age of tree	50% stock solution	Water	Amount of dilution to use per tree	Sufficient to treat
Years	Quarts	Quarts	Pint	Trees
1	1½	8½	½	160
2	3	7	¼	80
3	3	7	½	40
4 and over	4	6	½	40

LESSER PEACH TREE BORER

The lesser peach tree borer, *Aegeria pictipes*, attacks the larger limbs and the trunk above ground, especially where wounds exist. Injuries caused by machinery, sunscald, or weak crotches will attract this insect.

A solution of paradichlorobenzene in cottonseed oil is an effective remedy. One pound of the material is dissolved by warming in 2 quarts of crude cottonseed oil. The solution is applied with a paint brush, to the infested areas only, when treatments are made for the peach tree borer.

SAN JOSE SCALE

Before adequate control methods were developed, the San Jose scale, *Aspidiotus perniciosus*, threatened the fruit interests of the United States. When abundant, the large number of scales give the bark a grayish appearance. Individual scales when small are black, with a nipple-shaped center, becoming grayish on maturity (fig. 16). Often a reddish area around a scale may be observed on the fruit.

The insects usually pass the winter in the smaller, immature stages and become mature about the time that apple trees bloom. The mature male comes from a circular scale with a raised nipple in the center, while the female develops under the oval-shaped scale. The adult male is a very small, two-winged insect which moves about. The female remains under the scale and produces living young, which look like

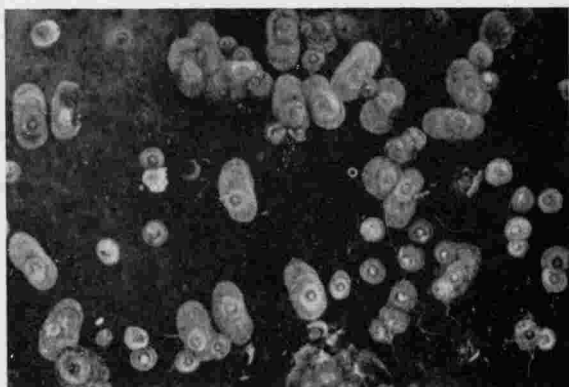


Fig. 16—San Jose scale (enlarged).

Tiny insects under the scale look like small yellow sacks.

small mites or lice. These young move about for a short time, find a place to insert their beaks, and begin sucking sap. After awhile they shed their skins and appear as small yellow sacks fastened to the bark by mouth parts. Soon a waxy secretion from the insects covers their bodies.

CONTROL

Oil sprays have largely supplanted the lime-sulfur sprays for the control of the San Jose scale. A thorough application of oil spray when the trees are dormant will reduce the scale population to 1 percent or less. Ready-mixed lubricating-oil emulsions are available. Oil emulsion may be obtained from dealers as a stock emulsion, usually having an oil content of 66 percent or more. In preparing oil sprays, it is necessary that the oil content of the emulsion be known and dilutions made accordingly. To determine the amount of emulsion to use in 100 gallons, multiply the percent of oil required by 100 and divide by the percentage of oil in the stock emulsion. The result is the gallons of that emulsion to use. For example, 100 gallons of spray material to contain 3 percent of oil will require 3.6 gallons of 83-percent oil emulsion: $3 \times 100 \div 83 = 3.6$.

Emulsions made by the cold-pumped method also are quite satisfactory, provided certain precautions are taken:

1. Use only a good grade of lubricating oil, having a Saybolt viscosity of 100 seconds or more at 100° F. If oils below this standard are used, considerable damage to trees may result.
2. Make the emulsion only when the temperature is above 50° F.
3. Be sure that all the oil is run through the pump, and do not store an emulsion in a drum that contains even a small amount of unemulsified oil.
4. Use a good emulsifying agent. Dry lignin pitch appears to be one of the cheapest and most effective materials tested in our experiments for this purpose. If lignin pitch is not available, use powdered soap.

To make a 50-percent stock emulsion, add 5 pounds of dry lignin pitch or 15 pounds of soap to 25 gallons of water, in a sprayer tank, and run through the spray pump, overflowing back into the tank. Now add slowly 25 gallons of oil and let it run through the pump back into the tank, together with the lignin-pitch solution. After all the oil has emulsified, which will be within 5 to 10 minutes, it should be pumped through a coarse nozzle into a drum for storage. The best product will be obtained when the emulsion is pumped into the drum under considerable pressure. The emulsion should be used within a relatively short time. Emulsions containing other percentages of oil can be made by the same process.

When preparing to spray, it is important to put the emulsified oil into the tank first, before any water is added. Sometimes a poorly made emulsion breaks if poured into a large volume of water. Never use a broken emulsion, because the oil, which is the toxic agent, will be floating on top, and this pure oil when sprayed on trees is injurious.

Where peach leaf curl is present, a 2-2-50 bordeaux mixture is used with the oil spray; that is, 2 pounds of copper sulfate and 2 pounds of lime in each 50 gallons of water. Bordeaux mixture can be used as an emulsifying agent for oil in power sprayers if it is made with just enough water to pass through the pump. The bordeaux mixture is prepared first; then the oil is added slowly so that it is sucked into the pump. When it goes through the pump under high pressure, the oil becomes emulsified and will mix with the water. After the oil is all taken up and emulsified, finish

filling the tanks; then spray at once, for this method forms a "quick-breaking" emulsion, which will separate it not used promptly.

Oil emulsion is also quickly made by the use of an injector, a funnel-shaped reservoir attached by a valve on the suction line between the intake opening and the pump. This reservoir is filled with oil, and after the emulsifying agent, either bordeaux or soap, is added, the valve is opened very slowly. By this method it is assured that all the oil goes into the pump—and with practice the emulsion can be made with very little extra time and trouble.



TERRAPIN SCALE

The terrapin scale, *Lecanium nigrofasciatus*, is found occasionally on the lower side of peach twigs (fig. 17). The honeydew excreted by this insect encourages a fungous growth that produces a sooty appearance on the twigs and limbs.

Oil emulsion as used for San Jose scale is effective against the terrapin scale, but must be used in a 4-percent strength for good control.

SHOT-HOLE BORER

The shot-hole borer, *Scolytus rugulosus*, is primarily an enemy of weakened or diseased trees. Numerous small round holes in the bark are a sure indication of its presence.

Trees that are seriously injured by this borer should be removed and burned. Prunings should not be allowed to remain in the orchard. Keeping the orchard in a good state of vigor, through good orchard practice, is the best insurance against the shot-hole borer.

Fig. 17—Terrapin scale on peach twigs.

ACKNOWLEDGMENTS

The authors acknowledge the very helpful cooperation of Mr. Charles Proffit, of Alcoa; Dr. Z. P. Zirkle, of Kingston; Mr. S. N. Varnell, of Cleveland; and Mr. Harry Wallace, of Knoxville, who have permitted the use of their orchards for the testing of sprays under practical conditions.

PEACH SPRAY PROGRAM

SPRAYS DESIGNATED BY HEAVY TYPE ARE ALWAYS ESSENTIAL

Name of spray	Time to spray	To control	Material to use in 50 gallons of water
Dormant	When trees are dormant, before bud scales crack	Scale Leaf curl	Bordeaux 2-2-50 and 3% oil for San Jose scale or 4% oil for terrapin scale
Pink-bud	When buds begin to separate	Blossom blight caused by brown rot fungus	Lime-sulfur 1½ gallons
Shuck stage	When most of dried floral parts (shucks) split open	Curculio Scab Brown rot	Wettable sulfur 4 pounds, or flotation sulfur 3 pounds Hydrated lime 2 pounds Zinc sulfate 1 pound Lead arsenate 1 pound
First-cover	About 2 weeks later than above	Curculio Scab	Same as above
Second-cover	Early in June	Brown rot Scab	Wettable sulfur 4 pounds, or flotation sulfur 3 pounds
Third-cover	Early in July	Curculio Brown rot	Wettable sulfur 4 pounds, or flotation sulfur 3 pounds Hydrated lime 2 pounds Zinc sulfate 1 pound Lead arsenate 1 pound
Pre-harvest	About 10 days before harvest	Brown rot	Wettable sulfur 4 pounds, or flotation sulfur 3 pounds

REFERENCES

- (1) Borden, A. D. Private correspondence. Cal. Agr. Exp. Sta.
- (2) Brunson, M. H., and Allen, H. W. Mass liberation of parasites for immediate reduction of oriental fruit moth injury to ripe peaches. Jour. Econ. Ent. 37: 411. 1944.
- (3) Chapman, P. J. The plum curculio as an apple pest. N. Y. Agr. Exp. Sta. Bul. 684. 1938.
- (4) Haenseler, C. M., and Martin, W. H. Arsenical injury of the peach. Phytopathology 15: 321. 1925.
- (5) Hurt, R. H. Cryolite as a lead arsenate substitute. Proc. Va. Hort. Soc. 31: 47. 1943.
- (6) Marcovitch, S., and Stanley, W. W. Cryolite and barium fluosilicate: their use as insecticides. Tenn. Agr. Exp. Sta. Bul. 140. 1929.
- (7) ——— Stanley, W. W., and Anthony, M. V. A preliminary report on arsenical substitutes for peach spraying. Jour. Econ. Ent. 24: 844. 1931.
- (8) ——— and Stanley, W. W. Experiments on the control of arsenical injury on peach. Jour. Econ. Ent. 25: 213. 1932.
- (9) Paden, W. R., and Albert, W. B. Effect of the addition of arsenical compounds to soils. S. C. Agr. Exp. Sta. 43rd Report, p. 31. 1930.
- (10) Quaintance, A. L., and Jenne, E. L. The plum curculio. U.S.D.A. Bur. of Ent. Bul. 103. 1912.
- (11) Snapp, O. I., and Hollon, J. P. An improved curculio jarring sheet. U.S.D.A. Bur. of Ent. and Plant Quarantine. E-608. 1941.
- (12) Steiner, H. M., and Worthley, H. N. The plum curculio problem on peach in Pennsylvania. Jour. Econ. Ent. 34: 249. 1941.

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE

JAMES D. HOSKINS, President

AGRICULTURAL COMMITTEE

W. P. COOPER	HARRY S. BERRY	I. B. TIGRETT
CLYDE B. AUSTIN	W. P. RIDLEY	
O. E. VAN CLEAVE, Commissioner of Agriculture		

STATION OFFICERS

ADMINISTRATION

C. A. MOOERS, Director
F. S. CHANCE, Assistant Director
E. G. FRIZZELL, Associate Secretary

AGRONOMY

C. A. MOOERS, Agronomist
A. G. BURG, Asst. Agronomist
HENRY CUMMINS, Farm Supt., Crossville
W. A. CHRISMAN, Plot Assistant
J. G. FAULKNER, Plot Assistant
N. I. HANCOCK, Assoc. Agronomist
O. H. LONG, Asst. Agronomist
R. L. LONG, Plot Assistant, Bell Buckle
F. D. RICHEY,¹ Assoc. Agron. (Corn Breeding)
J. K. UNDERWOOD, Assoc. Agronomist
JOHN B. WASHKO, Assoc. Agronomist
W. O. WHITTLE, Asst. in Agronomy
ERIC WINTERS, Assoc. Agronomist

ANIMAL HUSBANDRY

C. E. WYLIE, Dairy Husbandman
H. R. DUNCAN, Assoc. Animal Husb.
S. A. HINTON, Asst. Dairy Husb.
B. J. McSPADDEN, Poultry Husb.

CHEMISTRY

W. H. MacINTIRE, Soil Chemist
G. A. SHUEY, General Chemist
MARY K. GOOD, Asst. Gen. Chemist
BROOKS ROBINSON, Asst. Soil Chemist
K. B. SANDERS, Assoc. General Chemist
W. M. SHAW, Assoc. Soil Chemist
S. H. WINTERBERG, Assoc. in Soil Chemistry
J. B. YOUNG, Asst. Soil Chemist

ECONOMICS AND SOCIOLOGY

C. E. ALLRED, Agricultural Economist
H. J. BONSER, Assoc. Agr. Economist
A. H. CHAMBERS,¹ Asst. Agr. Economist
B. H. LUEBKE, Assoc. Agr. Economist
C. C. MANTLE, Asst. Agr. Economist
F. N. MASTERS, Asst. Agr. Economist
W. P. RANNEY, Assoc. Agr. Economist
BENJ. D. RASKOPF,² Asst. Agr. Economist

ENGINEERING

M. A. SHARP, Agricultural Engineer
H. A. ARNOLD, Assoc. Agr. Engineer
A. L. KENNEDY, Assoc. Agr. Engineer
ARTHUR H. MORGAN, Mech. Engineer

ENTOMOLOGY

S. MARCOVITCH, Entomologist
W. W. STANLEY, Assoc. Entomologist

FORESTRY

R. F. KROODSMA, Forester, Greeneville
R. D. CARPENTER, Asst. Forester, Greeneville
LLOYD FORD, Asst. in Forestry, Greeneville

HOME ECONOMICS

FLORENCE L. MacLEOD, Home Economist
DOROTHY E. WILLIAMS, Nutrition Chemist
MARY L. DODDS, Assoc. Home Economist
ELISE MORRELL, Asst. Nutrition Chemist
JUANITA SMITH CARR, Asst. in Home Econ.
PAULINE JONES, Asst. in Home Econ.

HORTICULTURE

BROOKS D. DRAIN, Horticulturist
J. P. OVERCASH, Asst. Horticulturist, Jackson
N. D. PEACOCK, Assoc. Horticulturist
C. R. SPANGLER, Asst. in Horticulture
A. B. STRAND, Assoc. Hort., Dandridge
JOAN K. WILEY, Asst. Horticulturist

INFORMATION

A. J. SIMS, Head of Department
F. H. BROOME, Editor and Secretary
SARAH C. CURRELL, Librarian

PHYSICS

K. L. HERTEL, Physicist
HARRY CUPP, Asst. in Physics
REBA LAWSON, Asst. in Physics

PLANT PATHOLOGY

C. D. SHERBAKOFF, Plant Pathologist
J. O. ANDES,² Assoc. Plant Pathologist
E. S. BROWN, Asst. in Plant Pathology
JAMES M. EPPS, Asst. Plant Path., Jackson
DENNIS H. LATHAM, Assoc. Plant Pathologist, Springfield
T. L. SENN,² Assistant Plant Pathologist

SUBSTATIONS

LESTER WEAKLEY, Assistant, Highland Rim Experiment Station, Springfield.
L. R. NEEL, Superintendent, Middle Tennessee Experiment Station, Columbia.
JOHN A. EWING, Asst. Supt. Middle Tennessee Experiment Station, Columbia.
J. J. BIRD, Associate Agronomist, Plateau Experiment Station, Crossville.
E. L. BOHANAN, Assistant Agronomist, Plateau Experiment Station, Crossville.
J. L. VANDIVER,¹ Assistant Agronomist, Tobacco Experiment Station, Greeneville.
B. P. HAZLEWOOD, Superintendent, West Tennessee Experiment Station, Jackson.

¹Cooperative with U. S. Department of Agriculture.

²On military leave.