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The Oriental Fruit Moth in Missouri

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SUMMARY

The Oriental fruit moth (*Grapholitha molesta* Busck), an introduced pest of the peach in the United States, has been, for the last ten years, a major pest of the peach in Missouri. Heavy damage, thus far, has been generally confined to the southern and eastern portions of the state.

Various host plants are attacked by the pest, but only peach, apple, and quince have been seriously damaged in Missouri.

The insect attacks and damages both the twigs and fruit of the peach. Twig damage is, generally, not considered to be of great importance, the fruit damage being of more concern to the orchardist.

There are four stages in the life cycle of the Oriental fruit moth—egg, larva, pupa, and adult. In South Missouri, five generations of the pest are recorded each year. The larva, or worm, is the destructive stage of the insect, and spraying and dusting control measures are directed at the egg and larval stages.

The orchardist is materially aided in controlling the Oriental fruit moth by numerous parasites. Thirteen species of larval parasites of the Oriental fruit moth have been recorded in Missouri.

Stomach poisons will not control the Oriental fruit moth larva due to the fact that larval feeding proper begins only after the sprayed surface of the host plant has been removed and discarded.

Results of experimental spraying and dusting tests conducted for three years in Missouri indicate that oil-sulphur dusts and oil-nicotine sprays will materially increase the amount of clean fruit at harvest time.

Recommendations for the use of oil-sulphur dust, oil-nicotine and fixed nicotines are given.

Various supplementary control practices in the orchard and packing shed are also recommended.

The Oriental Fruit Moth In Missouri

CURTIS W. WINGO

The Oriental fruit moth, *Grapholitha molesta* (Busck), was first recorded in the United States in the District of Columbia in 1916. It is believed that the pest was first introduced into this country from Japan with shipments of Japanese flowering cherry in 1912 and 1913.

Since its introduction it has spread slowly through the peach growing regions of the United States. During the last ten years the pest has moved westward until, at the present time, it has been reported as far west as Dallas, Texas, and eastern Kansas.

The Oriental fruit moth first appeared in Missouri in 1930. It was probably introduced into the state in shipments of infested peaches from the eastern states. It is now established in every section of the state, but, so far, has been a major pest of the peach in only the eastern and southern parts of the state, where peaches are more intensively planted and where the fruit moth was first introduced.

In the northwest corner of the state, the pest was not found until 1935, when it was taken in codling moth bait traps. Bait trap records in 1936, 1937, 1938 and 1939 indicate that the insect is on the increase in that section, and it is possible that within a few years it may increase to proportions capable of inflicting some damage.

Hosts

Nearly all orchard fruits are attacked by the Oriental fruit moth to a greater or lesser degree. Peach twigs and fruit are the pest's preferred hosts, while the twigs and fruit of quince, apricot, apple, pear, cherry, and ornamental quince, peach, and cherries are fed upon by the insect when such plants are available in abundance. In Missouri, only peach, apricot, quince, and apple have been reported as seriously damaged by the Oriental fruit moth.

The twigs of the various host plants, and especially of peach, are attacked by the early broods of larvae. The small, newly-hatched worms bore into the tender, growing twigs and feed upon the soft inner tissue, hollowing out the twigs for a distance of 2 to 4 inches from the tip. One larva may feed on as many as two to five twigs, depending upon the brood and upon the condition of the twigs at the time of feeding. As the worm works down the center of the twig a small quantity of white and brown borings and frass is pushed from the entrance hole. Infested twigs are easily recognized by this frass and the wilted terminal leaves.

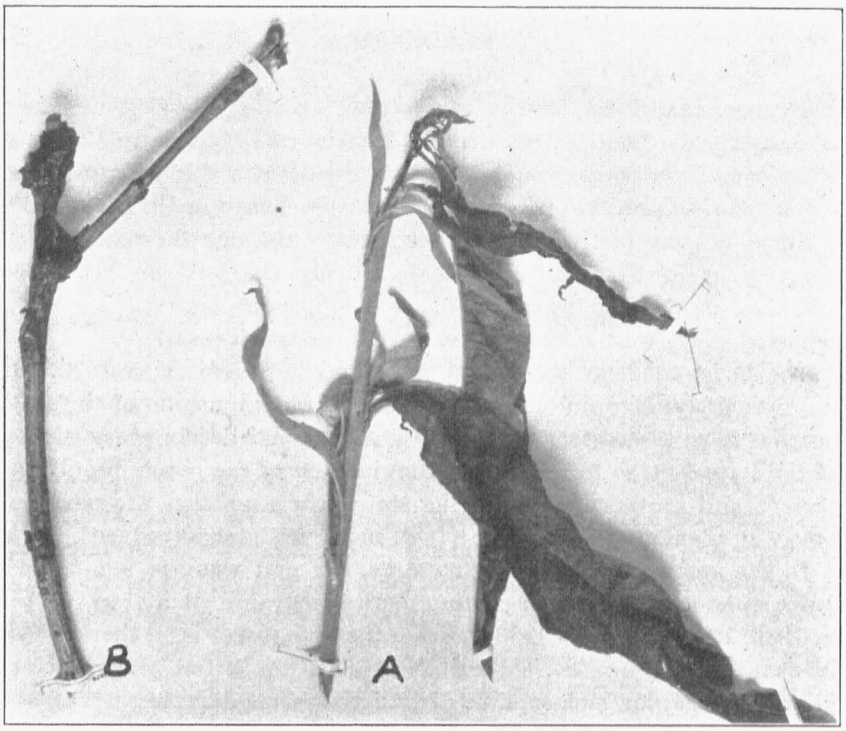

Fig. 1.—A, Peach twig injured by Oriental fruit moth larva;
B, Injured twig after the leaves have dropped in the fall.

As soon as the tender inner tissue of the twig is exhausted or the worm becomes full-fed, it bores out through the side of the twig and seeks either a cocooning place or a fresh twig.

The later broods of larvae feed on both the twigs and the fruit of the host plants. Oriental fruit moth injury to peaches is very similar to the injury of codling moth larvae to apples. The fruit is tunneled somewhat more extensively and fungus diseases and rot soon complete the utter breakdown of the fruit. Oriental fruit moth injury to apples in August and September is usually characterized by shallow and extensive tunnels just under the skin of the fruit. This injury resembles the small, shallow mines of the so-called codling moth "pin worms" found in the fall.

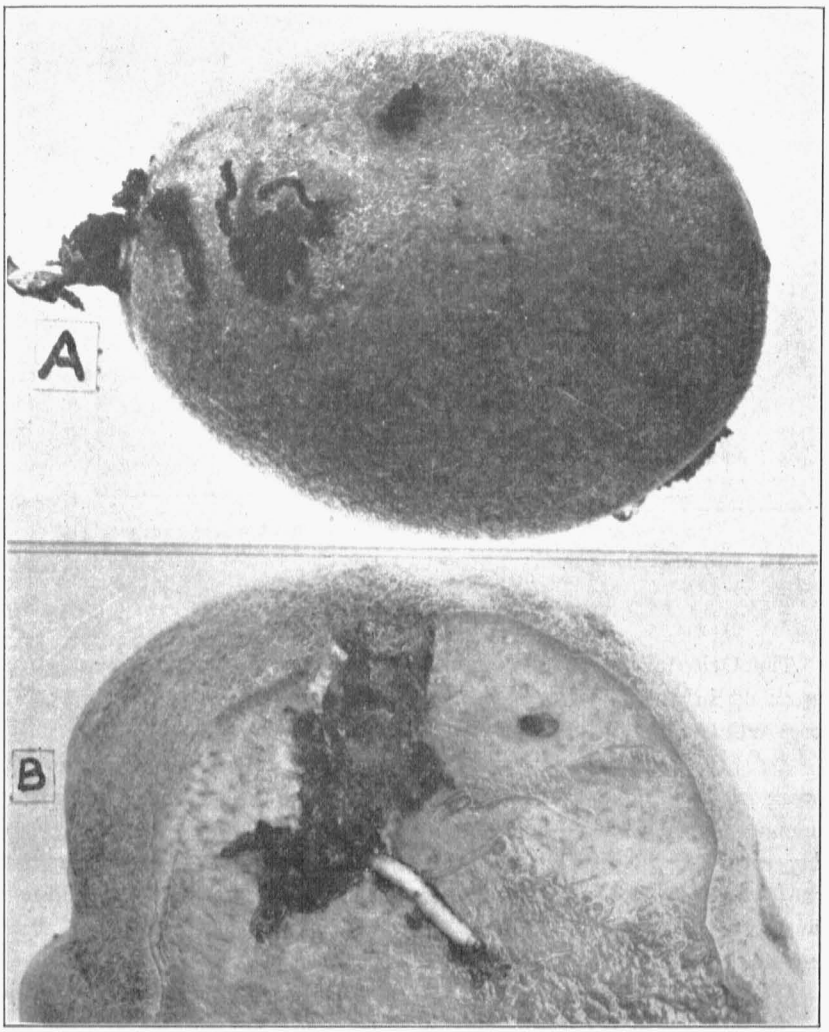

Fig. 2.—A, Peach infested with Oriental fruit moth larva;
B, Larva working within the peach (after U. S.D.A., Bureau of Entomology and Plant Quarantine).

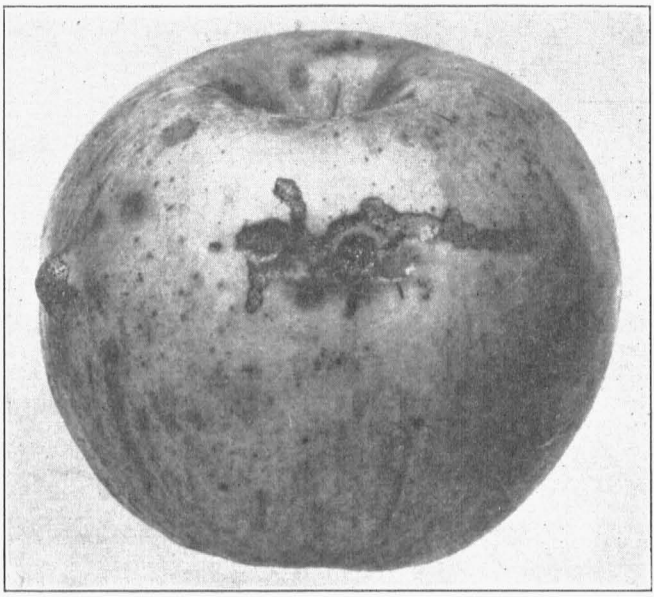

Fig. 3.—Typical entrance hole and shallow mines in an apple infested with Oriental fruit moth larva (after U.S.D.A., Bureau of Entomology and Plant Quarantine).

LIFE HISTORY AND HABITS

The Oriental fruit moth spends the winter as a full-grown larva spun up in a cocoon in debris in the orchard, in peach mummies, on tree trunks, limbs, and occasionally on old injured twigs.

Early in the spring (in Missouri the last week in March to the first week in April) the overwintering larvae begin to pupate and, after spending from 5 to 30 days in the pupal stage, the moths emerge to lay eggs for the first brood of worms. The eggs are laid, for the most part, on the under surface of the terminal leaves and hatch within 4 to 12 days, depending of course upon the temperature. The eggs are quite small, being about 0.7 mm. in diameter.

When the eggs have hatched, the small larvae find suitable tender twigs and begin feeding. During July and August, when peaches are ripening, the larvae of the midsummer broods may begin feeding either on the twigs or the fruit. Quite often a worm may begin feeding on twigs and finish its growth in the fruit. Usually, unless an early summer drouth is experienced and the twigs harden earlier than usual, the first two broods of worms and about one-half of the third brood confine their feeding almost entirely to the twigs. The last half of the third brood and the fourth and fifth broods feed indis-

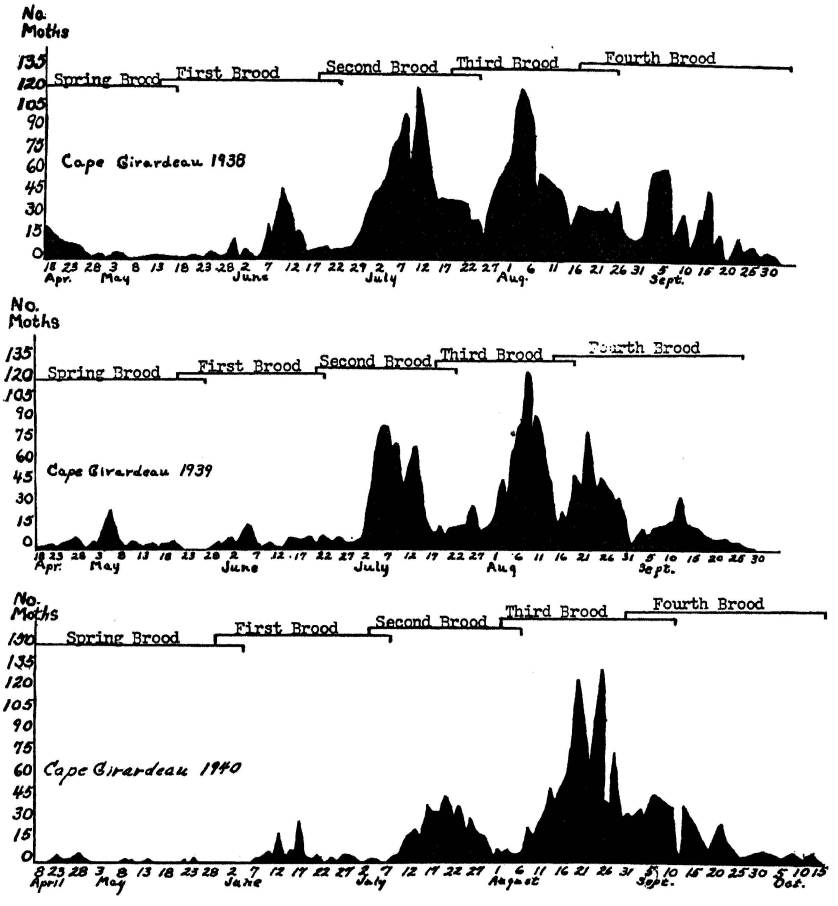

Fig. 4.—Oriental fruit moth bait trap records (three years) showing the flight duration of the various brood of moths in the orchard (Leming Orchard, Cape Girardeau, Missouri).

criminately on both twigs and fruit. If rainfall is below normal and twig growth during July, August, and September is slow or at a standstill, the twigs become too hard and tough for the larvae to feed in. Under such conditions, heavy damage to the fruit may occur if the infestation is large.

The larvae ordinarily require from 8 to 24 days to complete their growth. When full-grown, they spin their cocoons under bark, in weeds and trash, and on various parts of the tree. The summer broods are more given to cocooning in the upper parts of the tree, frequently on the twigs and on peaches. The pupal period during the summer is usually short (4 to 8 days) and soon the moth emerges and lays eggs for the next generation.

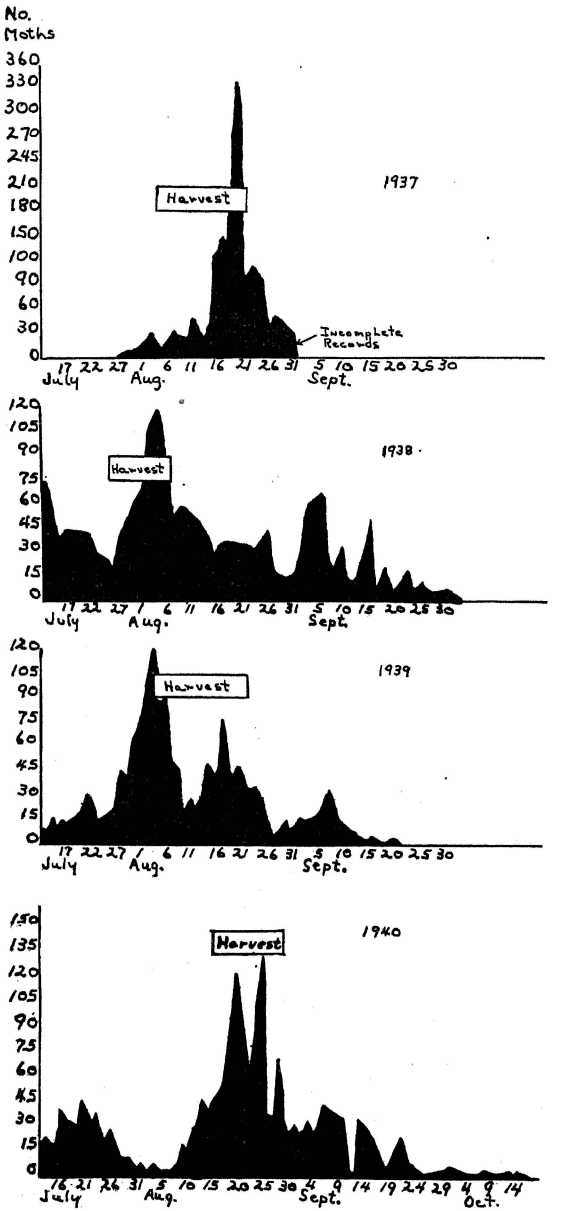

Fig. 5.—Relation of occurrence of third brood Oriental fruit moths to Elberta harvest as shown by bait traps (Leming Orchard, Cape Girardeau, Missouri).

In Southern Missouri, there are five full generations of the Oriental fruit moth each year. This means that from April until October there are five broods of worms in the orchard. In the northern portion of the state there are probably only four full generations and a partial fifth, the size of the fifth being dependent upon the continuance of warm weather and other favorable conditions in the fall.

CONTROL

Spraying and Dusting

Applications of stomach poisons for the control of Oriental fruit moth larvae are of little or no value. Unlike the majority of the chewing insects, this small worm does not ingest the first few mouthfuls of food but bores into the twig or fruit a short way before it actually begins feeding. In doing this the worm discards the outer portion of the plant, which has the poison spray on it, and thus takes none of the spray poison into its system.

Fumigation is not practicable, which leaves the orchardist with only one class of insecticide—contact, with which to combat the pest. Sprays containing oils and nicotines have been found to be effective against both the egg stage and the larval stage. Dusting mixtures containing sulphur, talc, lime, and lubricating oil have been found effective. This dust acts as a larvicide, as a physical hindrance to the larvae, and to a small extent, perhaps, as an ovicide.

At the present time, little effort is made to control the twig-feeding larvae, since experience has shown that the yearly twig growth of vigorous and healthy trees is not materially impaired by the feeding of the larvae. All spray and dust programs are directed to control the eggs and larvae present in the orchard at the time peaches are ripening. This period of time is normally about 30 days, depending upon the variety of peach to be protected.

Biological Control

Like many other destructive insects, the Oriental fruit moth is attacked by several predators and parasites. The egg, larva, and pupa stages are all susceptible to the attack of parasites. The twig-feeding larvae are especially vulnerable to parasite attack, and Missouri orchardists have been greatly aided by larval parasites during the last few years in their fight to control the Oriental fruit moth.

To date, there have been thirteen larval parasites of the Oriental fruit moth found in Missouri. These are, with one exception, native parasites which, in past years, have been parasitic on related cater-

pillars native to the state. Since the Oriental fruit moth became established in the state these native parasites have transferred their attention to it.

TABLE 1.—ORIENTAL FRUIT MOTH PARASITES RECORDED IN MISSOURI.

Species	Order	Family
Ananchaetopsis tortricis Coq.	Diptera	Tachinidae
Apanteles sp.	Hymenoptera	Braconidae
Bassus annulipes (Cress.)	Hymenoptera	Braconidae
Cremastus forbesii (Weed)	Hymenoptera	Ichneumonidae
Cremastus minor (Cush.)	Hymenoptera	Ichneumonidae
Eubadizon pleurale (Cress.)	Hymenoptera	Braconidae
Glypta rufiscutellaris (Cress.)	Hymenoptera	Ichneumonidae
Lixophaga variabilis (Ald.)	Diptera	Tachinidae
Macrocentrus ancylivorus (Roh.)	Hymenoptera	Braconidae
Macrocentrus delicatus (Cress.)	Hymenoptera	Braconidae
Macrocentrus instabilis (Mues.)	Hymenoptera	Braconidae
Macrocentrus pallisteri (De Gant)	Hymenoptera	Braconidae
Microgaster ecdytolophae (Mues.)	Hymenoptera	Vipionidae
Trichogramma minutum (Riley)*	Hymenoptera	Trichogrammidae

(*Egg parasite, not observed parasitizing Oriental fruit moth eggs but has been observed in codling moth eggs in Missouri.)

In 1931, the department of entomology of the University of Missouri and the Bureau of Entomology and Plant Quarantine in a cooperative project started an investigation of the parasitism of the Oriental fruit moth in Missouri. It was through this cooperative project that colonies of two imported species of parasites were released in the state. These were *Macrocentrus ancylivorous* Roh., imported

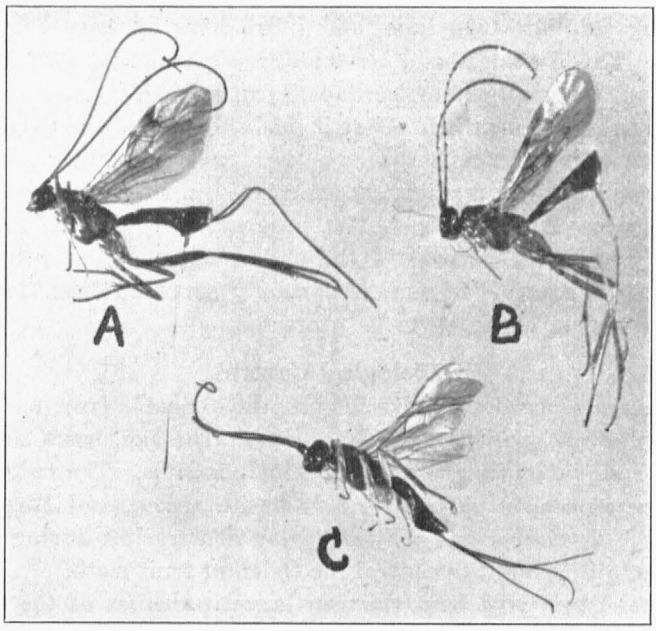

Fig. 6.—Larval parasites of the Oriental fruit moth: A, *Macrocentrus ancylivorus*, imported from the East and colonized in Missouri; B, *Macrocentrus delicatus*, native to Missouri; C, *Eubadizon pluerale*, native to Missouri.

from the eastern United States, and *Dioctes molesta* Uchida from Japan. Subsequent collections of larvae, from the orchards in which the parasites were released, have shown that *M. ancylivorus* has become firmly established in southern Missouri in Cape Girardeau, Scott and Lawrence counties. No recoveries of *D. molesta* have been made.

During the past three years the following parasites have been most abundant in Oriental fruit moth larvae in Missouri orchards: *Macrocentrus delicatus* Cress., *Macrocentrus ancylivorous* Roh., *Eubadizon pleurale* Cress., and *Glypta rufiscutellaris* Cress.

Experimental Spraying and Dusting

For the past three years the department of entomology has been conducting spraying and dusting experiments designed to test the efficacy of two or three of the more promising contact insecticides in controlling Oriental fruit moth in peach orchards.

In 1937 and 1938, the tests were confined to Cape Girardeau county. In 1939, the experiments were expanded to include tests at the State Fruit Experiment Station at Mountain Grove and in the Ehlers Orchard in St. Louis county.

1937 Experiments

TABLE 2.—SPRAYING AND DUSTING TESTS, OCHS ORCHARD, CAPE GIRARDEAU, MISSOURI

Treatment (Quantities for 100 gallons)	% Clean Peaches	% Wormy Peaches
3 sprays 1 gal. Summer Oil plus 1 pt. Black Leaf 40	95.4	4.6
3 dusts Oil-Sulphur Dust (Illinois formula)	93.5	6.4
Untreated Check	72.6	27.3

Variety: Elberta
Harvest Period: August 4 - August 11
Date of first application: July 3
Date of last application: July 20

Both the oil-nicotine sprays and the oil-sulphur dusts substantially increased the percentage of clean fruit. Parasitism of the twig-feeding broods of larvae found in the Ochs Orchard was very low in 1937. The third brood of Oriental fruit moths was very large and damage to unprotected peaches ripening by August 15 was as high as 30 per cent in some orchards in the district.

1938 Experiments

TABLE 3.—EXPERIMENTAL SPRAYING AND DUSTING, CAPE GIRARDEAU, MISSOURI

Treatment (Quantities for 100 gallons)	Orchard	Variety	% of Twig-feeding Larvae Parasitized		% Clean Peaches	% Wormy Peaches
			June Brood	July Brood		
4 dusts—Oil-Sulphur Dust	Leming	Elberta & Diamond King	...	...	97.6	2.4
4 sprays—1 gal. Summer Oil plus 1 pt. Black Leaf 40			39.5	5.6	98.1	1.9
3 dusts—Oil-Sulphur Dust	Pioneer	Elberta & Belle of Ga.	31.1	48.9	92.5	7.5
No treatment	Schultz	Elberta & Diamond King	21.9	No Record	81.4	18.6

Harvest Period: July 30 - August 5
Date of first application: July 5
Date of last application: July 25

Twig infestations of the early broods were comparable in the three orchards in Table 3. These three orchards checked in 1938 are all within a radius of 8 miles of Cape Girardeau, Mo. Applications of both oil-sulphur dust and oil-nicotine materially increased the percentage of clean fruit at harvest time. Parasitism as recorded in the table above undoubtedly had some effect upon the size of the Oriental fruit moth populations in the orchards.

1939 Experiments

TABLE 4.—EXPERIMENTAL SPRAYING AND DUSTING, PIONEER ORCHARDS, CAPE GIRARDEAU, MISSOURI

Treatment (Quantities for 100 gallons)	% Clean Peaches	% Wormy Peaches
4 sprays—¾ gal. Summer Oil + 1 pt. Black Leaf 40	94.9	5.1
4 sprays—4 lbs. Black Leaf 155	94.0	6.0
4 sprays—3 lbs. Black Leaf 155 Concentrate	96.5	3.5
2 dusts—Illinois formula Oil-Sulphur Dust	96.1	3.9
Untreated Check	90.3	9.7

Variety: Elberta
Application Dates—
Sprays: July 5, 14, 21, and Aug. 2
Dusts: July 7 and 21

Parasitism—
June brood, 59.8%
July brood, 31.4%

At the Ehler Orchard in St. Louis county a block of Elberta trees were given four sprays, during the 30-day period prior to harvest, containing ¾ gallon of summer oil plus 1 pint of nicotine sulphate per 100 gallons. The trees protected with the oil-nicotine sprays produced 86.4% clean fruit, while an adjoining unsprayed block produced only 67.9% clean fruit. No records on parasitism in this orchard are available.

One year's experiments at the State Fruit Experiment Station at Mountain Grove, Missouri, in 1939, included some work with varieties

ripening two weeks to one month later than Elberta. Fixed nicotines with varying percentages of nicotine were used on these late varieties and indications are that four to five applications of these materials, or the oil-sulphur dusts, or oil-nicotine sprays, applied during the 30-day period preceding harvest may give a substantial increase in clean fruit at harvest. In normal seasons, the first application, for varieties ripening the last week in September, would be put on about August 20-29, followed by applications at 5 to 7-day intervals. Table 5 shows the relative susceptibility of four varieties when not sprayed or dusted at Mountain Grove in 1939.

TABLE 5.—VARIETAL SUSCEPTIBILITY OF PEACHES TO ORIENTAL FRUIT MOTH INJURY, STATE FRUIT EXPERIMENT STATION, MOUNTAIN GROVE, MISSOURI

Variety	Harvest Date	% Clean Peaches	% Wormy Peaches
Champion	August 14	96.3	3.7
Elberta	August 23	95.6	3.4
Frank	September 5	33.9	66.1
McGraw	September 22	14.5	85.5

It has been the policy of the entomologists and horticulturists of the state to discourage the planting of peach varieties which ripen later than mid-August. This is still necessary, since as yet no satisfactory dust or spray has been found for protecting late peaches. Several of the materials have shown definite promise but more work is needed on this phase of the problem.

1940 Experiments

Tables 6 and 7 give the results of the 1940 experimental spraying and dusting plats. The summer of 1940, in Southeast Missouri, was distinctly abnormal, since Elberta harvest was delayed two weeks by dry weather and White English Cling harvest was early by 10 days. Because of this, the results from 1940 are somewhat complicated, as

TABLE 6.—EXPERIMENTAL SPRAYING AND DUSTING, PIONEER ORCHARDS, CAPE GIRARDEAU, MISSOURI

Treatment (Quantities for 100 gallons)	% Clean Peaches	% Wormy Peaches
2 dusts—Oil-Sulphur Dust	87.2	12.8
4 sprays—3 lbs. Black Leaf 155 Concentrate	86.2	13.8
Untreated Check	73.9	26.1

Variety: Gage Elberta
Harvest Period: August 15-29
Application Dates:
Sprays—July 19, 26, Aug. 2, 16
Dusts— July 19, Aug. 2

Parasitism:
June brood, 45.4%
July brood, 56.8%

TABLE 7.—CALDWELL ORCHARD, JACKSON, MISSOURI

Treatment (Quantities for 100 gallons)	% Clean Peaches	% Wormy Peaches
3 sprays—3 lbs. Black Leaf 155 Concentrate	91.6	8.4
Untreated Check	86.9	13.0

Variety: White English Cling
Harvest Period: September 1-9
Application Dates: Aug. 22, 30, Sept. 4

Parasitism:
June brood, 30.0%
July brood, 62.8%

the heavy worm entrance usually expected to occur on varieties ripening after Elbertas did not take place in the case of the White Clings.

Additional tests on late ripening varieties will be necessary before any definite recommendations can be made.

RECOMMENDATIONS FOR CONTROL IN MISSOURI

Dusting

Oil-Sulphur Dust.—Oil-sulphur dust for dusting peaches is prepared according to the following formula:

60 lbs. dusting sulphur
20 lbs. talc
15 lbs. dusting lime
5 lbs. lubricating oil of 80-110 viscosity

The dust should be thoroughly combined in a dust mixer. Simply stirring the ingredients together will not suffice.

Four applications should be made, starting 30 days before peach harvest, the dusts to be applied at 5 to 7-day intervals so as to maintain an adequate coverage of dust on the foliage and fruit. Cost per tree for the season, using four dusts, will be approximately 10c for the material.

Oil-sulphur dust is perhaps the most satisfactory material to use on peaches, where dusting equipment is available, for the sulphur contained in the formula will also control brown rot. As a general rule, dusts are much easier and cheaper to apply than sprays.

Spraying

Oil-Nicotine.—Four sprays should be applied at 5 to 7-day intervals, beginning 30 days before peaches are to be harvested. Each application should contain ¾ to 1 gallon of summer oil and 1 pint of nicotine sulphate per 100 gallons. *This spray is incompatible with sulphur and should never be used when there are large deposits of sulphur remaining on the foliage.* If the oil-nicotine spray is being used and heavy brown rot infections appear the treatment should be discontinued and sulphur applied for brown rot control 4 to 5 days after the last

oil-nicotine spray. Seasonal cost for this material, using four sprays, is about 35c to 40c per tree.

Fixed Nicotines.—The manufacturer's recommendations should be followed when fixed nicotines are used. They may be used safely with sulphur and the fixed nicotines with a higher content of nicotine should be more effective. Seasonal cost for this material, using four sprays, will be about 35c per tree and upwards, depending upon the nicotine content of the material used.

Control Practices Other Than Spraying and Dusting

Several practices in the orchard and packing shed will materially aid orchardists in keeping Oriental fruit moth infestations as low as possible if they are followed.

Spring cultivation and cleaning the orchard of unnecessary debris will remove or destroy many overwintering larvae.

Paradichlorobenzene treatments for peach tree borer control will kill many of the larvae in cocoons around the base of the tree and on the trunk of the tree enclosed in the mound.

Packing sheds should be screened and kept closed during April while the moths from the overwintering larvae are emerging.

Wormy peaches unfit for any purpose should be removed from the orchard and shed and buried at least a foot deep or fed to the hogs.

Peach mummies should be removed from the trees in the fall and destroyed soon after harvest.