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Spraying Program

and Pest Control for Fruit Crops

Prepared by the

Departments of Botany, Entomology, and Horticulture

of the Ohio State University
and the Ohio Agricultural Experiment Station

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Bulletin 128—"SPRAYING PROGRAM AND PEST CONTROL FOR FRUIT CROPS,"
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Spraying Program

and Pest Control for Fruit Crops

THE MANY orchards in Ohio represent a wide range in conditions such as: age of trees, location, cultural practices, varieties, and susceptibility to insects and diseases. A spray program cannot be formulated that will meet the requirements of each individual orchard. Seasonal variations, orchard cultural practices, and general environmental conditions largely govern the severity of both fungous diseases and insect outbreaks. For these reasons some orchards may require a rigid or complete spray program to control pests, while in others during the same season, such a program may not be necessary.

Spraying should be looked upon as a form of insurance. Important sprays should not be omitted unless the grower is reasonably certain that he can afford the risks that will develop in the absence of spray protection.

Changes in spraying procedure becomes necessary from year to year. This is due in part to the ever-changing conditions concerning the pests against which the treatments are directed, and in part to the development of new sprays and to new information concerning older ones. Rapid advances are being made in perfecting spraying materials, and new ones continue to appear.

This bulletin discusses the principal spray materials now offered for sale, and suggests proper combinations that will best control both insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested; these having been thoroughly tested and approved. Formulas and dilution strengths are based on 100 gallons of spray as a unit. For small plantings not requiring that much material, a conversion table is given on page 22.

The three main considerations in successful spraying are: *correct timing, thorough application,* and the *use of proper materials.* These are the "big three" responsible for success in spraying, and if any one is neglected the structure falls, for without all three of them success cannot be attained.

The Ohio Spray Service

The Ohio Spray Service is entirely informational, and deals largely with the timing of sprays. Its chief object is to help the grower to adapt his spray program to the seasonal requirements.

The information is distributed by the Extension Service of the College of Agriculture, and is of two general types: (1) letters, and (2)

radio broadcasts. The information upon which recommendations are based is collected from all parts of the state and assembled at Columbus. Suggestions on the necessary spraying procedure are then sent to the county agents, who in turn notify every fruit grower on their mailing lists.

Each fruit grower is sent a letter for each apple spray. No further information is necessary for the dormant spray. For the pre-blossom sprays, a letter is mailed in advance giving all the necessary information, except the time of application. The time for spraying is announced over the radio for each fruit season. The exact time and place of broadcasting is sent each spring to all fruit growers on the mailing lists.

The calyx spray is timed by the fall of the petals and no further information is necessary than that contained in a letter. Information regarding the ten-days to two-weeks spray is disseminated over the radio. The dates for applying the codling moth cover sprays are given in letters sent to the individual growers; the time for spraying varies for the different fruit sections. These letters are supplemented by weekly radio broadcasts.

Every fruit grower in Ohio is entitled to receive the spray information. This service is free. Apply to county agent in your county.

Spray Programs for Control of Insects and Diseases

The Apple Spray Program

Within recent years the apple spray program has become more complicated; first, because codling moth has grown more destructive in certain parts of the state and, second, because of the necessity of avoiding excess spray residues on the marketed product. Because of these facts, it is no longer possible to recommend a uniform schedule applicable to all conditions; therefore, two different codling moth spray schedules are offered.

The first of these schedules is proposed for use in orchards in which codling moth has not increased greatly in abundance. This schedule is so arranged that under seasonal conditions in which rainfall is normal, there should not be a residue of either lead or arsenic in excess of amounts permitted by present regulations.

The second schedule is proposed for use in the so-called "problem" orchards in which codling moth is not controlled by the restricted schedule. A special effort is made in this schedule to control the early season brood of codling moth, and arsenicals are continued in the late season sprays for later broods. It must be clearly understood that *it will be necessary to wash the harvested fruit* in dilute hydrochloric acid if this schedule is applied.

Five Stages of Apple Bud Development

Fig. 1. — Green bud stage (see Schedule No. 1)

Fig. 2.— Delayed dormant stage (see 2-a).

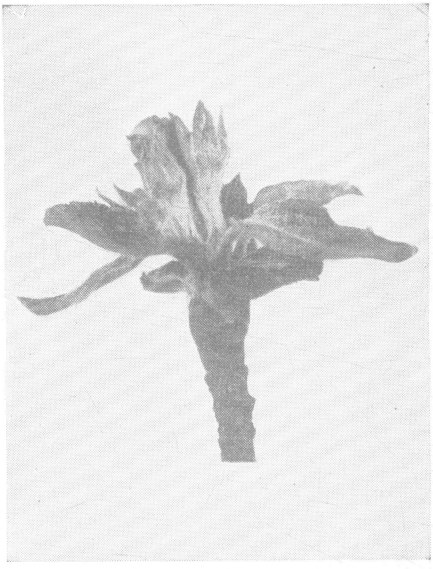

Fig. 3.—Pre-pink stage (see Schedule 2-b).

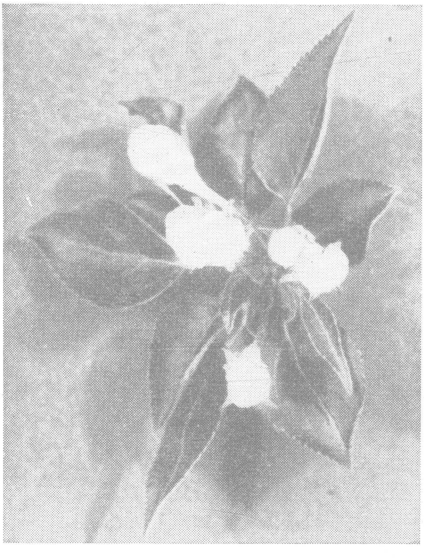

Fig. 4.—Pink stage (see Schedule 2-c).

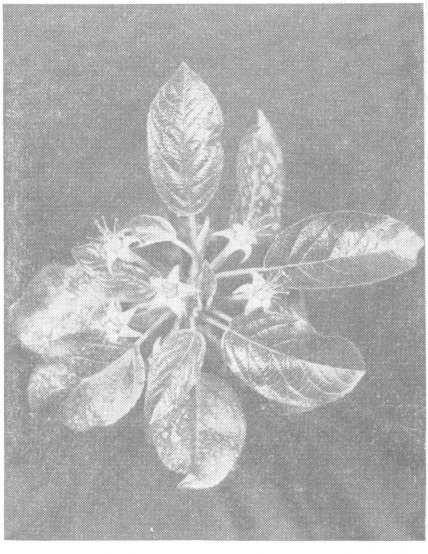

Fig. 5.—Calyx cup stage (see Schedule 3).

The spraying schedules are divided into periods numbered 1 to 5, and the individual sprays of each are designated by letters a, b, and c. (For small scale needs see Conversion Table on page 22.)

APPLE SPRAY PROGRAM — FOR ALL ORCHARDS

Name and Time of Spray	Materials to Use	To Control	Further Suggestions
1 **Dormant** In spring when buds are dormant or beginning to swell (see Fig. 1).	Oil emulsion carrying 3% oil *or* Miscible oil, or emulsible oil at manufacturers' recommendations.	Scale (see Fig. 8) Red mite	Oils can be applied safely up to the green bud stage. They sometimes cause burning in the delayed dormant. For use of tar oils and "dinitro" oils against rosy aphis, see page 23 (see Fig. 9). For ground (eradicant) sprays for scab, see page 12.
2 **Pre-blossom** (a) Delayed Dormant When blossom buds show ½ inch green (see Fig. 2).	**Liquid lime-sulfur. 2 gals. Water to make.....100 gals.	Scab (see Fig. 10)	If rosy aphis is a problem, add 1 pint of nicotine sulfate to 100 gallons of the lime-sulfur spray.
(b) Pre-pink Following delayed dormant and before petals show (Fig. 3). (*Listen to the radio Broadcasts*).	**Liquid lime-sulfur. 1½ gals. Water to make.....100 gals. (For flea-weevil control, see page 12)	Scab Black rot (frog-eye) (Fig. 11) Flea-weevil (see Fig. 15)	On varieties such as Baldwin, Grimes, Jonathan, and Golden Delicious, where lime-sulfur may cause serious russeting or leaf injury, the reduction of strength of lime sulfur, *or*, the addition of 5 lbs. of hydrated lime, *or*, the substitution of flotation type sulfur s advisable (see page 30).
(c) Pink After blossom stems separate and before bloom opens (Fig. 4). Finish in bloom if necessary.	*Flotation type sulfur 12 lbs. *or* ***Liquid lime-sulfur.* 1½ gals. Water to make.....100 gals. (For need of arsenical see suggestions at right)	Cutworms (see pg. 55) Scab Black rot Cankerworm (if present) Flea-weevil	If cankerworms are troublesome, add 3 lbs. of lead arsenate and 5 lbs. of hydrated lime in the Pink.
Spraying in early bloom is advisable if scab threat is serious. Do not apply lead arsenate at this time.			
3 **Calyx Cup** When the last of the petals are falling (see Fig. 5).	*Flotation type sulfur 10 lbs. Lead arsenate..... 3 lbs. Hydrated lime..... 5 lbs. Water .....100 gals.	Scab Codling moth Curculio Cankerworm	If red-bugs are present add 1 pint of nicotine sulfate (see page 13). Lime is added to decrease burning. (Cover all blossoms).

* For convenience or where flotation sulfur is not available, use a wettable sulfur at manufacturers' recommendations. See pages 29 and 30.

** For convenience, dry lime-sulfur, 8 lbs. in 2(a), or 6 lbs. in 2(b and c), can be substituted for the liquid lime-sulfur.

Primary apple scab infection may occur during rainy periods from the delayed dormant to the ten-day spray. Failure to protect the foliage and fruit with sulfur fungicide during this time may prove costly. Listen to the radio broadcasts.

Fig. 6.—"Ten-day" stage (see Schedule 4-a).

Fig. 7.—First cover stage (see 4-b).

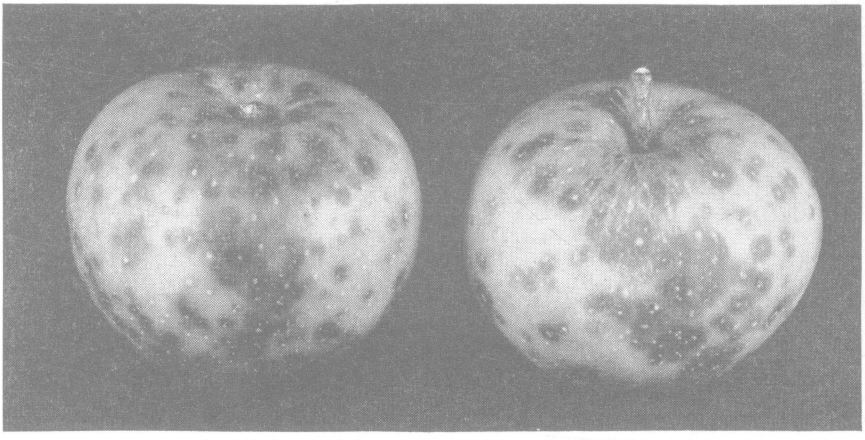

Fig. 8.—Apples infested with San Jose scale.

FOR ORCHARDS WITHOUT SERIOUS CODLING MOTH PROBLEM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
4 (a) **Ten Days to Two Weeks after petal-fall.** (See Fig. 6). (Watch Spray Service recommendations)	*Flotation type sulfur. 8 lbs. Lead arsenate..... 3 lbs. Hydrated lime..... 5 lbs. Water .....100 gals.	Scab Curculio (see Fig. 21) Blotch (see Fig. 29)	This spray is very important where scab has not been controlled in the pre-blossom period, *or*, if overwintering scab spores are still being discharged. Do not delay application beyond 10 days where curculio is a problem. Use 2-4-100 bordeaux mixture for blotch in southern Ohio.
(b) **First Brood Codling Moth Sprays** Three to four weeks after petal-fall (See Fig. 7). (Watch Spray Service recommendations)	*Flotation type sulfur. 8 lbs. Lead arsenate..... 3 lbs. Zinc sulfate..... 1 lb. Hydrated lime..... 3 lbs. Water .....100 gals. (See Suggestions) If zinc sulfate is not available, use 5 lbs. of hydrated lime.	Codling moth Curculio Scab (See Fig. 10) Blotch Brooks spot Black rot (frog-eye) (see Fig. 11)	Flotation type sulfur may be used in all localities except where copper sprays are needed. In Southern Ohio localities where Brooks spot and blotch are serious, use 2-4-100 bordeaux mixture. For order of mixing see last paragraph page 39.
(c) **Six Weeks Cover Spray** Two weeks after 4(b) (See under Suggestions)	Same as 4(b) (Do not apply this spray on Duchess and other early varieties) The sulfur fungicide may be omitted if no scab is present on leaves or fruit. (See Suggestions)	Codling moth Apple maggot (see Figs. 13-14) Black rot (Frog-eye) Scab	This spray is very important for codling moth and in some Northeastern Ohio orchards where apple maggot is a problem (see Fig. 14). Where Brooks spot or blotch is serious, replace the zinc sulfate and lime with 2-4-100 bordeaux; where bitter rot is a problem use 4-6-100 bordeaux. Additional applications may be necessary in hot, humid weather.
5 **Second Brood Cover Spray** Nine to ten weeks after petal-fall. (Watch Spray Service recommendations)	*Flotation type sulfur. 6 lbs. Zinc or calcium arsenate ..... 3 lbs. Hydrated lime..... 8 lbs. Water .....100 gals. (If lead arsenate is used, replace the 8 lbs. of lime with zinc sulfate and lime as in 4(b)	Codling moth Apple maggot Bitter rot Blotch Brooks spot Sooty fungus (see Fig. 12) Black rot (frog-eye) Scab	Avoid spraying if possible when temperature is abnormally high, or spray injury may follow. Foliage injury from calcium arsenate may be expected unless 8 lbs. of lime is used. Zinc arsenate is less likely to cause foliage injury. For Brooks spot and blotch use 2-8-100, and for bitter rot use 4-8-100 bordeaux mixture. (Coat apples thoroughly).

* For convenience, or where flotation sulfur is not available, use a wettable sulfur at manufacturers' recommendations. See pages 29 and 30. If lime-sulfur is used, 4 lbs. dry or 1 gal. of liquid per 100 gals. is suggested.

NOTE: Zinc and calcium arsenate are not as effective against codling moth as lead arsenate. The use of lead arsenate in the second brood cover spray may leave too much lead residue. Thorough brushing, or wiping of fruit could be expected to remove only a little of it. See page 35 for substitutes for arsenicals in this spray.

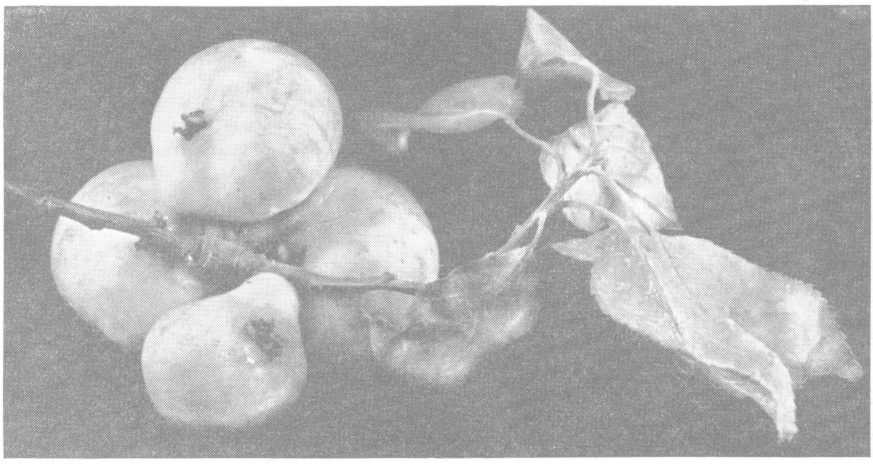

Fig. 9.—Apples stunted by feeding of rosy aphis on the nearby leaves.

Distribution of Principal Apple Pests in Ohio

One of the reasons that a general apple spray program for Ohio must be somewhat complicated is the peculiar and unequal distribution of some diseases and insects. Scab is general throughout the state. For this disease sulfur sprays are recommended.

Brooks spot, blotch, and bitter rot are confined largely to the southern apple growing section. For their control, bordeaux mixture is the most effective spray.

Scale insects, red mite, codling moth, flea-weevil, and curculio are generally distributed. Codling moth is a serious problem annually in Lawrence county and in isolated orchards over the western half of Ohio. Apple maggot and red bug are troublesome only in northeastern Ohio.

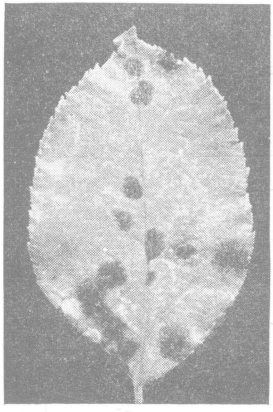

Fig. 10.—Apple scab.

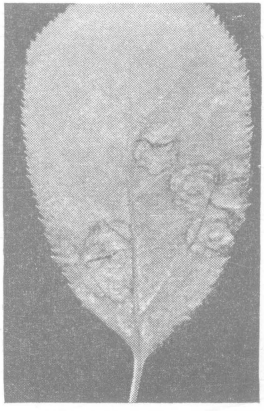

Fig. 11.—Frog eye.

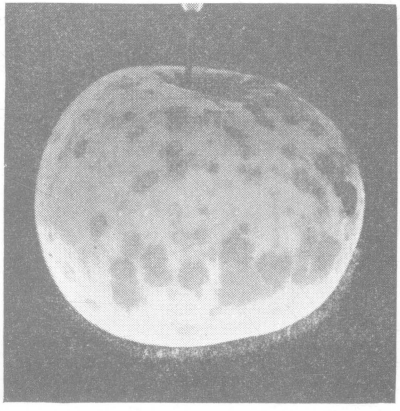

Fig. 12.—Sooty fungus.

Varietal Susceptibility to Disease and to Spray Injury

The various varieties of apples show marked differences in degrees of susceptibility and resistance to scab and spray russeting. Fortunately varieties most susceptible to scab are those most resistant to russeting by caustic spray. On the other hand, most apple varieties very easily and seriously russeted by spraying are so resistant to scab that only very mild spray formulas are necessary to keep the disease under control.

In the following table is listed the susceptibility of different varieties to diseases and to spray injury. By observing these responses, one can adjust the spray recommendations to better fit the orchard.

Apple scab and fire blight attack vigorously growing trees more frequently and severely than trees of low vitality. The opposite is true of black rot and apple measles. Trees making poor growth are likely to be injured by sprays which do not harm vigorously growing trees of the same variety. The margin of safety for effective sprays is narrow, and constant search is being made for safer and better materials.

Degree of Susceptibility of Ohio Apple Varieties to Diseases and Spray Injury

Variety	Scab	Bitter Rot	Blotch	Brooks Spot	Fire Blight	Cedar Rust	Bordeaux Russet	Lime Sulfur Russet
Baldwin	Moderate	Moderate	Slight	Slight	Slight	Slight	Very	Very
Ben Davis	Very	Very	Moderate	Slight	Slight	Slight	Very	Very
Cortland	Very	Very	Very	Slight	Very	Moderate	Slight	Slight
Delicious*	Very	Moderate	Slight	Moderate	Slight	Moderate	Slight	Moderate
Duchess	Moderate	Slight	Very	Slight	Slight	Slight	Slight	Slight
Golden Delicious	Slight	Very	Moderate	Very	Slight	Slight	Very	Very
Grimes	Slight	Very	Slight	Very	Very	Slight	Very	Very
Jonathan	Slight	Very	Slight	Very	Very	Moderate	Very	Moderate
McIntosh	Very	Very	Very	Slight	Slight	Slight	Slight	Moderate
N. Spy	Very	Moderate	Slight	Slight	Slight	Slight	Slight	Slight
R. I. Greening	Moderate	Very	Slight	Slight	Very	Slight	Moderate	Moderate
Rome	Very	Moderate	Moderate	Moderate	Moderate	Very	Slight	Slight
Stayman	Moderate	Moderate	Slight	Moderate	Slight	Slight	Moderate	Moderate
Wealthy	Moderate	Slight	Slight	Slight	Very	Moderate	Slight	Slight
Winter Banana	Very	Very	Slight	Slight	Slight	Moderate	Moderate	Moderate
Yellow Transparent	Moderate	Slight	Slight	Slight	Very	Slight	Slight	Slight

* Varieties like Delicious, Rome, Stayman, etc., include the red sports of those varieties.

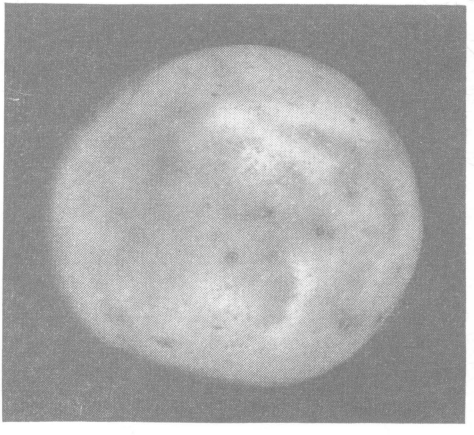

Fig. 13.—Grimes Golden apple showing egg laying punctures and tunneling of apple maggot.

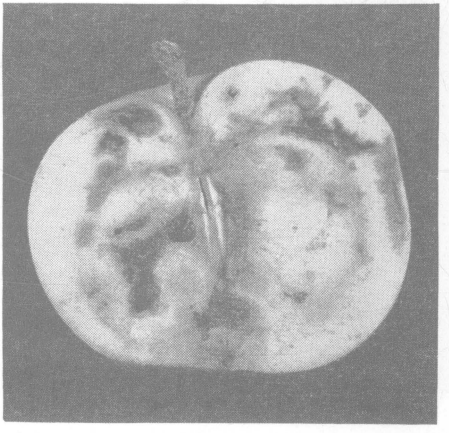

Fig. 14.—Injury of larvae of apple maggot, or "railroad worm."

FOR ORCHARDS HAVING A SERIOUS CODLING MOTH PROBLEM

SPRAY PROGRAM TO BE FOLLOWED BY WASHING

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
4 **First Brood Cover Sprays** (a) Ten days after petal-fall.	*Flotation type sulfur. 8 lbs. Lead arsenate.....3½ lbs. Hydrated lime ..... 5 lbs. Water .....100 gals.	Curculio (see Fig. 21) Codling moth Scab Blotch (see Fig. 29)	In addition to the control of early hatching codling moth, this spray is necessary: (a) where curculio is a serious problem, (b) where new leaves have some scab lesions, or (c) on varieties susceptible to blotch. Use 2-4-100 bordeaux for blotch control in southern Ohio.
(b) Two weeks later.	Lead arsenate..... 3 lbs. Summer oil ..... 3 qts. Zinc sulfate..... 1 lb. Hydrated lime..... 3 lbs. Water to make.....100 gals. (Sulfur fungicide cannot be used with summer oil. Bordeaux 2-4-100 should replace the lime in the above in southern Ohio where blotch or Brooks spot is serious)	Codling moth Curculio Scab Blotch Brooks spot (see Fig. 28) Black rot (frog eye)	For those who do not desire to use summer oil, or, where apple scab has not been controlled, use 3½ lbs. of lead arsenate, lime and flotation type sulfur without oil as in 4 (a). For order of mixing in the spray tank, see last paragraph on page 39.
(c) Two weeks later.	Lead arsenate..... 3 lbs. Summer oil ..... 3 qts. Zinc sulfate..... 1 lb. Hydrated lime..... 3 lbs. Water to make.....100 gals. (Use no fungicide with this spray unless bitter rot is a problem, in which case replace the lime with 4-6-100 bordeaux mixture)	Codling moth Apple maggot (see Figs. 13-14) Black rot (frog eye) (see Fig. 11)	This spray protects the fruit at the peak of first brood codling moth hatching. The three quarts of oil in this and the preceding spray kills codling moth eggs struck by the spray.
(d) Two weeks later.	*Flotation type fulfur.. 6 lbs. Lead arsenate..... 3 lbs. Zinc sulfate..... 1 lb. Hydrated lime..... 3 lbs. Water .....100 gals.	Codling moth Apple maggot Bitter rot Scab Brooks spot	Use 4-6-100 bordeaux mixture where bitter rot is a problem. Use of summer oil in this or later sprays will make residue removal difficult.
5 **Second Brood Cover Sprays** (a) Two weeks after 4(d) *or* 9-10 weeks after petal-fall.	*Flotation type sulfur. 6 lbs. Lead arsenate..... 3 lbs. Zinc sulfate..... 1 lb. Hydrated lime..... 3 lbs. Water .....100 gals.	Codling moth Bitter rot Apple maggot Brooks spot Sooty fungus (see Fig. 12) Blotch Scab	Avoid spraying if possible when temperature is abnormally high or spray injury may follow. For Brooks spot and blotch use 2-4-100 and for bitter rot use 4-6-100 bordeaux mixture. (Coat apples thoroughly)
(b) Two weeks later.	Lead arsenate..... 3 lbs. Hydrated lime..... 5 lbs. Water .....100 gals. (Fungicide usually not necessary though in southern Ohio 4-6-100 bordeaux mixture should be substituted for the lime for bitter rot control)	Codling moth Bitter rot	Avoid spraying in extremely high temperature. In most "problem" orchards this will be the last spray needed. Further spray applications necessary only under extreme codling moth infestation.

* For convenience, or where flotation sulfur is not available, use wettable sulfur at manufacturers' recommendations. See pages 29 and 30. If lime-sulfur is used, 4 lbs. of dry or 1 gallon of liquid is suggested.

SPECIAL, OR EMERGENCY SPRAYS FOR APPLE

While these sprays have value against the pest, or for the purpose listed, growers should bear in mind that some of them are still in the experimental stage and may not be entirely satisfactory under all conditions.

WHAT FOR	MATERIALS TO USE	REMARKS
Apple Scab (On old leaves on the ground)	Special dinitro sprays sold under commercial names. (Follow manufacturers' directions).	"Eradicant" sprays is the term used for this special spray to be applied in the spring to the old leaves on the ground for killing over-wintering scab. Experiments in Ohio and elsewhere indicate the possibilities of aid from such a spray in certain years, if applied correctly. However, if used on the old leaves, no regular scab spray on the new foliage can be safely omitted during the season.
Apple Flea-weevil (see Fig. 15) Pre-pink and pink	Flotation type sulfur.. 12 lbs. Cryolite or Dutox..... 5 lbs. Goulac ..... 3 oz. Water .....100 gals.	Apply very thoroughly, covering the expanding foliage as soon as first feeding is observed. If the presence of the insects is not discovered until trees open into bloom and codling moth is not serious, apply the Cryolite or Dutox combination with flotation type sulfur and spreader in the calyx spray, instead of lead arsenate and lime. Spraying to cover the under-surface of leaves is necessary.
Thinning-out Bloom, or "Deflowering" to regulate bearing. (Pink or early bloom)	Tar oil at 0.8% *or* Elgetol at 0.6 to 0.8% concentration has been used in experiments.	The use of caustic materials to reduce or eliminate fruit set is still in the experimental stage. No material has been effective without injury to the new leaves, although recovery of the tree is rapid. Attempts to destroy all flowers by spraying have been more successful than attempts to thin the crop, and gave best results when the spray was applied to apple flowers in the early pink stage.

Fig. 15.—Apple flea-weevil injury to foliage.

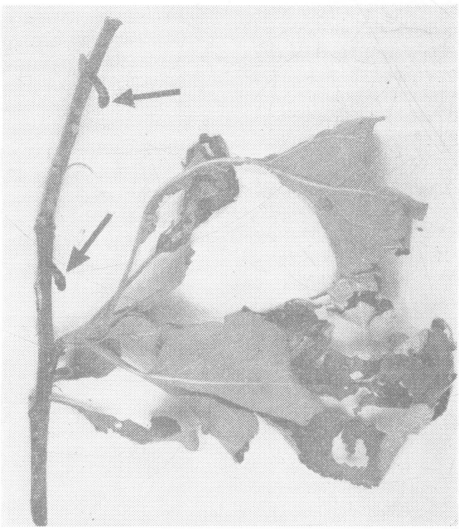

Fig. 16.—Pistol case-bearer and its work on apple (arrows point to cases enclosing larvae).

SPECIAL, OR EMERGENCY SPRAYS (Continued)

WHAT FOR	MATERIALS TO USE	REMARKS
Apple Red-bug (see Fig. 18) (Present only in northeastern Ohio)	Nicotine sulfate..... 1 pint added to each 100 gals. of spray recommended in the calyx-cup application on page 6	Since this is a contact spray for red-bug, great care is necessary to cover the growth in the center of the tree. The application should be made from the ground under the tree as well as from without, and is most effective if applied on a warm day. Recently it has been found that lubricating oil emulsions of 4 or 5% oil content, applied while the tree is dormant, give a considerable degree of control.
Green Aphis on apple (June or early July)	Nicotine sulfate..... ¾ pint Summer oil..... 2 qts. Hydrated lime..... 3 lbs. Water .....100 gals. *or* Nicotine sulfate combined with a regular codling moth cover spray.	Spraying for green aphis does not always result in satisfactory control. A few colonies clustered on leaf terminals can be ignored. Should all water-sprouts and succulent terminals become heavily infested, a nicotine spray may be a wise investment. To be effective, it must be very thoroughly applied so that the colonies may be struck with the spray. Complete each tree or row before going to the next.
Pistol Case-Bearer (see Fig. 16) (July)	Summer oil..... 3 qts. Nicotine sulfate..... 1 pint Water .....100 gals.	Apply very thoroughly in July when most of the eggs are exposed on the foliage and before new cases form. Consult county agent for proper timing.
European Red Mite on foliage (July or early August)	Summer oil..... ⅓ gal. *and either* Ground derris, or cube powder (4%).. 3 lbs. *or* Botano R..... 4 lbs. Water .....100 gals.	Apply only in case mites become numerous in July or early August. To be effective the spray must be put on just as soon as damage is detected. Very thorough coverage of the under-surface of the leaves is necessary. A spreader such as "Orthex" at 1 qt. to 100 gals. may be used in place of summer oil.
Apple Leafhoppers (August)	Nicotine sulfate..... ¾ pint Soap flakes..... 1 lb. *or* Fish oil soap..... 3 lbs. *or* Summer oil..... 2 qts. Water .....100 gals. (see page 33)	The nymphs usually appear in August after completion of the spray schedule. If present in alarming numbers, thorough and timely spraying from beneath as well as from without will kill the immature insects before they develop wings. Be sure to cover the foliage on the inside of the tree. Probably the best insurance against the development of leafhopper infestation is the inclusion of 1 pint of nicotine sulfate in the calyx-cup spray.
Codling Moth (August)	Fixed nicotine (14%)..1½ lbs. *or* Nicotine sulfate..... ¾ pint Summer oil..... 3 qts. Water .....100 gals.	This spray is advised for use during August in a non-washing program where an application of arsenical would leave too much residue on the fruit. This spray is necessary only under heavy codling moth infestation and where the crop is in danger of being ruined without further protection by spraying (see page 33).
Harvest Sprays (To prevent premature droppings)	Commercial sprays carrying naphthalene-acetic acid and sold under trade names.	A number of these commercial brands of the so-called "harvest sprays" have been tried at the Experiment Station and no difference has been noted in their effectiveness. They have been effective in preventing serious drop on the summer and fall varieties of apples. Definite and positive results were secured on Oldenburg, Red June, Williams, Joyce, Battle, and Wealthy. The spray becomes effective two days after application and continues effective for from 7 to 10 days. The results on varieties later than Wealthy have not been so pronounced. Fair results have been recorded with McIntosh, Jonathan, Delicious, and Stayman, and little or no benefit with Baldwin. The cost per application of the materials and labor on mature trees bearing average crops was from 2 to 2½ cents per bushel. On the basis of present information these sprays should be regarded as insurance for special emergencies rather than an accepted orchard practice.

Fig. 17.—Dropped apples, for prevention of which "harvest sprays" are used.

INSECT BLEMISHES THROWING APPLES OUT OF GRADE

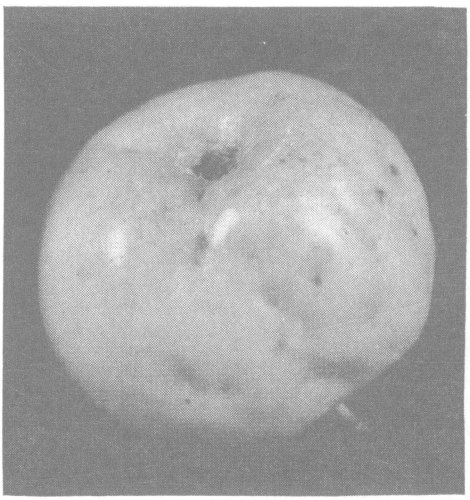

Fig. 18.—Fruit deformed by feeding punctures of the apple red-bug.

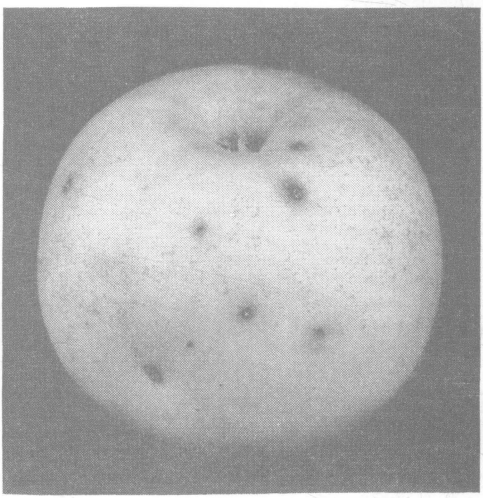

Fig. 19.—Codling moth "stings" on an apple kept covered with lead arsenate.

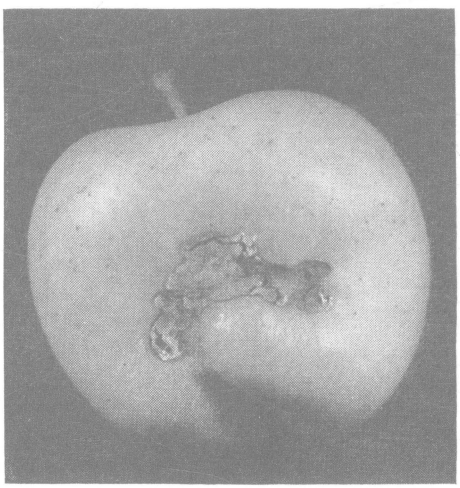

Fig. 20.—Injury by apple leaf-roller larvae.

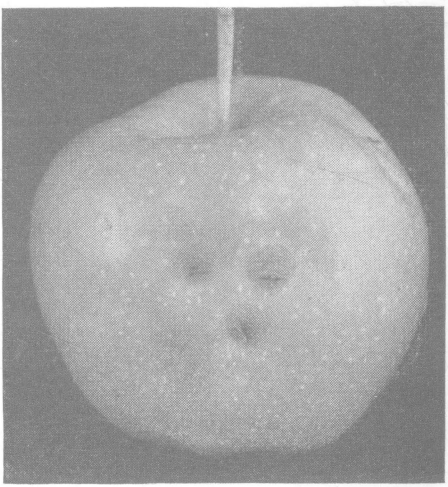

Fig. 21.—Egg-laying scars in apple caused by plum curculio.

PEACH SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant In the fall after leaves are shed or in spring before buds swell.	Liquid lime-sulfur.....6¼ gals. Water to make.....100 gals. *or* 6-8-100 bordeaux.	Leaf curl (see Fig. 22)	Leaf curl is best controlled by fall spraying with liquid lime-sulfur. If scale is present use 3% oil spray combined with 6-8-100 bordeaux in very early spring application. (see page 25).
Shuck-Fall When shucks are splitting and falling from the expanding fruits.	Zinc sulfate..... 1 lb. Hydrated lime..... 2 lbs. Lead arsenate..... 2 lbs. Water .....100 gals. *or* 90-10 lime-lead dust (see page 50). (For order of mixing in the tank see page 39).	Curculio	Do not apply unless curculio is a problem. If lead arsenate without zinc sulfate is used add 10 pounds of lime to avoid burning. Peach is very susceptible to arsenical injury. Be sure lime used is fresh.
Two Weeks Two weeks after the shuck-fall.	Flotation type sulfur.....8 lbs. *or* Wettable sulfur, commercial or home-made (p. 29).....6 lbs. Water .....100 gals. *or* 90-10 sulfur-lime dust (see page 50).	Brown rot Scab (see Fig. 23)	This is a very important peach scab spray.
Pre-harvest Seven to ten days before the fruit is picked.	Use materials as recommended for two weeks application.	Brown rot Scab	This is a dangerous period for brown rot infection. Additional sulfur sprays or dusts without lead should be applied whenever wet weather occurs.

Oriental Fruit Moth.—No spraying schedule can be recommended at this time that will give satisfactory control of this insect. Parasite introduction is in progress and offers the most promise. For peach canker control see page 51.

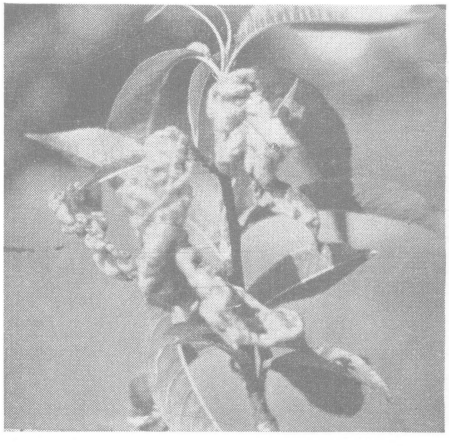

Fig. 22.—Peach leaf curl.

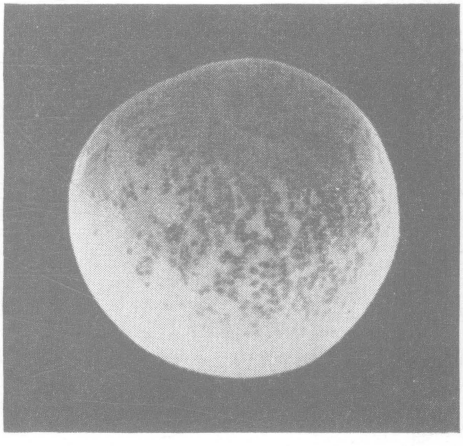

Fig. 23.—Peach scab.

SPRAYING PROGRAM FOR CHERRIES

Name and Time of Spray	Materials to Use	To Control	Further Suggestions
**Dormant (see note)	(see note)	Black cherry aphis	Sour cherries rarely require a dormant spray.
Shuck-Fall When the shucks are splitting and falling from the expanding fruits.	1-2-100 bordeaux mixture *or* *Fixed copper (based on 50% metallic).. 1½ lbs. Hydrated lime..... 3 lbs. Lead arsenate..... 2 lbs. Water ..... 100 gals.	Leaf spot (Fig. 24) Curculio Brown rot Slug	In some seasons an earlier application may be advisable for leaf spot. Watch Spray Service recommendations. Omit the extra lime if bordeaux is used.
First Cover Two to three weeks after the shuck-fall spray.	Same as shuck-fall, except omit lead arsenate.	Leaf spot Brown rot	This is a very important leaf spot spray.
Pre-Harvest When fruits are beginning to color.	Same as shuck-fall, except omit lead arsenate. (For sweet cherries use 8 lbs. flotation type sulfur instead of fixed copper).	Leaf spot Brown rot	This is a very important disease spray. If cherry maggot is a problem, include 2½ lbs. of calcium arsenate and apply to all sour varieties when "Early Richmond" first shows red, then wash fruit to remove residue.
After Harvest Immediately after fruit is picked.	Same as shuck-fall, except omit lead arsenate, unless slugs are present. (See note under Further Suggestions).	Leaf spot	This spray is important to protect the foliage. Cover leaves thoroughly. Trees which drop their leaves in midsummer set poor fruit buds. If slugs are present, include 2 lbs. of lead arsenate.

* A discussion of fixed copper compounds is given on page 32.

** NOTE — If black cherry aphis is a problem on sweet cherries use "Dinitro" or tar oil according to the manufacturers' directions. Use only in full dormant period. This insect may also be controlled with 2 gals. of liquid lime-sulfur and 1 pint of nicotine sulfate per 100 gals. spray applied in the delayed dormant period.

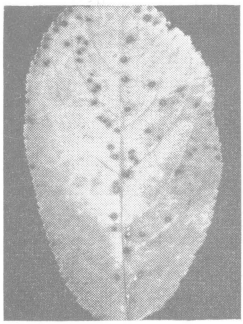

Fig. 24.—Cherry leaf spot.

Fig. 25.—Control of cherry leaf spot; excellent on left, sprayed with fixed copper; poor, on right, sprayed with lime-sulfur.

PEAR SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant Before buds open, or when beginning to swell.	Oil emulsion carrying 3% oil *or* Miscible oil, or emulsible oil at manufacturers' recommendations.	Scale Pear psylla Blister mite Red mite	This spray is necessary only in case one or more of these insects is serious.
Cluster Bud When blossom buds are separated in the cluster and before blossoms open.	Flotation type sulfur.. 12 lbs. Water .....100 gals.	Scab Leaf spot	This spray may be omitted where disease is not prevalent.
Calyx Cup When the last of the petals are falling.	Flotation type sulfur.. 10 lbs. Lead arsenate..... 3 lbs. Hydrated lime..... 5 lbs. Water .....100 gals.	Codling moth Scab Leaf spot Curculio	Spray blossom clusters thoroughly.
First Brood Cover Spray Three to four weeks after petal-fall.	Same as calyx cup spray.	Codling moth Curculio Scab Pear slug	Cover little fruits and foliage thoroughly.
Midsummer Nine to ten weeks after petal-fall.	Flotation type sulfur ..8 lbs. Zinc or calcium arsenate 3 lbs. Hydrated lime..... 8 lbs. Water .....100 gals. (See suggestions at right)	Codling moth Scab Leaf spot Sooty fungus	Lead arsenate will give better control and is advised if washing equipment is available. Avoid spraying if possible when temperature is abnormally high.

SPRAY PROGRAMS FOR PLUMS

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant When the tips of the buds first show green but before leaf tips are visible.	Oil emulsion carrying 3% oil *or* Miscible oil at manufacturers' recommendations. Water to make.....100 gals.	Red mite Scale	For black knot see page 60.
Shuck-Fall When shucks are splitting and falling from the expanding fruit.	*Fixed copper (based on 50% metallic)...1½ lbs. Lead arsenate.....2½ lbs. Hydrated lime..... 3 lbs. Water .....100 gals.	Curculio Brown rot Leaf spot	This is one of the most important sprays for stone fruits. One lb. of pwd. skim milk or wheat flour, or a commercial spreader improves the adhesiveness.
First Cover Ten days after shuck-fall spray.	Same as for shuck-fall.	Curculio Brown rot Leaf spot	It is advisable to use a sticker and spreader as given above.
Pre-Harvest Spray Seven to ten days before harvest.	Flotation type sulfur.. 8 lbs. *or* Wettable sulfur..... 6 lbs. Water .....100 gals.	Brown rot Leaf spot	This is a dangerous period for brown rot infection. Additional sulfur sprays or dusts without lead should be applied whenever wet weather occurs.

* A discussion of fixed copper compounds is given on page 32.

Program for Young Fruit Trees Not Yet Bearing

Young fruit trees not yet in bearing should be carefully inspected annually in advance of the dormant spraying season. If *scale insects, aphis eggs,* or *red mite eggs* are found, the trees should receive the dormant oil spray recommended for use on bearing trees of the same sort. Sour cherry trees rarely require a dormant spray.

Young peach trees should receive a dormant spray for *leaf curl* as given in the peach schedule (see page 15).

Young apple trees should receive at least one spray in the late pre-bloom period for *apple scab.* If scab is serious, a subsequent spray should be applied at the first cover period as given for bearing trees.

A watch should be maintained just previous to bloom for young *cankerworms.* If they are found, lead arsenate and lime should be applied along with the sulfur fungicide recommended for the pink spray as for bearing trees (see page 6). If the young orchard is near a woodland infested with cankerworms, an additional spray of the formula recommended for the calyx cup spray on bearing trees may be necessary.

If young apple trees become heavily infested with *green aphis,* it may be desirable to follow control suggestions given on page 13.

Because young cherry trees are as susceptible to *leaf spot* infection and *slug* attack as are bearing trees, the young cherry orchard should receive the sprays recommended for these two troubles in the program for bearing trees (see page 16).

Young peach trees should be examined in early September and in late April for *peach tree borers.* If found present, the borers should be removed by careful use of a knife, or the gas treatment given on pages 57 to 59 should be applied.

Tree hoppers sometimes seriously damage the trunks and branches of young trees by laying their eggs in the bark, particularly if alfalfa or sweet clover is used as a cover crop. If clean cultivation or frequent mowing of all ground cover is practiced until the end of June of each year, serious damage from tree hoppers will be avoided.

In years when the *periodical cicada* (17-year locust) is due to come, young trees, located near a woods or near old apple trees that have maintained a heavy brood of cicadas in previous years, should be protected by wrapping them with cheesecloth or muslin. The entire top, with all of the foliage and branches, should be enclosed during the period from June 1 to about July 15.

The next visitation of cicadas to the eastern half of Ohio will come in 1948; in western Ohio in 1953; and in twelve counties of southwestern Ohio, from Gallia to Clermont and Warren counties inclusive, in 1957.

Facts About Spraying Grapes

It is impossible to construct a spray schedule for grapes that will have general application. The insect and disease problems of vineyards located in different communities, and even in vineyards of the same community, are frequently quite variable. For example, grape mildew, while serious on the Lake Erie islands and at the west of Lake Erie, is rarely a problem in the commercial grape belt east of Cleveland. Rose chafer usually is troublesome only in vineyards with sandy soil. Many grape insects are quite localized in their distribution.

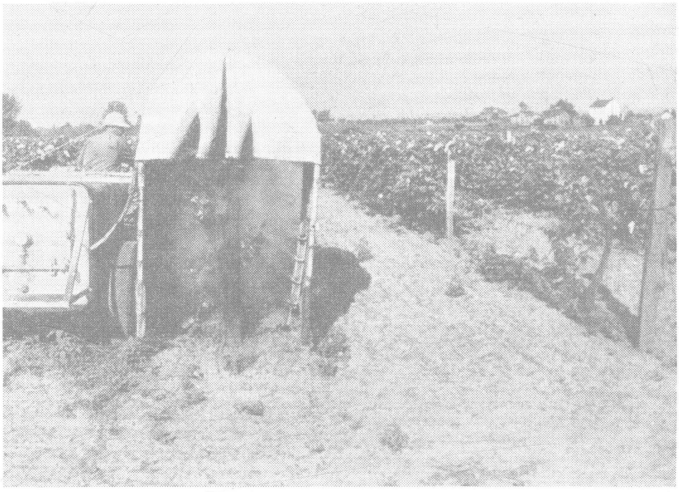

Fig. 26.—Spraying grapes with covered spray boom.

In many vineyards of recent plantings, and in some mature vineyards, excellent grapes are frequently grown without any sprays. In other plantings two, or at the most three spray applications are advisable. Only a few vineyards will require the full spray schedule.

Each grower should study his conditions and apply only such sprays as are found necessary. Thoroughness is very essential; berry-moth and leafhoppers cannot be controlled, except by very thorough applications. The use of a canopy covered spray boom secures better coverage with less waste of material than the open type of fixed boom (see Fig. 26).

Mature vineyards will require from 150 to 200 gallons of spray per acre per application, depending upon the size and density of foliage. Good pressure and careful adjustment of spray nozzles and boom are essential.

GRAPE SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Delayed Dormant When buds show ½ inch green.	8-10-100 bordeaux mixture. (see page 31). *and* Rosin fish oil soap[1].....2 lbs. Kerosene[1] .....⅓ pint	Black rot	In wet years and in localities where black rot has been serious. Watch out for injury to buds by climbing cutworms (see page 55). Where berry-moth is serious, plow to vines as soon as soil can be worked. Plow under all fallen leaves and trash in which cocoons are located. Do not work soil again until 10 days after bloom.
Pre-blossom Before blossom buds open. When the new shoots are 10 to 12 inches long.	6-8-100 bordeaux mixture. *and* Rosin fish oil soap[1].....2 lbs. Kerosene[1] .....⅓ pint	Mildew Black rot	Necessary only in case these diseases are present. Cover all leaves and bud clusters. Watch for rose chafers which may appear just before bloom and destroy blossom buds. If they appear, spray with 8 lbs. of lead arsenate and 2 gals. of molasses in 100 gals. of bordeaux or water.
Petal-Fall (Immediately after blossoming).	4-6-100 bordeaux mixture *and* Lead arsenate .....3 lbs. *and* Rosin fish oil soap[1].....2 lbs. Kerosene[1] .....⅓ pint	Berry-moth Mildew Black rot Leafhoppers (see under suggestions)	Very important where berry-moth is serious. If young leafhoppers are numerous on the underside of the leaves, add 1 pint of nicotine sulfate and, with high pressure, force the spray against underside of leaves.
Repeat Spray Seven to 10 days after petal-fall spray.	Same as for petal-fall spray.[2] (To avoid lead residue 3 lbs. of calcium arsenate[2] may be substituted for the lead arsenate in this spray)	Berry moth Root-beetle Black rot Leafhoppers (see under suggestions)	Very necessary where berry-moth is serious. Be sure to cover fruit clusters. If young leafhoppers are numerous apply nicotine sulfate as directed under previous application. Soil plowed for berry-moth control can now be worked down.
Special Root-Beetle Spray Early in July when first feeding marks are seen on leaves.	Fixed copper compound and lime according to manufacturer's direction *and* Calcium arsenate[2] .....2½ lbs. Water .....100 gals.	Root-beetle	Necessary only where root-beetle is serious. Watch for chain-like feeding marks on leaf and spray only upper surface of leaves.
Special Leafhopper Spray In late June or early in July as soon as leafhoppers are hatched.	Fixed copper compound and lime according to manufacturers' direction *and* Rosin fish oil soap[1]..1 or 2 lbs. *and* Nicotine sulfate .....1 pint Water to make.....100 gals.	Leafhopper	This special spray is sometimes necessary where nicotine spray has not been previously made in order to control leafhoppers and prevent "rusty" foliage. Direct it against insects as advised in Petal-fall spray.

[1] Rosin fish oil soap is the best sticker and spreader. It should be mixed alone in a bucket of hot water and added to the spray tank *last* with agitator going. Since its use frequently results in excessive foaming in the tank, the kerosene is added to reduce this foaming. Other spreaders and stickers, such as fish oil, fish oil soap, soap flakes, or casein-lime may be used, but are inferior to rosin fish oil soap.

[2] Although a heavy spray of arsenical and bordeaux mixture applied to grape clusters, either the last week of July or the first week in August, may give fairly good control of the second brood of berry-moth larvae, there is some danger of too much residue if arsenicals are applied to the grape clusters later than the "Repeat Spray." Where August sprays for second brood berry-moth are needed, fixed nicotine sprays offer a possibility. These should carry 3 lbs. of Black Leaf 155 (14%) and either ½ lb. of rosin fish oil soap, or 2 ounces of Dreft (a commercial soap) to each 100 gallons. Bordeaux mixture or lime *cannot* be used with the fixed nicotine, although some of the fixed copper fungicides without lime may be used if a fungicide is necessary. (See page 33). Two August sprays, spaced from 7 to 10 days apart are suggested. The first of these should be timed to immediately precede the first hatching of second brood berry-moth eggs, the time varying with the season and locality.

SMALL FRUITS SPRAY PROGRAM

GOOSEBERRIES AND CURRANTS

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Delayed Dormant In the spring when buds show ¼ inch green.	*Liquid lime-sulfur.. 12½ gals. Water to make.....100 gals. Nicotine sulfate ..... 1 pint (Used only in case aphis is troublesome) Dinitro oils as given for apple are recommended if both scale and aphis are to be combated.	Scale Anthracnose Aphis	Oil emulsion 4½ gallons or miscible oil at manufacturers' recommendation is preferred for scale if anthracnose is not a problem. The nicotine may be added to the oil if aphis is to be combated.
First Cover Spray Just after the first leaves have unfolded.	Bordeaux mixture 4-6-100 *or* *Liquid lime-sulfur.. 1½ gals. Water to make.....100 gals.	Anthracnose Leaf spot	
Second Cover Spray Ten days to two weeks after first cover spray.	Bordeaux mixture 4-6-100 *or* *Liquid lime-sulfur.. 1½ gals. Lead arsenate..... 2 lbs. Water to make.....100 gals.	Anthracnose Leaf spot Currant worm Powdery mildew	If the fruits are more than one-half grown 4 lbs. of ground derris root should be substituted for lead arsenate. If mildew is a problem use lime-sulfur instead of bordeaux.
After Harvest Spray	Bordeaux mixture 4-6-100 *or* *Liquid lime-sulfur.. 1½ gals. Water to make.....100 gals.	Leaf spot Anthracnose Powdery mildew	

* Dry lime-sulfur may be substituted for liquid at the rate of 4 pounds for 1 gallon.

STRAWBERRIES

As a commercial practice, spraying strawberries for the control of leaf spot is not advised. The growing of resistant varieties like Premier is recommended.

For the control of the strawberry leaf roller, dust with a fluorine bearing material (Kryocide, Alorco cryolite, or Dutox) at the rate of 1 part of the insecticide to 2 parts talc and 2 parts flour; or spray with the same material, using 5 pounds of the insecticide with an acceptable spreader, such as sulfated alcohol or goulac, in 100 gallons of water. Make the first application when the tiny larvae first appear and repeat at weekly intervals for 3 or 4 weeks or until the larvae disappear. Do not apply any of these materials after any fruits are more than one-half grown.

If an application is needed when the berries are more than one-half grown or when fruits are ripening, use a summer oil at a strength of 1½ per cent with Black Leaf 40 at the rate of 1 part to 1200 parts water; or use powdered derris root at recommended strengths to avoid fluorine residue. Fluorine treatments may be resumed if the second brood of larvae appears after the crop is harvested.

RASPBERRIES AND BLACKBERRIES

Only one spray is advised on raspberries and blackberries. A delayed dormant application just as the buds are showing green, using liquid lime-sulfur 5 gallons or 20 pounds of dry lime-sulfur to make 100 gallons of spray, is advised. No material for summer control of anthracnose or powdery mildew has been devised which will give control and not result in spray injury.

Spraying is not advised for virus or bacterial diseases (mosaics, streaks, curls, crown gall). Control of these diseases is secured by planting *disease-free stocks* in isolated locations.

INSECTICIDE AND FUNGICIDE CONVERSION TABLE FOR SMALL PLANTINGS

(Giving Small Quantity Dilutions for Home Fruit and Ornamental Plantings)

	Where and Why?	*Recommended Material*	Amount to Use to Make the Following Quantities. (*T = tablespoon, t = teaspoon*)						
			1 qt.	1 gal.	3 gals.	5 gals.	10 gals.	20 gals.	100 gals.
Dormant	Fruit Trees and Ornamentals *For:* Scale and Red Spider	2% oil	4 t.	5 T.	1 cup	1½ cups	1½ pts.	3 pts.	2 gals.
		3% oil	5 t.	½ cup	¾ pt.	1¼ pts.	2½ pts.	2½ qts.	3 gals.
		4% oil	1½ T.	⅔ cup	1 pt.	1½ pts.	1½ qts.	3¼ qts.	4 gals.
		5% oil	2 T.	1 cup	1¼ pts.	2 pts.	2 qts.	1 gal.	5 gals.
Summer	Sucking Insects on Flowers and Shrubs	Nicotine or Pyrethrum 1 to 200	1 t.	4 t.	4 T.	6½ T.	¾ cup	1½ cups	2 qts.
		1 to 300	⅔ t.	2½ t.	2½ T.	4¼ T.	½ cup	1¼ cups	1½ qts.
		1 to 400	½ t.	2 t.	2 T.	3¼ T.	6½ T.	¾ cup	1 qt.
		1 to 500	—½ t.	1½ t.	1½ T.	2½ T.	5 T.	⅔ cup	1½ pts.
		1 to 800	¼ t.	1 t.	3 t.	5 t.	3¼ T.	7 T.	1 pt.
Summer	Chewing Insects on Tree Fruits, Small Fruits, Flowers, and Shrubs	Lead or Calcium Arsenate		2 T.	6 T.	10 T.	1¼ cups.	2½ cups	3 lbs.
		Spray Lime		3½ T.	10 T.	1 cup	2 cups	4 cups	5 lbs.
		Derris or Cube Powder		3½ T.	10 T.	1 cup	2 cups	4 cups	5 lbs.
Summer	Diseases: Scab, Brown Rot, Leaf Spots, Blotch, Etc.	Dry lime-sulfur (Post Bloom)			10 T.	1 cup	1 pt.	1 qt.	5 lbs.
		or Wettable sulfur (Sprays)			12 T.	1¼ cups	1¼ pts.	1¼ qts.	6 lbs.
		Commercial Bordeaux	According to directions on container						
Summer	Cherry and Plum Leaf Spot	Fixed Copper (on basis of 50% metallic)			3 T.	5 T.	10 T.	1¼ cups	1½ lbs.
		plus Fresh Spray Lime			6 T.	10 T.	1¼ cups	2½ cups	3 lbs.
	Peach Leaf Curl	Dry lime-sulfur (dormant spray)			¾ lb.	1¼ lbs.	2½ lbs.	5 lbs.	25 lbs.

Information About Spray Materials

DORMANT SPRAY OILS

The orchardist has a choice of many different oils for use in the dormant season, according to his particular needs. Each of the different oils is suited for certain conditions that may arise in Ohio orchards. They are classified as follows:

1. Tar distillates or tar oils.
2. Dinitro with petroleum oil.
3. Petroleum oils:
    (a) Concentrated or mayonnaise-type emulsions
    (b) Miscible oils
    (c) Emulsible oils
    (d) Tank-mix oils

Tar Distillates

These are effective against the eggs of all aphid species when used in spray mixtures carrying not less than 2½ per cent of the distillate, but will not control European red mite and are not especially effective against different scales. To avoid injury they must be applied when the trees are completely dormant and spraymen and horses should be protected from any spray drift.

Dinitros with Petroleum Oil

In the past years the idea was developed that oils might be made more efficient by the addition of another toxic material so as to control both aphids and the other pests usually controlled by petroleum oils. This has been accomplished by the so-called dinitro compounds. These have been sold in solution with the oil and were quite effective. At the present time dinitro preparations are being sold in the form of a powder that can be added to any oil spray. This is an advantage, since the fruit grower can now vary either the dinitro or the oil in accordance with the demands of his insect problem. The directions on the package should be followed, as different manufacturers use different amounts of the active ingredient in their products.

A water suspension of sodium dinitro-ortho-cresylate (Elgetol) is also sold for use, either alone against aphids or with oils to control other pests as well. The manufacturer's directions should be followed and this material not allowed to dry out, as it then becomes highly inflammable and explosive.

Dinitro with oil is especially recommended where rosy apple aphis or the black cherry aphis is a problem. Sprays must be applied when the trees are completely dormant and spraymen and horses must be protected from drift.

These are widely used for dormant spraying due to their (1) low cost, (2) efficiency in general orchard cleanup, (3) non-corrosive action on spray machinery, and (4) general agreeableness of use. As now sold, there are several preparations having the same type of base oil but with different emulsifying agents. If used at the proper strengths, all should be equally effective. A spray rig should have vigorous agitation to insure uniform distribution of the oil in the tank.

(a) *Oil Emulsions.*—These contain from 65 to 85 per cent oil and may be purchased already prepared or they can be made at home. With the pump running, the emulsion is added to a small quantity of water

Fig. 27.—Branches on right show injury to the buds by a 6 per cent dormant oil spray applied when the buds were breaking. Left, branches were not sprayed.

already in the tank and mixes quite easily. A heavier dosage is required than with miscible or emulsible oils in order to compensate for the lower oil content. In storing such emulsions it should be remembered that they will freeze below 32° F. and that excessive heat will also break the emulsion. Their main advantages are, (1) low cost, and (2) ease of mixing. Commercial products are more convenient and usually safer, especially for the small grower.

(b) *Miscible Oils.*—Oils of this type have the emulsifying agent dissolved in the oil and emulsify easily with agitation, forming very stable emulsions. They usually contain above 90 per cent oil. The oil deposit is very uniform and usually not as heavy as that effected by other types.

(c) *Emulsible Oils.*—These also have the emulsifier dissolved in the oil, and usually contain from 95 to 98 per cent of oil. They require good agitation to emulsify them in the tank, and have the advantage that they generally deposit more oil on sprayed surfaces than do the miscible-type oils. As these oils contain no water they will not freeze.

(d) *Tank-mix Oils.*—This term is applied to oils which are emulsified by adding the emulsifier to the oil in the tank at the time of mixing. These oils are usually lubricating or transformer oils, and may be specified as follows:

Viscosity — from 75 to 150 sec. at 100° F. (Saybolt)
A.S.T.M. distillation — less than 10% off at 560° F.
A.P.I. gravity — minimum 21.5
Unsulphonatable residue (A.S.T.M., D-483-40) — minimum 6.5

Motor oil or crankcase drainings are unsuited for spray purposes.

Two tank-mix formulas are listed, these being much more widely used than others:

Formula I.	Lubricating oil	3 gals.
	Copper sulfate (fine crystals)	½ lb.
	Hydrated lime	¾ lb.
	Water to make	100 gals.

For a 200-gallon tank, double the foregoing formula; for 300 gallons, triple it; etc. This will give a 3 per cent oil spray. For a 4 per cent oil spray, use 4 gallons of oil.

In making the tank-mix, place enough water in the tank to reach the agitator shaft. Then with pump running, place the copper sulfate on the screen and wash into the tank. Next, sift in the lime, followed by the oil. Continue pumping until all the oil is emulsified and no free oil shows on the surface. The tank is then filled with water, and without shutting off the engine proceed to the orchard and spray.

Formula II.	Lubricating oil	3 gals.
	and	
	Calcium caseinate	6 oz.
	or, goulac	6 oz.
	or, blood albumin emulsifier	8 oz.
	Water to make	100 gals.

This formula is prepared in the same order as Formula I. Sift the calcium caseinate (goulac or blood albumin) into the small amount of water that is being pumped, then add the oil and continue pumping until emulsification is complete. Fill tank with water and spray immediately.

Either of the preceding formulas may be combined with 6-8-100 bordeaux mixture as an early spring dormant spray for control of peach leaf curl in addition to scale or red mite.

Cautions in Use of Petroleum Oil Sprays:

1. Some concentrated oil sprays stand freezing, others *do not.* Know the kind you are using and protect from cold if it is in the latter class.

(Cautions are continued on next page)

Cautions in Use of Petroleum Oil Sprays (Continued)

2. *Do not* spray with oils if temperatures are below 40°; or if low temperatures are forecast for the next 24 hours.
3. *Do not* spray with free oil floating on top of the spray solution.
4. Oils are used most efficiently during the period that buds are swelling, but when the leaf tips begin separating their use should be stopped. In some seasons oils used in the early delayed dormant period, and especially oil emulsions, have been safe. In others, injury has resulted.
5. Do not apply dormant oils in the fall because of likelihood of injury.

SPRAYS FOR SUMMER USE

Summer Spray Oils

At the present time only highly refined petroleum oils are used in summer spraying. These may fall into any of the four groups under dormant oils (page 23). The specifications for these oils, however, are much more exacting. It is suggested that they fall within the following limits:

Viscosity from 65 to 90 sec. at 100° F. (Saybolt)
A.P.I. Gravity 27–35
Unsulphonatable residue (A.S.T.M., D-483-40.....minimum 90%
Distillation range:
10 per cent point—not less than 560° F.
90 per cent point—not over 760° F.
50 per cent distilled when temperature reaches 636° F.

Summer oils are used in combination with lead arsenate and various nicotines against the codling moth (see pages 34 to 36). They also add greatly to the effectiveness of nicotine sprays against aphids, leafhoppers, and other sucking insects. They may be used in combination with rotenone against red mite in summer spraying.

Sulfur Fungicides

Sulfur fungicides can be grouped into two rather specific types or classes, namely: (1) combined sulfur, as calcium, sodium, or potassium sulfides, and (2) uncombined sulfur such as occurs in the wettable sulfur mixtures. In Type 1, the sulfur sulfides are formed. The definite chemical reaction in which complex sulfides are formed. The sulfides are very caustic, highly fungicidal, but very unstable when exposed to the air. When sprayed on a tree they break down to form elemental sulfur; this insures the lasting effectiveness of the spray. In general, they are apt to cause some injury to most types of foliage, and should not be used at all on such tender foliage as peach, plum, and sweet cherry.

Type 2, comprising uncombined sulfur, is prepared as a mechanical mixture in which the sulfur remains insoluble. This type is less effective as a fungicide, but causes practically no injury to any type of foliage that tolerates sulfur.

LIME-SULFUR

Previous to the introduction of oils, lime-sulfur was universally used for dormant spraying in Ohio. The chief objections to the use of dormant strength lime-sulfur are: (1) high cost of dilute spray; (2) failure to control red mite; and (3) its irritation to the eyes and exposed parts of the body of the operator. For these reasons it is declining in favor and is no longer recommended as a dormant spray except on peaches.

For the control of peach leaf curl there is no spray superior to lime-sulfur if applied when the trees are dormant. If scale is not a problem, lime-sulfur can be used on peaches at one-half the strength recommended for the control of scale insects.

Liquid lime-sulfur has been the standard spray material for apples for many years. Recently, however, rather severe losses have resulted from its use. The results from recent experiments have shown that not only is the foliage frequently burned and fruit russeted, but also the leaf is reduced in area and effectiveness. Hence, the entire vigor of the tree is reduced which, in turn, affects the set of fruit, and the appearance and quality of the apple. This injury is increased when lime-sulfur is combined with lead arsenate. It is for these reasons that lime-sulfur should be replaced by safer materials for summer spraying. There are a few reliable substitutes, one of which is the flotation type sulfur.

Liquid lime-sulfur, when held over winter, should be stored where it will not freeze, and sealed to exclude the air. The freezing point of concentrated liquid lime-sulfur is much below the freezing point of water. If the material has been allowed to freeze it should be tested with a Baumé hydrometer before using (see table, page 29).

Lime-sulfur is the most important member of the sulfide group. Practically all commercial brands of the concentrated form are of equal value, provided the Baumé reading is 32-33°. A lime-sulfur having a 30° Baumé reading contains 2.7 pounds of sulfur to a gallon of the concentrate. The sulfur is mostly in the form of penta-sulfides (a maximum combination of sulfur with lime), in which form it is most effective as a fungicide. Lime-sulfurs with lower Baumé readings (which frequently occur in home-made lime-sulfur preparations) are less effective in controlling diseases, and, when combined with arsenicals, are apt to cause injury to foliage.

Home Manufacture of Lime-sulfur Solution.—Of recent years there has been an increased interest on the part of growers in making their own lime-sulfur. Where some equipment and the necessary time is available a reduction in the cost of spray materials can be effected.

Equipment for boiling together lime and sulfur to make liquid lime-sulfur solution may be very simple, such as an evaporating pan or open steel tank with a fire box beneath, or a more elaborate and convenient outfit where live steam from a small boiler is used to cook the materials and heat the water.

Materials used for making lime-sulfur solution should be: (a) fresh high calcium lime containing 90 per cent or more of calcium oxide and not over 5 per cent of magnesium oxide, and, (b) fresh commercial ground or pulverized sulfur, also known as flour of sulfur, which should be about 98 to 99 per cent pure. The form of lime may be either stone or hydrated. Stone, or a grade of stone lime called pebble lime, is preferred, as it slakes quickly and gives off intense heat which helps toward the boiling process. If hydrated lime is used, 33 per cent more lime must be used in the formula than for stone lime.

A commercial grade of lime-sulfur testing 33° Baumé may be made in the home boiling plant by using 320 pounds of sulfur and 160 pounds of stone lime to each 100 gallons of water. However, this formula leaves considerable sediment after boiling and the materials are so bulky to handle that a slightly lower testing yet more economical formula for home manufacture is advised as follows:

Stone lime	100 pounds
Sulfur	200 pounds
Water	100 gallons

This lighter formula is far more readily handled with home equipment and the resulting product will test 28 to 29° Baumé.

The process of making lime-sulfur solution is as follows: Sift the sulfur (previously made free of lumps) into boiling water in the cooking tank, and stir to reduce the sulfur to a thin smooth paste. More water is then added to about half fill the tank. Into this hot sulfur paste the stone lime is poured and stirring at the bottom begun at once. The lime begins slaking quickly and gives off intense heat, so that when the slaking process is complete the whole mass is to the boiling point. More water is now added to bring the level of the mixture in the tank up to the 100-gallon mark.

This mixture of lime and sulfur should now be actively and continuously boiled until the materials have gone into perfect solution, stirring the materials at the bottom throughout the boiling process. As cooking proceeds, the color of the solution gradually becomes darker, until the finished product appears almost black. The required time for active boiling is 50 minutes. Time should not be counted until active boiling begins. Any water lost by evaporation should be replaced during the boiling so the level of the solution is kept at the 100-gallon mark. As soon as the solution has boiled the required length of time, it should be run off or pumped into steel drums or storage tank through a brass strainer (30 to 50 mesh) and is then ready to use.

If open top wooden barrels are used for storage a very small amount of oil poured on top of the solution will keep the air out and prevent crystallization. The oil can be skimmed off before using. More or less coarse sediment will remain in the bottom of the boiling tank after the liquid lime-sulfur has been run off. This should be cleaned out after each boiling. The amount of this sediment is dependent largely on the calcium content of the lime and the mechanical condition of the sulfur.

A special hydrometer having a Baumé scale is necessary for testing lime-sulfur, and the solution should be cooled to at least 60° Fahrenheit before testing. A table showing the amounts of lime-sulfur to use at different Baumé readings is given below. Home-made lime-sulfur concentrate is fully as effective for apple scab when properly diluted as the commercially prepared product.

More detailed information on the home manufacture of lime-sulfur solution may be obtained from Bulletin 572 of the Ohio Agricultural Experiment Station, or Farmers' Bulletin 1285 of the United States Department of Agriculture.

Amounts of Liquid Lime-sulfur for Dormant Spraying on Peaches, and Pre-blossom Spraying on Apples at Different Baumé Readings

Hydrometer reading	Amounts per 100 Gallons of Spray				
	Peach—Dormant Spray		Apple		
	Scale present	No Scale	Delayed dormant 2-100	Pre-pink and Pink 1½-100	Post-bloom 1-100
Degrees Baumé	Gal.	Gal.	Qt.	Qt.	Qt.
33	12½	6¼	8	6	4
32	13½	6¾	8⅔	6½	4⅓
31	14½	7¼	9⅓	7	4⅔
30	15½	7¾	10	7½	5
29	16¾	8¼	10⅔	8	5⅓
28	17¾	8¾	11⅓	8½	5⅔
27	18¾	9¼	12	9	6
26	19¾	10	12⅔	9½	6⅓
25	20¾	10½	13⅓	10	6⅔

Dry Lime-sulfur

For greater convenience in handling, shipping, and storing, manufacturers have devised powdered forms of lime-sulfur. Powdered or dry lime-sulfur contains the same ingredients as liquid lime-sulfur and, in addition, a stabilizer, making its manufacture possible. Chemically, 4 pounds of dry lime-sulfur is equivalent in sulfide content to 1 gallon of liquid lime-sulfur concentrate. In practice, the dry form has caused less injury than an equal concentration of the liquid. Since it is safer, and yet equally as effective as liquid lime-sulfur, it is preferred if either is to be used for summer spraying on apples.

The Wettable Sulfur Sprays

Sulfur alone cannot be used to make a spray, because water will not wet it. This difficulty has been overcome by the use of various seasoning or wetting agents. Mixtures of lime and calcium caseinate, or lime and glue, are the more common wetting agents, though such mixtures reduce the fungicidal action of the sulfur. Many manufacturers have developed other types of wetting agents and are producing excellent wettable sulfurs.

Wettable sulfur sprays are practically non-caustic, rarely cause injury to foliage, and little impairment in finish to fruit. While they are ideal from the standpoint of safety, many of them lack efficiency in control, especially of such apple diseases as Brooks spot, blotch, and bitter rot. In sections where these diseases do not occur, a flotation type of sulfur will prevent infection of apple scab after the pre-pink stage. Flotation type sulfur and other wettable sulfurs should not be used on peaches in combination with lead arsenate, because of possible foliage and twig injury.

A description of some of the better known wettable sulfur sprays follows. Very little, if any, lime should be added to these sprays on apples. Manufacturers' directions should be followed.

Flotation Type Sulfur.—One of the most effective wettable sulfur sprays for the control of apple scab is known as flotation sulfur. It is made from a by-product in the manufacture of artificial gas. It is colloidal in nature, contains a trace of insoluble materials, suspends well in water, and is sold on the market in paste form. Results from four seasons' experiments indicate that the paste form can be depended upon for the control of apple scab during the post-bloom period.

There are several flotation type sulfur products on the market. Discounting the amount of foreign material often found in some of these pastes, they are about equal in effectiveness. They contain around 40 to 50 per cent sulfur and should be used in pre-bloom at 12 pounds to 100 gallons of water, and after bloom 6 to 10 pounds to 100 gallons.

In addition to the regular flotation sulfurs there are a few prepared forms of sulfur pastes that physically resemble the flotation form. The results of one season's field trials indicate that two of these, Ultrafine and Flotox, are just as effective as the regular flotation, and are intended to be included in the flotation type sulfurs recommended in the spray schedules. They are a little higher in sulfur content.

Other Wettable Sulfur Sprays.—The following is a partial list of proprietary wettable sulfur compounds: Dritomic, Kolofog, Magnetic, Micronizer, Mike, Mist Brand, Mulsoid, and Sulfuron. While most of these were developed primarily for peach spraying, they have more recently been found satisfactory for apple scab during the post-bloom period or to supplement a weak lime-sulfur. They should be used according to manufacturers' directions or at the strengths suggested in the schedules.

Home-made Wettable Sulfur.—A promising wettable sulfur has been made by mixing dry a fine grade of dusting sulfur, 10 pounds; dried skim milk, 8 ounces; and a wetting agent, 1 ounce.

There are at present several suitable wetting compounds on the market. Among those now available are, Aresklene, Santomerse, Tergitol, Grasselli Spreader and Sticker, and Orthex. In experimental work, this mixture has proved satisfactory, and can be used in the same way

and in the same amounts as any of the commercial wettable sulfurs. A considerable saving in cost is the chief advantage.

Zinc Sulfate

Zinc sulfate has been introduced into the peach spray schedule to prevent arsenical injury. It has been found that it has practically no fungicidal value. Consequently, it is recommended only in the shuck-fall spray and this should be followed in 10 days or 2 weeks by a wettable sulfur spray for the control of scab and brown rot. Flaked zinc sulfate is the recommended form and is sold on the market in three standard grades: namely, 22¼ per cent, 25 per cent, and 36 per cent. The recommendations are based on the 25 per cent material. See pages 8, 11, and 39 for suggestions regarding the use of zinc sulfate on apples.

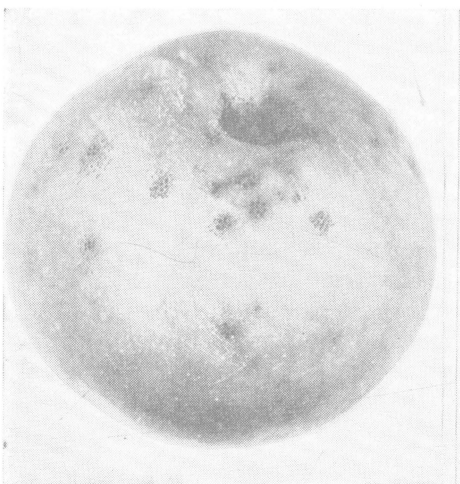

Fig. 28.—Brooks spot

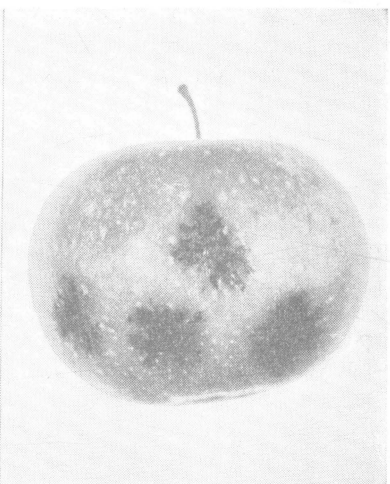

Fig. 29.—Apple blotch

These two diseases are controlled by bordeaux mixture.

Bordeaux Mixture

The old standard bordeaux mixtures were prepared with equal weights of copper sulfate and stone (lump) lime. Because of copper injury to foliage and fruit this formula has been changed to include a greater percentage of lime. It has also been found that equally as good bordeaux mixtures can be made with a special fine hydrated lime. In all recommendations included in this bulletin, a good grade of *freshly hydrated lime* is specified. A mixture made from 4 pounds of copper sulfate and 8 pounds of hydrated lime to 100 gallons of water is designated by the formula 4-8-100. The proportions are changed according to strength desired.

There are two general methods now in use for preparing bordeaux mixture. The standard method is Method I, prepared as follows:

Method I

Prepare a stock solution of copper sulfate by dissolving the required amount of copper sulfate in the ratio of 1 pound to 1 gallon of water. If copper sulfate crystals are used, suspend them in a sack submerged just beneath the surface of the water. The warmer the water, the more rapidly the crystals will dissolve, but they will dissolve in moderately cold water in a few hours. If the powdered form of copper sulfate is used, it will dissolve immediately.

The stock hydrated lime is prepared by making a lime paste of known strength which can be washed into the tank through a screen. If a good grade of freshly hydrated lime is available it may be sifted directly into the tank.

To fill a 100-gallon tank with a 4-8-100 bordeaux mixture, fill the tank two-thirds full of water, and start the engine to keep the agitator running. Mix the 8 pounds of hydrated lime into a cream and pour through a strainer into the tank; *when thoroughly mixed* add the 4 gallons of copper sulfate stock solution. Complete the filling of the tank to 100 gallons. If lead arsenate is to be used it should be added last.

Method II

The second method is the preparation of *instant bordeaux mixture,* using the powdered form of copper sulfate which dissolves quickly and no stock solution, therefore, is necessary. The mixture is made as follows: Fill the tank half full with water and, with the agitator running, wash in the hydrated lime through the screen. Next fill the tank two-thirds to three-fourths full, place the powdered copper sulfate on the screen and wash through, and then completely fill the tank.

Bordeaux mixture is not recommended for use in apple orchards in the northern half of Ohio. While it will control scab, it is likely to cause severe injury, especially during cool, damp weather. In the southern part of the state it is recommended for the control of Brooks spot and bitter rot, and on varieties particularly susceptible to blotch.

Fixed Copper Compounds

Many insoluble copper compounds have been developed as substitutes for Bordeaux mixture. In general they are not quite as effective in disease control but are somewhat less injurious to fruit foliage.

There are three general types of these fixed coppers: (1) The basic copper sulfate group, of which the tri-basic forms are generally used, include such trade named products as Basi-Cop, Spray Cop and Tri-Basic; (2) the basic copper chloride group includes copper oxychloride, copper oxychloride sulfate, CAC, and Cupro-K; (3) the copper oxide group includes Brown Cupric Oxide, the Red and Yellow Cuprocides and several others sold as oxides. The trade named products named above have been tested in Ohio and the list is by no means complete. The

chemistry of these compounds is extremely complex, and literally hundreds of chlorides and sulfates of copper can be made. Likewise, the concentration of copper varies with each, ranging from 12 to 87 per cent metallic. While there is some variation in their effectiveness and safety per unit of metallic copper, it is recommended that all spray formulas be calculated on a uniform copper basis.

All fixed coppers may cause foliage injury and fruit russet on apples if applied before midsummer. They controlled cherry leaf spot better than any other material during the last four seasons. Lime should be added as per schedule.

Nicotine Sprays

Nicotine is a very effective killing agent to use against insects where its value has been proved and the cost is not prohibitive. As yet it has no equal in summer applications for aphids, leafhoppers, and the apple red bug. Nicotine kills by contact and must be applied in the immediate presence of the insect to be killed.

Nicotine sprays are now used in two forms on fruit trees. These are: (a) in the compound known as *nicotine sulfate,* where it usually has 40 per cent actual nicotine, and (b) in combination with bentonite to form a more stable product known as *"fixed nicotine."* Both of these forms are applied with summer oil against certain insects. The oil acts as a spreading agent and also serves to retard volatilization of nicotine so that the insecticide remains toxic over a longer period of time—a quality desired in codling moth control. The home-made nicotine spray resulting from steeping, or soaking, tobacco stems or leaves is *not* recommended.

Nicotine Sulfate

This form of nicotine, marketed as a liquid, is preferred for use against most soft-bodied sucking insects. Its maximum effectiveness for this depends upon the rapid release of nicotine in the gaseous form. For this purpose an alkali, such as lime-sulfur, lime, soap flakes, bordeaux, or one of the commercial nicotine activators is added to release the nicotine.

Nicotine sulfate combines with all insecticides and fungicides, so is well adapted to use in combinations for disease and insect control. Its chief objections are: (a) cost, and (b) discomfort to the operator in applying. Its value against leafhoppers and aphids is well established.

For detailed information about the life history of apple aphids consult Ohio Experiment Station Bulletin No. 464.

Fixed Nicotine

This product is a powder and is sold under trade names, such as: Black leaf 155, which carries 14 per cent nicotine. In this form the nicotine is "fixed," or combined with bentonite, which locks up the

nicotine and prevents its rapid release. When sprayed on foliage the material will retain its toxicity in decreasing amount for several days and has considerable residual value—a quality greatly desired, but usually lacking in contact sprays. While having some value in controlling aphids, leafhoppers, and other sucking insects, its chief merit is in controlling late hatching codling moth and grape berry-moth, where spray residue deposit prevents the use of arsenicals.

Fixed nicotine cannot be used with alkaline materials, such as lime, lime-sulfur, and bordeaux mixture, but can be combined with summer oil, flotation sulfur, and certain fixed copper fungicides. The fixed nicotines are not so unpleasant to apply, but at present are expensive when repeated often enough to control codling moth and grape berry-moth.

Research work is under way, but lack of published results and expense of spray application makes the use of fixed nicotine advisable only when conditions demand this extra expense, and where arsenical residue cannot be removed by washing.

Lead Arsenate

Lead arsenate is the most extensively used stomach poison for controlling codling moth and other chewing insects in the orchard. That sold for tree fruits in the east is known as acid lead arsenate. This differs slightly in chemical composition from basic lead arsenate which is used on peaches on the Pacific coast. The acid lead arsenate is more toxic to insects than the basic form and is considered the more dependable for controlling fruit insects under eastern conditions. Powdered lead arsenate does not deteriorate with age. It should contain at least 30 per cent of arsenic pentoxide and not over $\frac{3}{4}$ of 1 per cent of water-soluble arsenic. The manufacture of lead arsenate is well standardized and there is little danger of getting an inferior product.

Lead arsenate has good physical properties for spraying and does not dissolve, but is held in suspension in water. It can be combined with fungicides, such as lime-sulfur or bordeaux mixture, in making a combination spray. Lead arsenate adheres well as a spray, which increases its effectiveness against insects, but this same quality prevents its being ideal for the purpose intended, because of the residue present on harvested fruit. Though many tests have been made with substitute materials, it still takes front rank in the degree of insect control secured in the orchard.

Lead Arsenate and Oil Combined

This combination is recommended for use only in orchards where the codling moth is severe and where extra lead arsenate sprays have failed to control. It is very effective against codling moth, especially if several applications are made. This is due to an increased load of lead arsenate which is resistant to weathering and also the fact that from

½ to ⅔ gallon of oil per 100 will destroy a considerable number of codling moth eggs. Such a program is limited to orchards where washing equipment is available.

As formerly used, lead arsenate and oil frequently gave severe foliage injury. This can now be avoided by adding zinc sulfate at the rate of 1 pound per 100 gallons of spray.

In "problem" orchards the use of lead arsenate-oil should be limited, if possible, to sprays against the first brood, since its use after this period rapidly builds up dangerous residues, very difficult of removal. *Injury to foliage will occur if oil follows sulfur too closely. Therefore, this combination should not be applied until about 2 weeks after a sulfur spray.*

One quart of summer oil per 100 gallons may be used as a sticker to "fix" the lead arsenate to fruit and foliage. It is more effective than other stickers that have been tried to date. Three quarts per 100 gallons have a definite ovicidal effect, and when such a spray is applied just before a peak of egg hatching, excellent results are obtained.

Lead Arsenate Substitutes

When the problem of arsenical residue came into the foreground there developed an immediate interest in arsenical substitutes. It would be useless to list the materials that have been tried in the hope that they might replace lead arsenate, since almost all of these have been failures. Only those that have given some encouraging results and have been well tested will be discussed.

Non-lead Arsenicals.—In areas where there is no third brood of codling moth and where the infestation is not severe, non-lead arsenicals, the chief of which are calcium arsenate and zinc arsenate, may be use to good advantage in midsummer spraying. If these materials are substituted they should be used at the recommendations given, and 8 pounds of lime should be added per 100 gallons of spray.

In tests covering a number of years, calcium arsenate has been found to be about equal in worm control to zinc arsenate. However, if the season is cool and damp, calcium arsenate has shown a decided tendency to burn foliage. This injury is offset largely by the use of lime as previously noted, but even so, some late defoliation may result. Zinc sulfate has not been tested as an additional safety agent where calcium arsenate is used. The use of zinc arsenate has not been attended by injury. Attempts to increase the efficiency of calcium and zinc arsenates by adding stickers, such as soap, oil, and soybean flour, have not been successful due to the increase in foliage injury that has occurred in some seasons.

Oil-Nicotine.—Experiments and practical use have clearly demonstrated the value of oil-nicotine in codling moth control. This combination leaves no harmful residue, but if applied too soon after lead arsenate, the latter may be "sealed" on the fruit by the action of the oil. For a short time after application it is very toxic to insects; hence, the more

numerous the applications, the more effective it becomes, especially in preventing unsightly codling moth stings. Although certain varieties of apples are occasionally spotted by summer oil it usually leaves the fruit with good finish and free from objectionable residue.

The use of oil-nicotine against second and third brood worms should be seriously considered in "problem" orchards by growers not prepared to wash. On the other hand, the material is expensive and is difficult to combine with a satisfactory fungicide. The formula suggested under Ohio conditions is: summer oil 3 quarts, to which is added either nicotine sulfate ¾ pint or fixed nicotine (14 per cent) 1½ pounds, to make 100 gallons of spray. Sulfur fungicide *cannot* be combined with this. Neither should the oil-nicotine combination immediately follow a sulfur fungicide application until two weeks have elapsed, or vice versa.

Materials Not Recommended

Under Ohio conditions the following materials are *not* recommended for use in the orchard against codling moth: natural cryolite, synthetic cryolite, barium fluosilicate, pyrethrum, derris or rotenone, xanthone, and phenothiazine. Likewise, summer oils are not recommended unless fortified with lead arsenate, or nicotine.

Suggestions Concerning Spray Practices

PROTECTING THE FRUIT

The Problem of Spray Residue

Where apple trees are thoroughly sprayed with one or more applications of lead arsenate after July 1, the amount of residue may exceed the present tolerance. These tolerances as established by the Federal Security Administration in 1940 are: 0.05 grain of lead, 0.025 grain of arsenic trioxide (As_2O_3) and 0.01 grain of fluoride per pound of apples and pears. On other fruits and vegetables the maximum tolerance of lead allowed is 0.025, and of arsenic trioxide 0.01 grain per pound of product.

In orchards where the spray schedule requires the use of lead arsenate late in the season, the residue may be brought within the tolerance by washing the fruit in a weak solution of hydrochloric acid. For detailed information concerning the Removal of Spray Residue the reader is directed to Bulletin 584, Ohio Experiment Station, Wooster, O.

Cleaning the Fruit.—It has been demonstrated that apples having relatively heavy deposits of residue, frequently as much as 8 or 10 times the present tolerances, may be satisfactorily cleaned by washing in the flood type of washer. The flotation types of washers, while not

quite so efficient as the flood type, have generally been satisfactory under Ohio conditions.

The mechanical brush cleaners cannot be depended upon for the removal of more than 25 per cent of the total residue and are not recommended for this purpose.

Successful washers have not yet appeared on the market for the removal of residue from grapes that have been sprayed for the control of berry-moth. Until such washers have been developed, the grape spray schedule will of necessity have to be curtailed so as to enable the harvested fruit to be marketed with the least possible residue.

Spray and Weather Injury

Spray and weather injury may be very similar in appearance and frequently it is necessary to examine an unsprayed tree before the

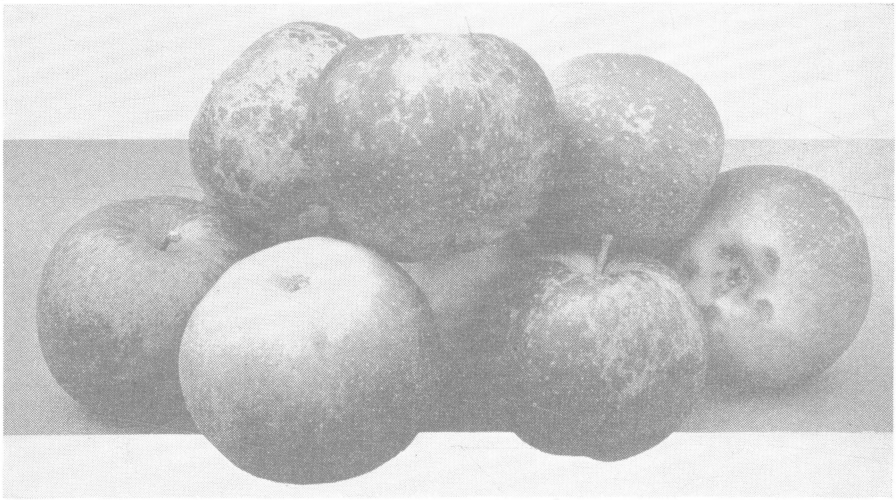

Fig. 30.—Fruit showing the effects of spray and weather injury.

correct amount of spray injury may be determined. Spray injury develops when improper materials have been used, or when the right materials have been applied in the wrong way, or when weather favors injury. Weather injury may result from exposures to extremes of temperature or moisture. Varieties vary greatly in their susceptibility to spray and weather injuries (see table, page 10).

Trees lacking vigor are injured frequently by spray and weather conditions, whereas vigorous trees would not be affected so easily. Similarly, foliage that has been injured previously by insects, diseases, hail or wind whipping, is more susceptible to spray injury than healthy foliage. Accordingly, orchards which are maintained in a

healthy condition are injured less frequently by spray materials or adverse weather conditions.

Bordeaux Injury.—Bordeaux mixture sprays on apples may injure the fruit in the form of russeting. Varieties such as Grimes, Golden Delicious, Jonathan, Baldwin, Ben Davis, Gano, and Ensee are very susceptible to russet injury. Other varieties such as Rome, Gallia Beauty, Delicious, Northwestern Greening, Duchess, and Wealthy are comparatively resistant to russet injury. Applications of bordeaux in the pre-blossom, petal-fall and 10-day sprays cause the most russeting, and the chances for russeting continue until about six weeks after petal-fall. Bordeaux injury is increased by the slow drying of sprays, and cool, wet weather with high relative humidity. The safest time to spray is when trees are dry and the weather favors quick drying of the spray material on the trees. High temperatures do not induce bordeaux injury, but tend to reduce it.

Bordeaux injures apple foliage by causing yellowing of the leaves and in many cases premature defoliation. This injury is reduced by using a weak bordeaux such as 2-4-100. Stronger bordeaux should not be used unless needed for control of such diseases as bitter rot.

Lime-Sulfur Injury.—The results of each new research on lime sulfur injury seems to narrow further its range of safety. It is well known that it will burn both foliage and small apples if the spray is applied during very hot weather, or in strong concentrations, or under weather conditions resulting in slow drying of sprays. This visible injury is manifest by edge burning, crimping, deforming and scalding of the leaves. It often causes dwarfing, both during the early stages and later. This reduces leaf area, affects the proper growth of the fruit, and impairs finish and quality. Foliage dwarfing and crimping also result from low temperatures in early stages of leaf development. This is similar to lime-sulfur injury, and is often confused with it.

During recent years it has been shown that even very dilute lime-sulfur sprays markedly reduce the photosynthetic activity or food manufacturing ability of apple leaves. This reduction was found to be as much as 40 per cent under controlled conditions. Generally older trees are affected much more than trees 10 to 15 years of age.

Lime-sulfur, either liquid or dry, is not safe for the summer spraying of peach trees. Materials less likely to burn are recommended in the peach spray program.

Arsenical Injury.—Peaches are very susceptible to arsenical injury when lead arsenate is used alone or combined with sulfur fungicides. The leaves are damaged in two ways: (1) They may show many small injured areas, giving a "shot hole" appearance, or (2) they may turn yellow and drop prematurely, or both. Frequently, tender growing peach twigs are injured in spots where the spray material has accumulated. As the wood ages, scaly bark may develop from this injury. While the fruit is not often directly injured, the damage to

foliage may so seriously reduce the manufacture of food that the fruit will be small, of poor color and quality, and may drop prematurely.

To prevent arsenical injury on peaches use the minimum number of lead arsenate applications, and not any more lead arsenate than recommended in the peach spray program (page 15). One application of lead arsenate, combined with zinc sulfate and lime is sufficient for curculio control in most orchards.

Apple foliage and fruit may be injured by arsenical sprays. The damage to the foliage may be manifest in two ways. The first and more noticeable type is marginal foliage burning, which probably is the result of heavy concentrations of spray materials which collect at the tips and margins of leaves. The second type of injury is a yellowing of the foliage, which may be caused by the absorption of the arsenic by the leaf or by injury to the petiole. In extreme cases of burning the damage may amount to almost total defoliation.

Arsenical injury to the fruit is usually expressed by a blackened area around the calyx end (Fig. 31), which later becomes sunken. Secondary rot infections of the fruit may follow such injuries.

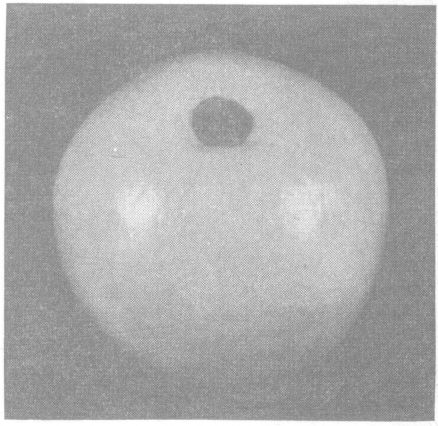

Fig. 31.—Injury caused by arsenical spray.

Arsenical burning on apples is largely prevented by the addition of excess lime, or zinc sulfate and lime, to the lead arsenate, lime-sulfur combination. While present evidence indicates that excess lime tends to decrease the efficiency of both the fungicide and the arsenical, the finish of fruit is improved when excess lime is added.

Recently zinc sulfate in combination with lime has been used with good success in apple spraying. Extensive field tests have shown that 1 pound of zinc sulfate per 100 gallons of spray will correct arsenical injury and prevent damage by black rot, or frog-eye. Practically all varieties have responded favorably to this treatment. It is, therefore, recommended that growers, who are having foliage difficulties due to an extensive program of arsenical sprays, use zinc sulfate at the above rate as a corrective. It should not be introduced into the spray schedule before the second cover spray, but from this time on may be included up to the first week in August.

In mixing, the zinc sulfate should be added to a small quantity of water in the tank and this followed by the lime with the sprayer running. Other materials should then follow; the lead arsenate being the last ingredient placed in the tank.

Mechanical Injuries.—Mechanical injury to the foliage and fruit comes from the improper use of spray equipment, poor break-up of the liquid, coarse particles in the spray material, and drenching of the foliage. It appears in the form of russeted fruit, dwarfed or torn leaves, and in part accounts for the lack of finish and quality of fruit in many orchards. Prevention of these injuries may be secured by following the recommended spraying methods.

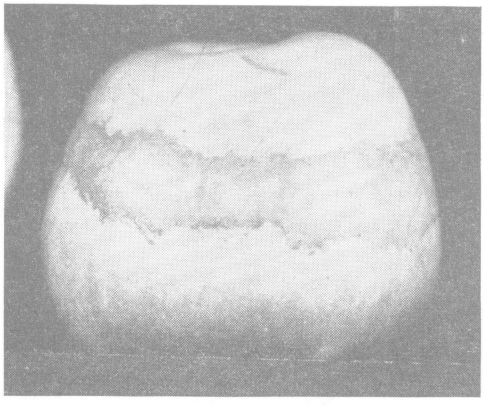

Fig. 32.—Russet ring caused by frost, when apple was very small.

Weather Injury. — Weather injury to fruit and foliage is often confused with spray injury. Low temperatures and frosts during the blossoming period and early part of the growing season may cause varying amounts and kinds of russet injury. Often this injury takes the form of a belt of russet around the apple (see Fig. 32).

Leaves may be injured by frost so that dwarfing and crimping develops, and, when severely injured, blisters may develop on the under surfaces. Leaves so injured often turn yellow and drop prematurely.

Extremely hot weather sometimes causes sunburn on the fruit. This is manifested by a discoloration and in extreme cases by a blistering and cracking of the skin on the exposed area. Very hot weather may also cause a bronzing of the red tones and a whitening of the green color tones of the fruit.

Use of Proper Lime Important in Preventing Spray Injury

Lime is used in summer sprays solely for the prevention of spray injury. It has no other effect, except possibly as a guide to the spray operator to see when the foliage is thoroughly covered. During recent years the problem of selecting a suitable spray lime has been greatly simplified. Freshly manufactured hydrated lime is the only form now recommended for spraying.

Hydrated lime has several characteristics which the grower should investigate before buying. First, it should be free from grit and so finely divided that 99 per cent of the particles will pass through a 325-mesh sieve; all should pass through a 300-mesh. Second, the lime should be freshly hydrated before it is shipped. Lime kept over 90 days should not be used for spraying purposes. Such lime may be added to the soil. A supply of spray lime purchased in the spring will be satisfactory for that season.

Use of Spreaders

Extensive data taken in many experiments show that very little is gained by the use of spreaders in tree sprays. Spreaders usually make the sprayed tree look somewhat better in that the spray coat is more even. They are reported to make a given amount of spray cover more trees, but this gain is usually offset by the additional cost of the spreader.

In almost all instances spreaders are not to be recommended, except for grapes, where either a soap or a commercial spreader has proved valuable for the control of berry-moth.

AMOUNT OF SPRAY REQUIRED FOR COVERAGE

The amount of spray solution required to properly spray a tree of a given size depends upon a number of variable factors, such as: type of gun or nozzle, volume and pressure developed by the spray pump, velocity and direction of the wind, type of pruning practiced, and the nature and abundance of diseases and insects; more than anything else, however, it depends on the judgment of the individual operating the rod or gun. To spray until a tree drips is not a safe guide to follow. Such a rule may lead to wastefulness, but more often to inadequately spraying a tree.

Growers are cautioned when changing from one type of discharge nozzle to another or from one rate of pressure or volume to either a higher or lower to make sure that they are securing proper coverage.

Records of spray solution required in the Experiment Station orchards have been kept over a long period of years. During this time the spraying was done under the direction of the same man. The sprayers used have been of moderate capacity ranging from 15 to 35 gallons per minute, and carrying pressures of 375 pounds or more. In these orchards trees less than 12 years of age were pruned in such a manner as to leave them moderately dense, while the trees of full bearing age were more openly pruned.

The data submitted in the tables following are taken from the spraying records in those orchards. The amounts of material per tree

Gallons of Spray Solution Applied per Tree (Wooster)

Age of Trees	Average Amount per Application for Season, in Gallons			
	Apples	Peaches	Cherries, Sour	Cherries, Sweet
2 to 3 years	.5	.7		
5 years	1.5	3.0		
10 years	6.0	5.4		
12 years	8.0			
15 to 20 years	12 to 18		7	10
21 to 35 years	18 to 35			

used at Wooster have at all times corresponded very closely with the amounts used in the orchards of the various sub-stations and county experiment farms. The figures given are not intended as arbitrary recommendations to be followed in every case, but suggestive of the amounts found necessary for good results under the conditions previously mentioned.

Seasonal Distribution of Spray Solution

The seasonal distribution of the amount of spray solution used in two of the apple orchards at the Experiment Station for a 3-year period is shown in the accompanying table. One orchard was planted in 1915 and the other in 1922.

Percentage of Total Distribution of Spray Solution Per Year Over a 3-Year Period

	Period	1941		1940		1939	
		Age of Trees		Age of Trees		Age of Trees	
		26 yrs.	19 yrs.	25 yrs.	18 yrs.	24 yrs.	17 yrs.
Pre-bloom	Dormant	12	11	10	11	9	10
	Pre-bloom 1	11	13	10	12	11	11
	Pre-bloom 2	11	12	10	11	11	11
	Pre-bloom 3	11	14	11	11	11	10
	Before bloom, per cent	45	50	41	45	42	42
After Bloom	Calyx cup	13	14	14	14	13	14
	First cover	14	12	15	13	15	15
	Second cover	14	12	15	14	15	14
	Third cover	14	12	15	14	15	15
	After bloom, per cent	55	50	59	55	58	58

Estimate of Materials for Season

In ordering materials for any season, the first consideration should be to determine as nearly as possible the program to be followed, especially during the early part of the year—the number of sprays, the materials to be used, and the dilution. Then, by using the amounts applied per tree as shown in the table on page 41, it is relatively easy to calculate the amount of material needed to spray a given number of trees.

Custom Spraying

In communities having many small orchards and vineyards the spraying with small individually owned rigs often results in unsatisfactory pest control. Large type truck mounted, or tractor pulled spray rigs owned by a commercial sprayer, who knows how to spray properly, will service many orchards and result in improved market quality of the fruit in the community.

DEFINITE PROCEDURE IN SPRAYING

Methods of Spray Application

The most important factor in getting a spraying job well done is the sprayman himself. He must start each needed application on time, finish on time, and use equipment and methods skillfully so that each tree is thoroughly sprayed inside and out, top to bottom, with finely broken spray fog, applied to give safe, uniform coverage. There is no substitute for a skillful, alert, thorough working sprayman.

It is relatively easy to get a good spray job with small trees. With trees about 15 feet, the tops, and especially the top centers, are difficult to cover. With trees 20 feet or higher it is rare to find a sprayman giving thorough coverage to the upper third and top center of the trees. Scab and worms too often tell the sad story of failure to spray thoroughly the upper third of the tree.

"Skimpy gallonage" is responsible for most spraying failures. The top central third of mature trees, the "pest nest," requires special attention. After most so-called thorough spray applications the "top" often carries a third less spray material than the "bottom." Special top-off sprays may be needed during critical periods of scab and codling moth control to equalize gallonage applied to the tops with the coverage on the lower half of the tree. Apples may double their surface area every week soon after fruit has set, and applications spaced no more than a week apart during the first month after petal-fall are often needed to build up effective spray barriers where codling moth is a problem. Varieties that increase rapidly in size early in the season, such as Delicious, Rome, and Greening, need more frequent coverage than varieties growing more slowly as Grimes, Jonathan, or Winesap.

Multiple cluster nozzles or fog drive brooms may not place enough spray material in the tops, which can often be covered best with single or double nozzle spray guns. A tower on the rig is often needed to get a good job on tree tops when spraying from a moving machine. Lower the tops of any trees too tall to spray thoroughly. Prune away underhanging branches and thin out any dense areas to permit thorough application of sprays, especially where large capacity rigs are used and sprays applied to the outside of the trees only.

Spray fog must be driven over the tops of mature trees to cover the top center. To secure this the sprayman must carry the up-stroke high enough to see the top of the tree below the spray fog drive. Timely, speedy applications directed from the outside to cover the upper surfaces of expanding leaves and blossoms is most needed in early season scab sprays. For control of such pests as codling moth, bitter rot, Brooks fruit spot and blotch, the cover sprays applied when trees are in full leaf and relatively dense should be applied all around the apples. This often necessitates supplementing usual outside spraying with spraying from the ground underneath the branches, directing

spray fog out and up at all angles to cover thoroughly all surfaces of fruit in the interior of the tree.

Cover sprays cannot be applied uniformly unless the sprayman stands under the center of the tree and applies one-third or more of the gallonage from the inside out with sufficient time and emphasis directed at the top central third of the tree. Pruning away of inside underhanging limbs and cutting convenient pie-shaped "walk in" alleys on large trees allows the sprayman to get in and under trees easily and spray interiors thoroughly. Effective insect and disease control demands thorough timely coverage and the tree pattern must lend itself to permit quick thorough spraying (see Figs 33 and 34). Large trees with bushy interiors and branches hanging to the ground cannot be covered by any practical method of spraying.

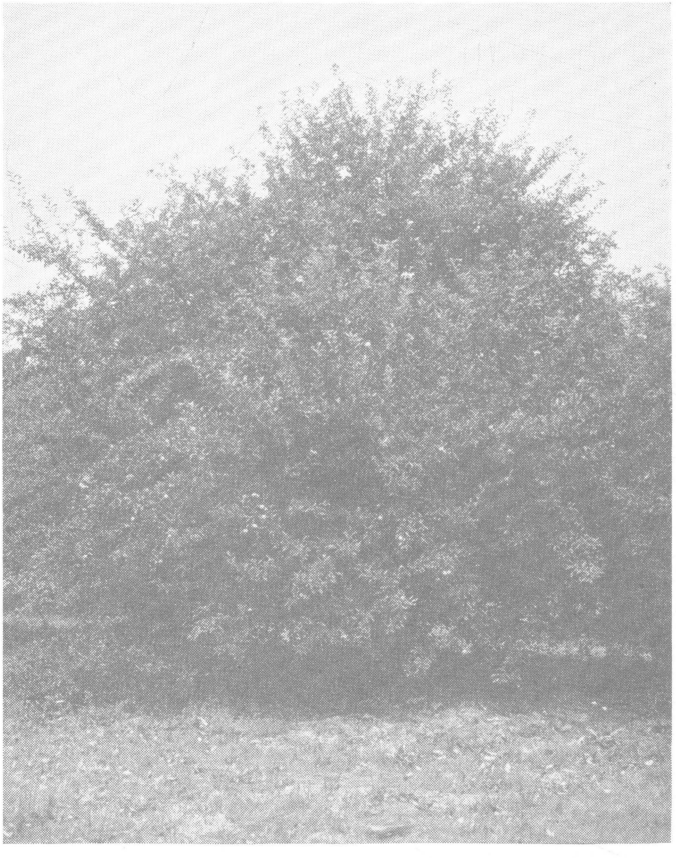

Fig. 33.—Too dense to spray thoroughly.

In spraying demonstrations conducted by the Extension Service, brown or black sponge rubber balls of 2- to 3-inch diameter, stuck on wire hooks, hung in different parts of typical trees and taken down for observation after the spray had dried, were found helpful in studying type of coverage actually secured in different parts of the tree from the different methods and combinations of equipment. Any grower can use this convenient, inexpensive check-up to study the coverage he is getting in his own orchard.

With satisfactory working pressure, fog drive guns or brooms in good order have given no mechanical injury when fruit and foliage

were sprayed almost to the orifice of the nozzles. Single nozzle guns on the wide fog adjustment were usually found safe to within 3 to 5 feet of the nozzle, but when wide open to get distance or height were seldom safe closer than 10 to 15 feet from the nozzle. An alert sprayman with spray fog sense is absolutely necessary to operate single nozzle guns safely without risk from mechanical injury. Yet the single nozzle gun has its place when tall trees are sprayed from the ground, and for spraying the tops of tall trees from the tower on a portable sprayer.

The actual spray application methods used must be worked out to fit the needs of each orchard. The results will soon tell the grower whether the method he uses can be improved upon.

Spraying from the top of portable rigs where practicable is most convenient for the sprayman, and permits use of broom and gun combinations that take the capacity of the larger pumps, giving the sprayman more gallons per minute to handle than any other method. Yet it has marked disadvantages in working against wind, especially with fog drive brooms and over soft ground early in the season. Also it is often difficult to secure satisfactory penetration of spray from all angles and thoroughly spray the interior of the trees.

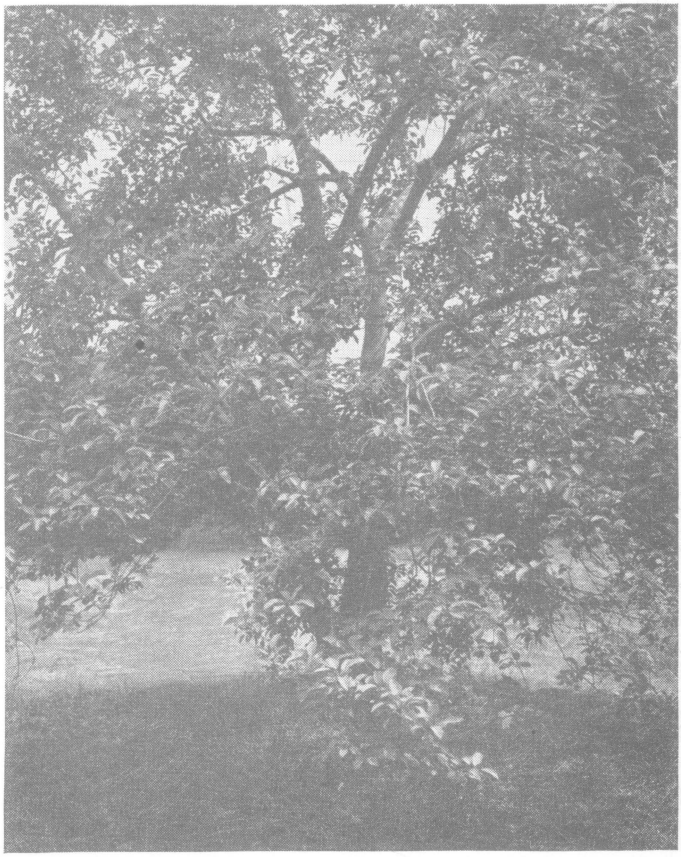

Fig. 34.—Properly pruned for spraying.

Tank spraying has given best results when it has been completed on time for control of such diseases as apple scab and cherry leaf spot, and has given less satisfactory results in the control of such troubles

as codling moth, scale, red mite, aphis, flea-weevil, bitter rot, Brooks fruit spot and blotch.

Combinations of tank and ground spraying are often effective. Excellent coverage of mature trees is being secured with ground spraying when guns of sufficient capacity are used for top spraying. This method is still widely used with many portable sprayers and with the stationary systems.

Many difficulties are encountered when growers insist on only "spraying with the wind," because often the orchard is not completely sprayed within the necessary time interval for best control of pests. Applications must be completed on time and methods employed that secure prompt complete coverage. Commercial apple orchards in Ohio should use equipment and methods that provide for a complete application in three days or less, especially for apple scab sprays. Occasionally a critical scab spray must be applied in about 24 hours' time for best control.

Selecting the Sprayer and Equipment

Size of Pump.—To determine size of spray pump for the job, figure gallonage requirements for one application (see table below) and secure pump with sufficient gallons per minute capacity to apply the spray solution in three working days or less. Keep in mind time needed to refill sprayer and allow for emergencies. Convenient water supplies, orchard filling stations, or hauling water to sprayer promotes the most efficient use of portable spray pumps. Stationary spray pump installations permit almost continuous use of spray pump capacity. Portable sprayers seldom deliver on the trees more than half the rated pump capacity in a day's time, due to delays and inefficiencies.

Select tanks for portable rigs as large as can be pulled to advantage to save time in refilling. With power take-off rigs, be sure sufficient reserve power is available in tractor above that necessary to pull filled sprayer over most difficult areas, to provide sufficient horsepower according to manufacturers' specifications to drive pump efficiently. The following table is roughly suggestive of pump sizes needed for various sized orchard requirements. In addition use spray pump manufacturers' suggestions on requirements.

Size of Pumps Needed for Given Quantities of Spray

Spray material required for one application	Pump size required in gallons per minute on portable rigs
Less than 500 gallons.....	Hand pumps
500 to 3000 gallons.....	Power pumps rated up to 10 gallons
3000 to 6000 gallons.....	Power pumps rated at 12-15 gallons
6000 to 10,000 gallons.....	Power pumps rated at 15-22 gallons
Above 10,000 gallons.....	Power pumps rated at 35 gallons or more according to need

Check up your pump occasionally to determine gallons per minute actually delivered through hose and nozzles. Spraying into a large

open head drum of 50-gallon capacity or larger for a given period, such as one minute, and measuring discharge with gauge stick previously notched in gallons, is helpful for check-up work. Time required to empty tank also tells you gallons per minute discharged. Many rigs, especially after some use, are found to deliver far less than the rated pump capacity, and need attention to valves, packing, leaks, etc. Sometimes restrictions in pipe lines, and size or condition of hose or fittings, or use of nozzles with too small disks prevent discharge of pump capacity. Keep your pump efficient.

Pressure.—Pressure at nozzles of 350 pounds or more on power rigs has given finest break-up of spray fog and most economical coverage. Pressure of 600 pounds or more gives splendid coverage. High pressures are limited only by added power costs and ability of hose and equipment to withstand the higher pressures. With fine fog break-up the higher pressures have given least mechanical injury and most satisfactory coverage for the gallons applied.

Many pressure gauges, especially the older ones, have been found inaccurate in the orchard. Over 60 per cent of the gauges checked at work in Ohio orchards registered incorrectly, often indicating 200 pounds or more pressure than was actually carried in the hose line. Some county agents have calibrated gauges to assist growers in checking their pressure gauges for accuracy, and adjusting pressure regulator to carry pressure desired.

Capacity of Spray Guns.—There is a place for both single guns and multiple fog-drive guns or brooms. Combinations of both are often effective, using the single gun for treetops and where thorough coverage with brooms is difficult or impossible.

Capacity of Single Nozzle Spray Guns in Gallons per Minute

Pounds pressure	Diameter of discs—Fraction of inch					
	3/64	5/64	3/32	7/64	1/8	11/64
300	1.1	2.4	2.7	4.3	5.6	9.4
400	1.2	2.7	3.0	4.8	6.3	10.9
500	1.3	3.0	3.3	5.3	7.0	12.3
600	1.4	3.2	3.5	5.7	7.7	13.6

Capacity of "Fog-Drive" Guns in Gallons per Minute

Total discharge capacities of fog-drive guns which are regularly equipped with discs with 4/64 inch diameter holes.

Pounds pressure	3 Nozzles	4 Nozzles	6 Nozzles	8 Nozzles
300	4.1	5.5	8.2	11.0
400	4.7	6.3	9.5	12.6
500	5.4	7.2	10.8	14.3
600	5.9	7.9	11.9	15.9

5/64 inch discs give ⅛ more capacity and 3/64 inch discs give ⅛ less capacity than is indicated in the above chart.

Since sprayers are purchased to put a needed number of gallons on your orchard in a given time, see that combinations of nozzles used permit efficient discharge of the rated capacity of your spray pump. See that the parts of nozzles that soon wear, such as discs and whirl plates, are replaced as necessary. Wornout nozzles and a disc too large for the eddy chamber of the nozzle result in coarse wasteful sprays.

For ground spraying, single or double nozzle guns and fog-drive brooms up to 6 nozzles can be used. Higher pressure pumps of large capacity are now permitting smaller, lighter hose for ground spraying, such as $\frac{3}{8}$-inch. It is not necessary to use larger than $\frac{1}{2}$-inch hose for ground spraying. The shortest length of hose for ground spraying should be 50 feet and many use up to 100 feet or more for hillside spraying and for stationary plant work. For tank spraying, hose should be as short as it is convenient to handle, and large enough to carry capacity of the fog-drive broom used. Usually short lengths of $\frac{3}{4}$-inch hose are used for tank spraying with brooms of 8 nozzles or more. A swivel that does not leak is a handy device to place between gun and hose to prevent twisting and kinking of the hose.

Water Supply System

A water supply system, set up so that the sprayer can be filled quickly and so that there will be only a short haul, is necessary. Locate supply tanks in the center of each 20-acre block of orchard. In most cases the water can be pumped at the source of supply into one tank, and piped from there by gravity to supply tanks located at convenient points. All tanks should be set up so that they serve as overhead filling stations with a large 2- to 4-inch discharge pipe equipped with a gate valve for quickly filling the sprayer. Such an arrangement greatly speeds up the work of spraying and, according to cost records at the Ohio Agricultural Experiment Station, reduces the cost materially.

Where a pond or stream is used as a water supply, a tank filler helps in filling the sprayer quickly. In some cases, supply wagons or trucks are used to haul water from the sources of supply to the sprayer. This requires extra teams or trucks, but is a method which probably enables the grower to secure the most efficient use of his sprayer.

Care of the Sprayer

The proper care of the sprayer does much to increase its useful life. At the end of each day's spraying, water should be pumped through the spray pump, hose, and nozzles to clean out all chemicals. At the close of the spraying season, the pump, hose, and all equipment should be thoroughly cleaned with water and drained. Then the hose, rods, and guns should be taken off the sprayer and looked over carefully, and any needed repairs made. Nozzles should be cleaned and oiled. The pump should be filled with oil and parts apt to corrode should be cleaned and coated with grease before the rig is put away for the winter.

Equipment for Night Spraying

High winds and occasionally high temperatures during the day often interfere with proper application of sprays and dusts. The time may be so limited that the equipment at hand is inadequate to cover the orchard in the required time, working only during the day. Since the wind actually dies down about nightfall, conditions at night are generally more favorable for spraying and dusting than during the day. However, on occasional nights the humidity is so high and the rate of drying of the spray so slow that the spray may not dry until morning. Under these conditions very severe burning and russeting of foliage and fruit may occur. Where spraying is done at night the operator should make certain that the spray is drying on the trees in a moderate length of time.

Night applications are limited to situations where the operator rides the moving spray tank or duster. In order to spray at night a light must be provided on the sprayer. A single electric headlight bulb attached to the top of a pole, elevated above the operator's head at about the center of the spray machine, has been found to give the most satisfactory lighting for night spraying. Electricity may be supplied by an ordinary storage battery, charged with an automobile generator operated by the sprayer engine or by the tractor drawing the sprayer.

Stationary Spray Plants

Stationary spray plants are rapidly gaining favor with many growers. With the stationary system, the spray solution is pumped from one central plant through pipes to all parts of the orchard. Only one power plant is needed. In a modified system the spray plant is portable and can be moved from one pipe system to another.

Some advantages of the stationary system are: (1) It eliminates use of wheeled trucks, and tractors, thereby preventing the compacting and subsequent eroding of the soil; (2) there is less wear and tear on machinery than where portable sprayers are used; (3) the cost of transporting liquid through the orchard is less through pipe line than by hauling; (4) it obviates loss of time in refilling portable tanks; (5) it allows the spraying to be done promptly, regardless of soil conditions; (6) all spraying must be done from the ground, which is conducive to a more thorough job of spray coverage.

Some disadvantages of the stationary system are: (1) High first cost of installation; (2) interference of pipe lines with other operations; (3) inability to spray at night; and (4) the harder physical labor involved in dragging a longer length of hose on the ground, than that of spraying from the top of a movable rig. With high pressure pumps and the use of lighter ⅜-inch hose this latter difficulty is greatly reduced. Further information may be obtained by sending for Ohio Agricultural Experiment Station Bulletin 572.

Dusting

Apples.—Dusting apples for controlling insects and diseases has been thoroughly tested in Ohio and has very limited application. It frequently will suffice when the orchard is coming into bearing, but in bearing orchards dusting of apples and pears is now limited to supplementary applications. A duster may be drawn through an orchard where mud interferes with the movement of a heavy sprayer. Also dusts can be applied for scab control during light rains when spray applications cannot be made. If a dusting program is followed for control of curculio and codling moth in a mature orchard, from five to seven post-blossom applications will be necessary in most seasons. Growers whose plantings are not extensive enough to justify the ownership of both a sprayer and duster would do well to place their dependence on spraying.

Other Fruits.—Dusting of peaches, plums, and sweet cherries for control of brown rot has produced good results and is a method highly recommended where the application is properly timed. An 80-10-10 sulfur-lime-lead arsenate dust, or, in the absence of fungus, 90-10 lime-lead arsenate dust is recommended for early applications where curculio control is important. For later applications a 90-10 sulfur-lime mixture is preferred.

Dusting of grapes has very limited application, and thus far is recommended only for leafhopper control where a nicotine spray cannot be applied. To be successful in dusting for grape leafhoppers, one should use calcium cyanide dust specially designed for this purpose. Owing to the danger of dusting with calcium cyanide, this should be done preferably by a commercial operator familiar with the method.

Troubles Combated by Methods Other Than Spraying

Fire Blight

Blight of blossoms, twigs, limbs, and fruits are all manifestations of the disease "fire blight." The bacteria causing fire blight over-winter in "hold-over" cankers on the trunk and limbs which result from the advance of the bacteria from infected twigs, spurs, suckers, and sprouts.

A preventive spray of 2-6-100 bordeaux mixture at blossoming time has checked the spread of blossom blight. Usually this spray is applied when about three-fourths of the blossoms are open.

On apple the larger blighted branches and cankers should be cut out in the fall, or winter. If limbs should be saved, treat the cankers with the fire blight canker solution. Check closely for cankers on limbs and trunks that may have resulted from infected spurs, water sprouts, or shoots.

Fire Blight Canker Solution.—To 3 ounces of concentrated hydrochloric acid add 1 quart of hot water in an enamel kettle, and in this

mixture dissolve 9 pounds of dry zinc chloride powder. Commercial grades of chemicals are satisfactory for this solution. Add sufficient red or blue coloring, using a dye such as the Diamond brand, easily secured from local drug store, so that areas treated can be checked for thorough work. After cooling, pour the above solution into 7 pints of denatured alcohol and mix thoroughly.

Store in tightly stoppered large glass bottles or jugs to prevent evaporation. Apply with small paint brush.

When still small remove all spurs, shoots, suckers, and water sprouts from the crown, trunk, and large branches. This will tend to prevent cankers.

A soil management program involving sod and limited use of nitrogen fertilizers will aid greatly in checking fire blight. Excessive nitrogen fertilizers favor fire blight.

In the case of pear, removal of the blighted twigs, shoots, and spurs as soon as observed is the best method to prevent rapid spread of the bacteria into the larger branches and trunk. Following bloom, pear trees should be inspected every two or three days and blighted portions cut out. Cuts should be made at least 6 inches below the affected portion. The tools and cut portions should be disinfected with a solution made by dissolving two tablets of bichloride of mercury and two tablets of cyanide of mercury in one quart of water. A rag or sponge tied to the end of a stick makes a convenient swab for the larger pruning shears or saw. This mixture should be carried in a glass or wooden vessel. *It is extremely poisonous and should be kept out of the reach of children and livestock.*

A soil management program involving sod with inorganic nitrogen (never organic) added only in sufficient amounts to maintain moderate growth should be established. In establishing young orchards the intermediate stock Old Home should be purchased, and the desired variety grafted or budded on the branches 18 or more inches from the trunk.

Peach Canker

Peach canker is present in some Ohio peach orchards and sometimes has caused considerable injury. The disease is caused by a fungus which enters the trees through weakened or dead tissues, such as those caused by winter injury, or through pruning cuts which have not properly healed. Infection usually takes place in the fall and the fungus develops and injures the tree during the fall, winter, and early spring months. When tree growth starts in the spring, canker development is stopped and the injured area does not increase further until fall. Cankers may occur on the trunk or large branches, especially in crotches, and sometimes infection occurs on injured twigs, resulting in a die-back.

Sprays are of little or no value in controlling peach canker, but the following practices have been found to check the disease.

1. Train young trees carefully to avoid narrow, weak crotches.

2. Postpone pruning until very late winter or early spring, at which time all small branches showing canker and all dead wood should be removed.

3. Make pruning cuts close to branches to promote rapid healing. Large cuts should be protected with a good tree paint.

4. Clean out cankers in crotches and on large limbs during late May and June. Cut around cankered area to green, live bark, making the cuts clean at the sides and bringing them to a point at the top and bottom. Paint the wounds with a water-asphaltum-emulsion tree paint in which bichloride of mercury has been dissolved at the rate of 1 to 500 (two 1-gram tablets containing 50 per cent of bichloride of mercury in 1 pint of asphaltum-emulsion paint makes the desired strength).

5. Sow a cover crop in the orchard as early as possible to promote proper wood maturity. In young non-bearing orchards the cover crop should be sown as soon as possible after July 1. In bearing orchards sowing of the cover crop can be delayed until about August 1. In any case it is inadvisable to work the ground deeply after this time.

6. Avoid the use of too much nitrogen, especially in young orchards or when the trees are not bearing a crop.

Cedar Rust

Cedar rust has become increasingly prevalent on Rome Beauties in southern Ohio. This is a disease that varies a great deal from season to season, and from locality to locality (see Fig. 35).

Spores, which infect apple trees, are produced on the cedar trees during rainy periods and are blown by the wind to apple trees, where they cause infection on the leaves and fruit. Records have been obtained where cedar rust spores have been blown for a distance of 5 miles and produced infection. However, severe infection usually is not accomplished unless the cedar trees are within 3 miles of the orchard. Infection will be more severe when the cedar trees are located near the orchards.

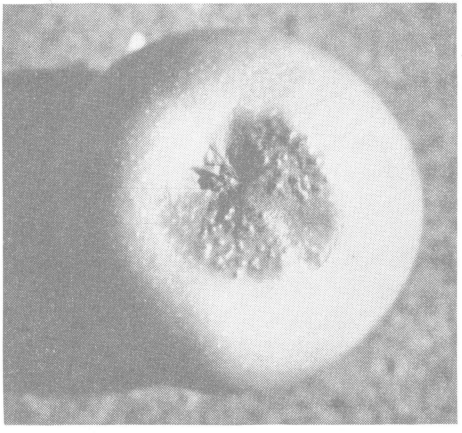

Fig. 35.—Cedar rust.

Varietal susceptibility varies greatly, as indicated in the chart on page 10. Rome Beauty, Jonathan, and Delicious are some of the more susceptible varieties grown in southern Ohio.

This disease is difficult and expensive to control by spraying. If the cedar trees are removed the disease is no longer a factor.

Codling Moth

Reducing Losses with Chemically Treated Tree Bands

In orchards where codling moth is a serious problem, growers have found chemically treated tree bands a valuable aid in reducing the worm population. These bands consist of strips of single faced corrugated paper, cut 2 inches wide, and which have been dipped in a solution of beta-naphthol dissolved in oil. This results in the paper taking up much of the chemical which is toxic to insect larvae, but does not harm the mature tree.

Young trees with smooth bark should not be banded.

When old trees are banded, the trunk and lower limbs are scraped to remove all loose bark. This scraping should extend up about 10 feet. A special tool for scraping, such as a box scraper, or even a short handled hoe is desirable.

The chemically treated band is then wound tightly around the tree trunk and fastened with large headed roofing nails or special wire staples (see Fig. 36). Care must be taken to fit the band into the depressions of the trunk.

The bands should be applied just before the larvae of the first brood leave the apples. It is these worms that must be killed before they transform to moths. The bands should be in place in southern Ohio by June 1, in central Ohio by June 8, and in northern Ohio by June 15. Since the bands, when applied, slowly lose their toxicity, they should not be made up or placed on the trees long before the above dates.

Fig. 36.—Chemically treated band on tree trunk kills the larvae which go under it to transform.

When the larvae, after leaving the apple, search for a place to spin their cocoons, they find the paper band and spin up in the corrugations and in the grooves of the paper held tightly against the tree (see

Fig. 37. If the bands are properly made, the worms will be killed during June or July within a few days after they go under them. By autumn the bands have lost much of their toxicity and do not kill all of the larvae. These, however, are affected by the chemical and usually die during hibernation. The bands are serviceable only for one season, and should be taken off the trees early in December and burned. The cost of scraping and banding including labor averages about 20c per mature tree.

It is estimated that on a well scraped tree the bands catch from 50 to 70 per cent of the worms which leave the apples. Their use should make it much easier to control with sprays, though the bands do not make it possible to eliminate any sprays. They are recommended only in orchards where the spray program has failed to control the codling moth satisfactorily.

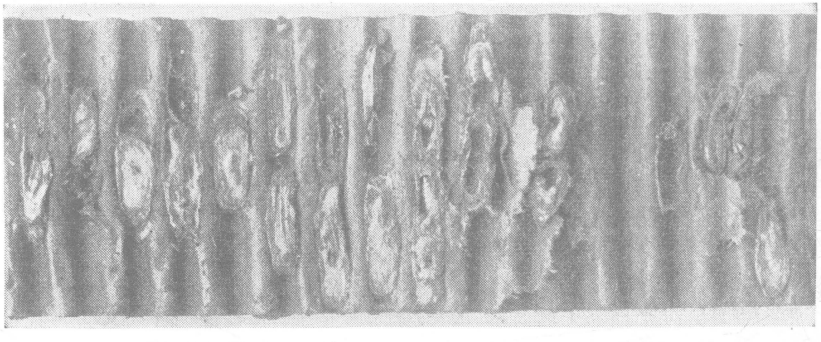

Fig. 37.—Codling moth cocoons under corrugated paper band.

Reducing Losses by Orchard and Packing House Sanitation

Orchard sanitation is important as a method of reducing codling moth losses. This includes: (a) elimination of hibernating places such as piles of wood, cut trees, or other debris on the ground, and (b) the prompt disposal of wormy apples. While a sod mulch or cover crop is not utilized freely as a cocooning place, a mulch consisting of cornstalks, wood shavings, or coarse weeds will shelter many transforming larvae.

Thinning operations afford an opportunity to remove from the orchard apples containing first brood larvae. Prompt gathering of worm infested dropped apples and burying them or otherwise disposing of the same, prevent these worms from adding to the over-wintering population.

Packing house sanitation is very important in orchards where the codling moth is a serious problem. The larvae leave the apples soon after placed in the packing house or storage rooms, and crawl into cracks and crevices and into joints of the apple crates. These moths, if allowed to escape, would cause worm-infested fruit within several tree rows of the packing house.

Packing houses and rooms where picking crates are stored should be tightly screened or otherwise kept closed during early summer to prevent the escape of the moths.

Protecting Against Climbing Cutworms

Opening buds of grapes and newly expanded leaves and blossom buds of apple are often devoured in April or early May by climbing cutworms. These feed only at night, and hide under trash on the soil during the day. Unless the grower is keeping close watch, many fruit buds may be devoured, or even an entire crop of grapes destroyed, before the presence of the insect is discovered (see Fig. 38).

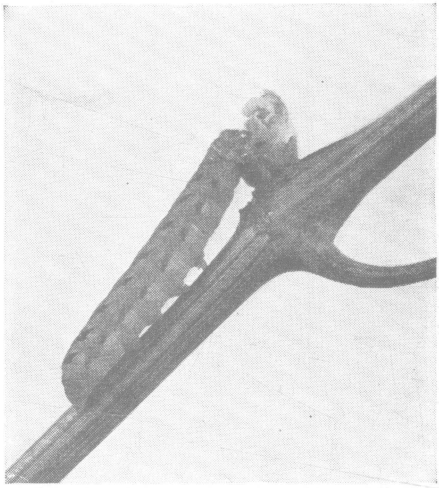

Fig. 38.—The climbing cutworm feeding on grape bud.

Application of a narrow band of sticky tree-tanglefoot on the trunks of fruit trees, and beneath the bottom wire on grape canes and posts in vineyards, will put a stop to this damage. The application should be made as soon as the worms are discovered. They are unable to cross such a band to reach the succulent buds. Many can be killed by scattering poisoned bran mash bait on the ground. The poisoned bait is dependable only where tanglefoot has been previously applied to prevent their ascent.

While applications of lead arsenate in the pre-blossom spray on apples fails to control, it has been observed that spraying with fluorine spray, as given for apple flea weevil (on page 12), is a satisfactory method.

Apple Tree Borers

Infestations of the round-headed apple tree borer must be attacked with reference to the percentage of trees infested. If no more than 5 per cent are being injured, mound all trees and cut out borers in September of each year. If up to 15 per cent are being attacked, wrap the trunks of the trees to a height of 18 inches with stout paper in early June. Put clean earth around the base of each wrapped tree so that borers can not get to the trunk below the paper. Remove wraps in September.

If more than 15 per cent are attacked wrap and spray the trees in early June and spray again in early July with lead arsenate 3 pounds,

lime 3 pounds, water 100 gallons to combat the adult beetle found on the leaves. Inspect young trees each autumn for borer damage.

Tarnished Plant Bugs and Stink Bugs

These sucking plant bugs deform young peaches and to some extent other fruits during the summer. The injury to peaches is shown in Figs. 39 and 40.

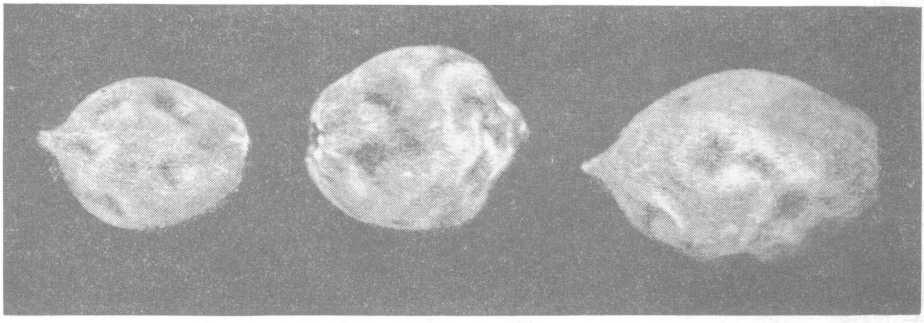

Fig. 39.—Peaches injured in June by the tarnished plant bug, which came from undergrowth beneath the trees.

The control of these pests is one of prevention. The most effective measures consist of the elimination of such cover crops as alfalfa and sweet clover from the orchard and its vicinity; also by reducing as far as possible the amount of weed growth, or tall grass, in the orchard both beneath and between the trees. The alert grower may detect the presence of the bugs in time to derive some benefit by the use of a strong contact spray such as nicotine sulfate or pyrethrum, correctly timed to strike the insects. The expense of materials and difficulty of timing such contact sprays make their use of questionable value.

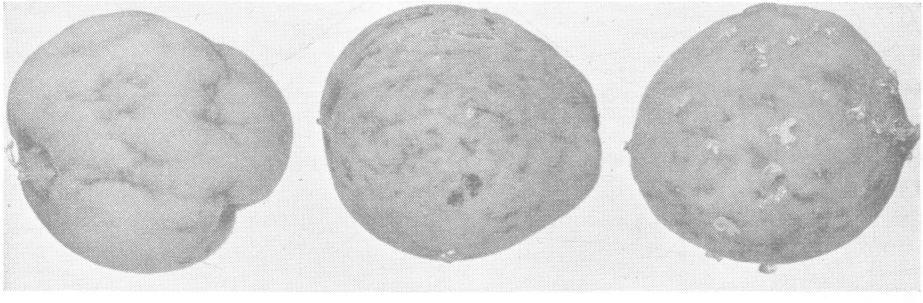

Fig. 40.—Peaches injured by the green soldier bug, or "stink bug."

Paradichlorobenzene

This chemical, sometimes called P. D. B., Paracide, and by other trade names as well, is now widely used to control the peach tree borer located at or just beneath the ground surface. This material is sold as fine granulated crystals.

Directions for Using Crystal-ring Method.—One ounce of the chemical is advised for treating a full grown tree and from ½ to ¾ ounce on trees from three to five years old, depending upon the size of the trees. Not more than 1½ ounces should be used in any case. Trees less than three years of age can be treated only with the risk of some injury by the chemical. Where borers are present in young trees, lack of treatment will probably result in losses far in excess of any caused by the chemical.

1.—Apply in the latter half of September or early October when the soil is dry. This will kill the borers while young, and after all eggs are hatched. The temperature of the soil at time of application should be above 55° F. for best results. If fall treatment has not been made and the life of the tree is threatened, a spring application can be made as soon as the soil temperature becomes high enough. This is usually about May 15. At lower temperatures, the ethylene dichloride emulsion treatment is preferred.

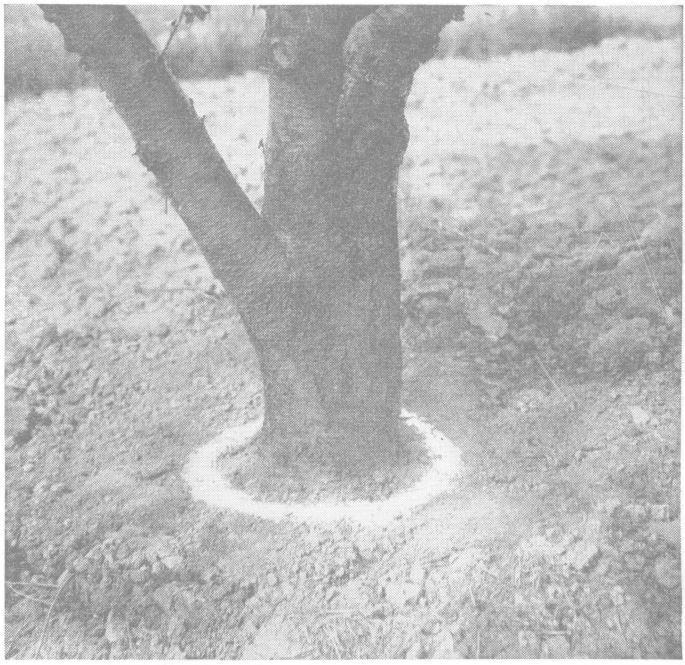

Fig. 41.—Paradichlorobenzene properly applied around base of tree, 2 inches from the trunk. Cover the chemical about 3 inches deep with a cone of earth, mounded against tree to confine gas in soil about channels of borers.

2.—Clear off the trash about the base of the tree for a distance of

6 inches from the trunk. Do not dig into the surface crust more than necessary. If considerable gum is present about the base of the tree, remove this before treating. Have the soil surface level with the highest point of gum exudation, and if necessary build up the dirt to this point. The gas given off by the chemical is heavier than air and is most effective below the point of application.

3.—The crystals of paradichlorobenzene are then evenly distributed in a narrow, continuous circular band on the soil about the tree. Place this ring about 2 inches from the trunk. Have the band about 1 inch wide, and none of it closer than 1 inch to the trunk (or large roots), otherwise injury to the tree might result (see Fig. 41).

4.—Place several shovels of soil (free from trash) over the ring of chemical. Pour the first shovelfuls of fine soil carefully against the base of the tree. Cover chemical about 3 inches deep with a cone of earth. Compact this with the back of the shovel or with the foot.

5.—*Airing.*—Three to four weeks after application, remove the mound of earth from the base of trees younger than four years. If the soil has been wet, wait from five to six weeks before uncovering. This is a precaution against possible injury to young trees. It is not necessary to remove the mounds from older trees. However, these mounds of earth should be leveled off in the spring.

A method has been developed recently whereby the paradichlorobenzene is dissolved in cottonseed oil and the solution sprayed in the correct amount directly on the soil around the base of the tree. This method has been tested and results obtained are comparable to those secured by the crystalline method. However, it possesses no advantages over the use of ethylene dichloride emulsion and is slightly more expensive.

Ethylene Dichloride Emulsion

Experiments conducted in several states have shown that ethylene dichloride emulsion is more effective at low temperatures than are paradichlorobenzene crystals. It is prepared by mixing ethylene dichloride and fish oil soap and then diluting with water.

This emulsion is now available commercially and ready to be applied to trees after the required amount of water is added.

The emulsion is applied by spraying or pouring the material on the base of the tree and on the soil immediately surrounding the trunk. Cupping the soil may be necessary to prevent run-off of liquid. The quantity to be applied should be regulated rather carefully.

Different strengths and different amounts of the emulsion are required for trees of different age. The recommendations of the U. S. Department of Agriculture are as follows: For 1-year-old trees, ⅛ pint of 7½ per cent emulsion; for 2-year-old trees, ¼ pint of 15% emulsion; for 3-year-old trees, ½ pint of 15% emulsion; and for average sized, mature trees, ½ pint 25% emulsion.

Methods of preparing the soil and mounding after treatment are the same as those employed in the use of paradichlorobenzene crystals.

There is little advantage gained by the use of this material provided the soil temperature is above 55° F. In treatments made late in the season, after cool weather arrives, and as an emergency in the spring before the soil becomes warm, this material has given a better kill, than paradichlorobenzene crystals.

While many peach growers in Ohio have used this method to their entire satisfaction over a period of 3 years, some loss of trees caused by this chemical occurred in at least two Ohio orchards following application in April, 1941. In Michigan many trees were lost due to its use in the fall of 1940 and spring of 1941. Until more is known about the reason for this injury in certain seasons, the use of ethylene dichloride emulsion had better be restricted to late fall and *early* spring applications, where paradichlorobenzene had not been applied and where loss from borer injury would be serious before the regular fall treatment with that chemical could be made. Under no circumstances should the ethylene dichloride emulsion be applied when the temperature is exceedingly high.

Fig. 42.—Work of the lesser peach tree borer in old pruning scars. (For control of this species see page 60.). This borer must not be confused with the peach tree borer.

Lesser Peach-tree Borers Located on Trunk and Larger Limbs

Fumigating with dry paradichlorobenzene crystals is not possible for controlling the lesser peach borer, which works entirely above ground on trunk and older limbs (see Fig. 42). Considerable gum exudation is always found at points of larval feeding, which appear at abrasions on the trunk and in the crotches of the older limbs. Control consists of painting these wounds with crude cottonseed oil in which paradichlorobenzene is dissolved. The cost will amount to less than 1 cent per tree. Painting with ethylene dichloride emulsion is not effective. Under no circumstances should the entire trunk or limb be painted.

Directions for Preparing and Applying Paint.—To prepare the mixture, dissolve 1 pound of paradichlorobenzene crystals in 2 quarts of crude cottonseed oil, previously warmed. Apply this mixture with a paint brush so that the bark is covered well beyond the edges of borer indications. Apply only to the area of the wound. Removal of gum, frass, or loose bark from the infested areas is not necessary.

There has been no discernible injury to peach trees so treated, except where the paint has been sprayed or painted over more of the surface than necessary. The application should be made during mild weather the latter half of April or early in October. At this time of year the work of borers is easily visible. Inspection will reveal dead borers a few days after treatment.

It is preferable to use freshly prepared material. If the mixture is stored for a few days, place it in an airtight container. Linseed oil can be used instead of raw cottonseed oil, but it is not so easy to apply, being thicker and more sticky.

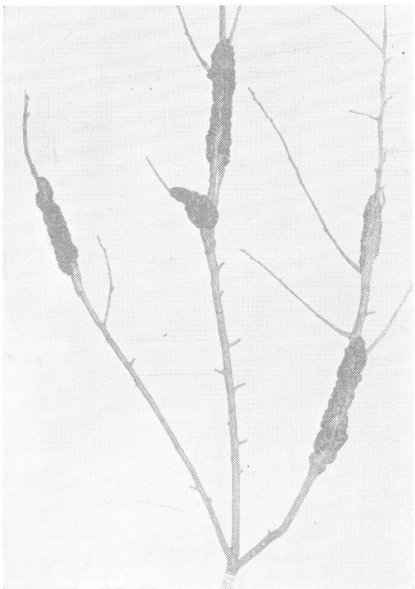

Fig. 43.—Black knot of plum.

Black Knot

Black knot occurs on both wild and cultivated forms of plum and cherry trees. This disease is caused by a fungus, and spores are produced during April, May, and June on the knots formed on twigs and branches (see Fig. 43).

Control is obtained by pruning out the knots in the winter and making the cut about 4 inches below the base of the visible swelling.

A second inspection should be made in May and new swellings should be cut out. All pruned wood should be burned immediately.

RODENT CONTROL IN ORCHARDS

The damage done in orchards by such animals as meadow mice, pine mice, and rabbits is extremely costly to many a grower. Much of this damage may be prevented by the use of inexpensive control methods and variations in cultural practices.

MOUSE CONTROL

The mice which cause most of the damage in all but the southern part of Ohio are the meadow mice (*Microtus*) (Fig. 44, right). This small creature lives primarily on the surface of the ground, making trails under the cover of surface vegetation. Most of the damage is done by feeding on the bark around the trunk of the tree.

In southern Ohio, the most troublesome mice are the pine mice (*Pitymys*) (Fig. 44, left). These mice spend most of their lives below ground, and during certain months have a particular fondness for apple tree bark, which they eat from the roots.

Fig. 44.—*Left:* Pine mouse, small body, short tail, sunken eyes, burrows underground. *Right:* Meadow mouse, large body, long tail, prominent eyes, makes surface trails.

Trees may be partially protected from meadow mice by the use of ¼-mesh galvanized hardware cloth. However, during heavy snows, mice may tunnel through the snow and do damage above the wire guards. Also, during mild winters, mice may tunnel through the frost-free soil and do damage below the wire guards.

Keeping mulch and other vegetative material removed from around the tree base gives partial protection when there is no snow on the ground, because these mice seldom feed in the open. A clear space of approximately 18 inches should be made around the tree trunk. The use of cinders, slag, sand, etc., may be used to keep grass, etc., from growing in this area. If cinders or slag is used, caution should be taken to use well leached material, as fresh slag may cause injury to the tree.

These preventive methods give only partial control for meadow mice, but for pine mice there are no known cultural methods which prevent mouse damage. *The use of poisons is the most efficient and practical method to control mice and should supplement all other methods.*

The Rodent Control Division of the Fish and Wildlife Service, U. S. Department of the Interior, has developed a new control method which has been used in the east for several years but which was made available for the first time in Ohio during the fall of 1941. The poison material (rodenticide) in which zinc phosphide is incorporated is made available through the U. S. Fish and Wildlife Service and its cooperating agencies, which in the counties, is the County Agricultural Agent. The poison is used on fresh baits which are placed directly in active mouse runways and then covered with grass or similar material. The following directions are recommended:

Time of Application.—Poisoning in the fall, well carried out, usually makes poisoning in orchards at other seasons unnecessary. Where poisoning has not been carried out in the fall, or where follow-up work is required, emergency poison methods may become necessary at any season. Examine orchard during open periods in mid-winter to check on efficiency of fall control. Re-poison *if* and *where* necessary. Apple baits should not be used in late fall until drops have been gathered.

Bait.—Cut apples into ½-inch cubes. Firm, ripe varieties are preferred. One quart of cubes should make 100 baits. One man can expose about 5 quarts each morning. Expose only freshly cut baits.

Preparation.—The zinc-phosphide poison is supplied in a shaker top can which contains enough to prepare 10 quarts of bait. Place about 2 inches of cut apple bait in the bottom of an enamel pan. Sift rodenticide over the bait while stirring until an even light coating is obtained. The use of 1 level teaspoonful per quart of cut bait is sufficient.

Caution.—Trust the mixing only to responsible persons and wash all utensils after preparation is completed. Do not use bare hands in mixing or placing baits. A sharp stick is convenient to spear and place the baits.

Exposure in Orchards.—Fresh apple bait must be placed directly in mouse trails UNDER COVER of mulch, or in burrows that enter the ground. Select clear, quiet, warm days (for the time of year) and place the baits early in the day, since afternoon is the most active period of the day for the mice. Use only one cube in a spot and make several placements about each tree, depending upon the number of trails and holes observed.

☞ **Important: Place so that other animals or birds will not reach the toxic baits.**

Growers who have been unable to attend a mouse control demonstration, and were unable to obtain this new rodenticide, can use strych-

nine coated grain and place in the mouse trails as previously discussed. It is anticipated that more demonstrations will be held in the future so that growers will be able to become acquainted with the zinc phosphide method.

Rabbit Control

In some parts of Ohio, damage done by rabbits to young apple trees and other tender fruit stock is severe.

Wire guards give some protection except during periods of deep snowfalls. Other protectors such as heavy paper, burlap, wood veneer, etc., offer the same protection as wire guards but are less permanent. Scattering freshly cut succulent prunings in the orchard before damage is done diverts rabbits from feeding on tree trunks.

Many commercial repellents are on the market and some home-made preparations have been used with partial success varying with climatic conditions and rabbit populations. The paint described below has been used with considerable success by many Ohio orchardists.

Home Made Rabbit Paint.—Use resin and alcohol in the proportion of 1 pound of resin to 1 pint of denatured alcohol. Warm the resin over a slow fire just to melting point but do not superheat it. Heat the alcohol to about the temperature of the resin. Do not heat the alcohol over a direct flame, but warm it in a pan or bottle immersed in hot water. Add the heated alcohol to the melted resin and stir to an even consistency. If the resin is too hot the alcohol will bubble and escape. Immediately place the preparation in a container that can be corked or sealed and keep sealed, except when in use. Keep snow and rain water out of the preparation, as moisture changes the texture of the paint.

Apply with a brush when bark is dry. Cover bark of trunk and lower limbs as far as rabbits can reach. Allow for snow which may permit rabbits to work higher on the trees.

Resin-alcohol rabbit paint covers easily and is economical. It has been used extensively under Ohio conditions and found safe and effective in preventing rabbit damage.

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