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Spraying Calendar
Michigan State University Extension Service
E.J. Rasmussen, Ray Hutson, Donald Cation
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SPRAYING CALENDAR

By E. J. Rasmussen, Ray Hutson and Donald Cation

MICHIGAN STATE COLLEGE

EXTENSION DIVISION

EAST LANSING

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SPRAYING CALENDAR

E. J. RASMUSSEN, RAY HUTSON, AND DONALD CATION

1. Directions given in this publication are intended for dealing with conditions which favor moderately severe infestations of disease and insects. Weather conditions, diseases and insects present, amount of disease infection, varieties, vigor of trees, and methods of application should all be considered in the spraying program. To plan an economical and effective spraying program, a grower should be familiar with the life history of the common insects and diseases in his locality; conditions which favor their development; kinds of spray materials and their uses; and the susceptibility of kinds and varieties of fruits to insect, disease, and spray injury.

SPECIAL INFORMATION

Every season hundreds of packages without written information are received by the various departments concerned with plant production and protection. Conversely, hundreds of letters telling of packages are received without the packages.

Prompt attention to such requests can be rendered only in case both letter and package are plainly marked to show their connection and reach us together. Describe conditions fully, state previous treatment, and if diagnosis of trouble is desired send material to show typical injury.

Always attach letter to the package, place your name and address upon it. Address the package and letter to Michigan State College, East Lansing, Mich.

Because of the small change necessary in recommendations in any one year it has been deemed advisable to revise the spraying calendar every two years instead of yearly. Any minor changes seeming necessary will be published as a supplement.

SAVE YOUR SPRAYING CALENDAR

Such knowledge will mean a substantial saving in spray materials and labor, and an increased production in the orchard. For example: In the control of apple scab, if rains occur frequently during the pre-bloom and calyx periods, liquid lime-sulphur will be most satisfactory because it is more adhesive than other materials and is capable of killing the scab organism two to three days after infection takes place. On the other hand, under less favorable conditions for scab development a wettable sulphur would be preferred because it causes less injury. Another example is in the use of an arsenical in the pre-bloom sprays. It is likely that the use of lead arsenate is unnecessary every year in all of the pre-bloom sprays. These sprays are principally for the control of scab and unless curculio, canker worm, or budmoth is a serious problem a poison in only one of these sprays should be necessary.

Varying the spray schedule to meet the susceptibility of the variety should also be considered when possible. Certain varieties such as McIntosh may require more sprays for scab control than Wealthy or Grimes Golden. Some varieties such as Jonathan and King are susceptible to arsenical injury. On such varieties the use of an arsenical corrective in the cover sprays or the substitution of one of the fixed nicotine compounds for lead arsenate will reduce arsenical injury.

Timeliness and thoroughness of application are as important in control of diseases and insects as the materials used.

Probably more spray applications are ineffective because of poor coverage than for any other reason. All fruit and foliage must be covered with a thin film of spray material. It makes no difference how this is accomplished—whether by light applications at frequent intervals or by moderately heavy sprays at longer intervals. A good thing to remember is that it does not pay to economize on spray materials if they are needed. Vigor of trees also is a factor which should be considered in modifying the spray schedule. A moderately vigorous orchard is less subject to spray injury than a weak one and sometimes less susceptible to disease infection. For instance cherry leaf-spot is more difficult to control in orchards of low vigor. On the other hand, oriental fruit moth and peach canker cause more injury to over-vigorous trees. Cultural practices which will maintain a moderately vigorous condition in the orchard will help to simplify the spray program.

2. Spray Injury. Over-spraying, too frequent applications, materials improperly used, or even standard materials used in the regular way may cause injury. Over-spraying is not a common practice. More often the grower applies too little rather than too much. Over-spraying usually occurs where a drenching application is made on the limbs and branches too close to the spray machine. Too frequent applications of certain materials will cause serious injury, not only for the current season but the injury may also affect the next year's crop. An example of the damage caused from too frequent applications is seen when liquid lime-sulphur is applied at intervals of less than 7 days in calyx and later applications. Liquid-lime-sulphur applied at such short intervals has caused premature dropping of fruit and reduced the amount of blossom bud formation for the next year. The adage "If a little is good, a lot is better" is not true in this instance. It is a dangerous practice. Sometimes growers rely on their memory when preparing certain combinations or mixtures of spray material. If you are not

certain, don't guess. The omission of one material—for instance, lime in the zinc sulphate-lime mixture recommended for correcting arsenical injury on peach—will cause serious injury. Weather conditions often influence the amount of spray injury. Sulphur injury occurs after periods of high temperature. Even though the right kind of sulphur was used and properly applied, injury from the sulphur may occur several weeks after the application if temperatures rise to 103° to 104° for a few hours. Severe injury may be just as serious as failure to control because of too little spray. Spray injury may cause loss of foliage, increased transpiration, excessive dropping of fruit, dwarfing of fruit, or it may affect the color of the fruit. Injury to buds, bark, and wood may also occur. The type of injury varies with the different kinds of fruit and with the material used. It is evident, therefore, that the trees must be properly sprayed to prevent injury by insects and diseases but that excessive and improper spraying should be avoided.

3. **Arsenical Injury.** Peaches and certain varieties of apples and plums are very susceptible to arsenical injury; leaves, wood and fruit often being badly injured by arsenical sprays and dusts. In general, dusting causes less injury than spraying as formerly practiced, but many severe cases of injury have also resulted from dusting. Recent investigations in Michigan and other states have enabled research workers to develop two combinations of spraying materials that are much safer than those formerly recommended. One is a combination of iron sulphate (ferrous sulphate) and hydrated lime and the other a similar combination of zinc sulphate and hydrated lime, to be used with acid lead arsenate, or acid lead arsenate and a sulphur spray. One of these should be used whenever acid lead arsenate is present in a peach spray. Iron sulphate is somewhat cheaper and dissolves more readily than zinc sulphate. Iron sulphate and lime mixture is satisfactory for use on peaches but not on apples. Iron sulphate is not recommended for apples because it interferes with normal coloring of the fruit. Basic lead arsenate does not require a corrective.

The Bearing of Tolerance Changes Upon the Use of Arsenicals

4. Many growers may reason that raising the tolerance for lead and arsenic residue upon apples and pears removes all restriction upon the use on fruits of spray materials containing these elements. Careful consideration of the problems involved in the use of arsenicals reveals, however, that such reasoning is in error. The careless use of arsenicals in Michigan on fruits may have the following results:

1. Cause arsenical injury;
2. Make washing necessary.

5. **Dusting.** The dusting method has many distinct advantages over spraying. The original investment for dusting equipment is much less, and depreciation and maintenance costs are lower. It is sometimes possible to use the lighter dusting equipment on soft ground where it is not possible to travel with a sprayer. An orchard may be covered much more rapidly with dust than with spray, which is a marked advantage, especially with large acreages. Many growers, who do not dust exclusively, do so as an emergency treatment to finish quickly

an application that cannot be completed before an expected infection period, with available spraying equipment. Lower labor costs are incident to the more rapid application. An easily available supply of water is not a factor in dusting.

Another marked advantage of dusting is that little injury to fruit and foliage usually occurs when appropriate materials are used. However, the use of copper dusts on some fruits may be followed by injury to both fruit and foliage. With peaches, the presence of lime is necessary in dusts containing lead arsenate.

One of the disadvantages of the dusting method is that there is no material known that can be recommended for some of the dormant applications. The cost of materials is almost always greater than for spraying. It is frequently more difficult to find weather conditions favorable for dusting than for spraying. Wind often interferes, and temperatures and humidity are sometimes important. However, the difficulty of finding favorable weather conditions is probably compensated for, in part at least by the greater speed of application.

Many insects and diseases, in fact the majority affecting the peach in Michigan during the summer period, may be satisfactorily controlled by dusting. For certain kinds of aphids, leafhoppers, and other insects, nicotine dust may be used to advantage, but there are other pests for which dusting is not always satisfactory.

The most important troubles for which dusting is likely to be used in Michigan are apple and pear scab, leaf-spot of the cherry and plum, curculio and brown-rot on stone fruits, codling moth on apples and pears, and for certain insects and diseases of the grape. In many instances, but not always, excellent results in the control of these troubles have followed the use of dust. The failures usually have occurred in seasons in which the disease to be controlled has been present in epidemic form, or, in districts where some insect, such as the codling moth, has been persistently severe. Under such conditions, it is apparently easier to obtain satisfactory control with spraying than with dusting. If dusting is employed under these conditions, it will probably be necessary to deviate from the regular schedule recommended for spraying in order to get the greatest benefit from the dusts.

The best information available concerning the control of scab and leaf-spot indicates that an application of dust should be made just before each predicted period of rain that may cause infection and spread of these diseases. If rains recur at frequent intervals, the dust application should be repeated accordingly. For the control of codling moth, dust has sometimes given excellent results, but in districts where this insect is a serious pest, it has not been demonstrated that dusting as usually done will afford satisfactory protection.

Difficulty is sometimes encountered with the use of arsenical dusts in the poisoning of honey-bees because the dust may drift onto the blossoms of cover-crop plants in the orchard, of wild plants in or near the orchard or to the blossoms of clover or other farm crops in adjacent fields.

To repeat, dusting has some marked advantages over spraying, but it also has some obvious disadvantages. Whether any particular grower should dust or spray, should be determined largely by a balancing of the advantages against the disadvantages as they apply to his orchard.

This will involve many considerations such as the acreage to be covered, the relative prevalence of insects and diseases, the susceptibility to disease of the varieties grown, the spraying equipment and labor supply available, and the water supply. In some instances, dusting may be the best procedure for the growing season applications, or the grower may prefer to take some chance of failure in order to avail himself of the advantages of the dusting method. In other cases, dusting may be substituted advantageously for spraying for part of the applications, or used as a supplement to spraying when it is not possible, with the available spraying equipment, to complete an application ahead of an expected infection period. There are, however, many growers who should adhere to the standard spraying practice. This is especially true of small growers whose operations are not extensive enough to justify the outlay necessary for both types of equipment and of all growers who do not care to follow up their control measures in the very careful way that is often necessary with dusting.

SPRAYING MATERIALS

Spraying materials are classified as fungicides, insecticides, and accessory materials.

Fungicides

6. **Lime-sulphur.** Recommendations in this bulletin for the use of lime-sulphur always refer to commercial concentrated solution. Most of the commercial products test 32° to 33° Baume, and all dilutions recommended herein are based on that strength of concentrated solution. Lime-sulphur contains calcium polysulphides which are soluble and caustic. The immediate solubility and caustic action kills certain fungous spores which are just germinating or partially established. The polysulphides break down, leaving a coating of finely divided sulphur which then gives a protective action similar to that of the wettable sulphurs. Lime-sulphur is conceded to adhere better and give greater protection than wettable sulphurs. Lime-sulphur is more likely to cause injury than wettable sulphurs. Lime-sulphur is also an insecticide and kills San Jose scale when used as a dormant spray at a dilution of 12½ gallons to 100 gallons of spray.

7. **Dry Lime-sulphur.** Dry lime-sulphur is, essentially, liquid lime-sulphur from which the water has been removed. A "stabilizer" is usually added to prevent extreme breaking down, during the dehydration process, of the sulphur compounds which are a part of lime-sulphur solution. Dry lime-sulphur varies in its exact composition from the liquid form, but in general, the two products are similar except that the one is a dry powder and the other a solution. Both depend on sulphur and sulphur-bearing compounds for their value.

Dry lime-sulphur, when substituted for the liquid concentrate, should be used in proportions that will give active ingredients approximately equal to those contained in the recommended amount of the liquid. Chemical analyses and field experiments have shown that 4 pounds of the dry lime-sulphur is approximately equal to 1 gallon of the liquid lime-sulphur. To determine the amount of dry lime-sulphur required

simply multiply the recommended number of gallons of liquid lime-sulphur by 4 and the result will be the number of pounds of dry lime-sulphur necessary to give equivalent results. For further discussion of the concentrations of lime-sulphur to use, refer to Section 35, page 19. This recommendation is based on experience with apple scab only and may not be found to apply for all diseases. Furthermore, there is undoubtedly enough variation between different brands of dry lime-sulphur so that the rule cannot be considered as absolute and unvarying.

Dry lime-sulphur may be expected to produce all the types of injury to foliage and fruit that follow the use of liquid lime-sulphur, but the injury often is less serious than with the liquid lime-sulphur, even though the two are used at equivalent strengths. Dry lime-sulphur is not recommended for scale insect control.

8. Wettable Sulphurs. Wettable sulphurs are composed of finely divided or pulverized sulphur incorporated with a wetting agent. The fineness of division is attained by several processes. The resulting product is sold in a dry powder form or as a paste such as flotation sulphur paste. The adhesiveness and fungicidal effectiveness of sulphur as a spray depend, within limits, upon the fineness of division or size of the sulphur particles. Thus the grains of sulphur in 325-mesh dusting sulphur are about $1/500$ of an inch, while the flotation sulphur paste and some of the better dry wettable sulphurs are largely composed of grains between $1/5,000$ and $1/25,000$ of an inch in diameter. Size is sometimes expressed in microns. (A micron is equivalent to $1/25,000$ of an inch.) An extremely small particle size of sulphur is not considered so important for the control of peach diseases as it is for the control of apple scab.

Wettable sulphurs do not possess the immediate caustic properties of freshly applied liquid lime-sulphur nor do they adhere so well; for those reasons they are not so efficient in killing fungi. Wettable sulphurs are far less injurious to fruit and foliage and for that reason only are they used to replace lime-sulphurs. Provided wettable sulphurs are used more frequently than liquid lime-sulphur or with accurate timing, they will adequately control apple scab and other fungous diseases of apples. The use of wettable sulphurs in apple sprays is increasing. The extent one can safely substitute wettable sulphurs for liquid lime-sulphur depends on the seriousness of the scab situation, the season, the variety, the spray equipment and the grower. Some growers successfully use wettable sulphurs for all the scab sprays. Such growers have spray machinery of ample capacity for quickly covering their orchard. They observe the weather and make sure their trees are covered before a rain and between protracted rainy spells during the critical scab period (between delayed dormant and first cover).

A better procedure for the average grower is to use lime-sulphur for the early sprays, substituting wettable sulphur in the first cover spray and possibly in the petal-fall spray if the main scab spore discharge has occurred in the pre-bloom period and scab is well under control. If scab is well established after the bloom period it is not advisable to apply two lime-sulphur sprays at intervals of less than 7 days. It is preferable to alternate lime-sulphur and wettable sulphur in successive sprays to avoid the certain injury which occurs when two lime-sulphur sprays follow one another closely.

Wettable sulphur sprays may be of considerable value as a full-bloom spray if the blossom period is unusually long and scab weather is imminent. This spray would be especially appropriate if wettable sulphurs had been used in the pink spray. Wettable sulphurs may be used advantageously on some of the varieties less susceptible to scab but subject to foliage injury and russetting of the fruit. Wettable sulphurs are especially valuable as peach sprays because they are not injurious to peaches at temperatures below 100° F. and are adequate to control brown rot and scab, the two general injurious peach diseases controlled by spraying. They are also used for the control of brown rot on sweet cherries and plums, but are not recommended to control leaf-spot on cherries. In general, 4 or 5 pounds of the better dry wettable or 8 to 10 pounds of the paste sulphur is equivalent to 1 gallon of liquid lime-sulphur in the control of apple scab. The average dose recommended is 5 to 6 pounds of dry wettable sulphur or 8 to 10 pounds of paste.

9. Bordeaux. Bordeaux is made from copper sulphate (bluestone, blue vitriol), lime, and water. Whenever bordeaux is recommended in this bulletin, a formula will be found, such as 4-6-100. The first figure always indicates the amount of copper sulphate in pounds, the second figure the amount of hydrated lime in pounds, and the third figure the amount of water in gallons. A 4-6-100 bordeaux will require:

4 pounds copper sulphate,
6 pounds hydrated lime,
100 gallons water.

The foregoing formula is an example only and should not be considered as a recommendation for any particular use. Refer to the schedules for each fruit for specific recommendations.

Copper sulphate may be obtained in several grades as to size of particles. For convenience in preparation, the rather fine, granular, and pulverized grades are desirable. These grades are referred to by the trade as powdered, snow, and small and large crystals. The powdered or snow forms are recommended for convenience.

10. Preparation of Bordeaux. There are several methods for preparing bordeaux. The one in most common use today is the "Instant Bordeaux" method. It has replaced the old stock solution method because it is more convenient to make and the mixture is entirely satisfactory. One precaution should always be remembered in making bordeaux. Never mix concentrated solutions of copper sulphate and lime. Such a mixture is coarse and does not adhere well to the fruit or foliage. The more dilute the solutions when mixed, the better the quality of bordeaux.

The "Instant" method requires different forms of materials than the old stock solution method. The lime used should be a good grade of chemical hydrate or spray lime (see Section 29). The copper sulphate should be the powdered or snow form. These forms go into suspension or dissolve readily in water. To make "Instant Bordeaux," proceed as follows:

1. Fill the spray tank $\frac{1}{4}$ to $\frac{1}{3}$ full with water.
2. With the agitator running, place hydrated lime on the tank

strainer and wash through or mix with water in a pail and pour through the strainer.

3. Fill tank nearly full with water.

4. Dissolve the copper sulphate in a pail and pour slowly through the strainer while the water continues to flow into the tank.

Allow about 2 minutes for the two solutions to mix and react in the tank.

5. Add lead arsenate or nicotine sulphate at this time if either is to be used. Fill the tank with water and apply. Keep the agitator in operation continuously after copper sulphate has been added.

11. Proprietary Copper Compounds. Proprietary copper compounds are spray materials containing a low-soluble copper. For the control of some diseases they may be substituted for bordeaux. The following materials, listed alphabetically, are some of those used in experimental work for leaf-spot control on cherry in Michigan: Basicop, Bordow, Copsil, Cupro K, Grasselli's Compound A, Oxobordeaux, Spraycop, Tennessee 26. None of these has fungicidal properties superior to those of bordeaux, but some cause less injury and dwarfing of sour cherry and are recommended where lime-sulphur or bordeaux have not been found satisfactory. They should be used according to the manufacturer's recommendations.

The value of these materials for use on apples has not been established.

Insecticides

12. Calcium Arsenate. A substitute for lead arsenate sometimes used on apple trees to avoid lead residue is calcium arsenate. Its physical characteristics and general appearance are much like those of lead arsenate. It contains more arsenic than lead arsenate, but pound for pound, is considerably less effective in codling moth control. If used without a corrective, injury is likely to occur. Calcium arsenate may be used on grapes in the usual sprays without injury.

13. Lead Arsenate. Acid lead arsenate has been the standard stomach poison for orchard spraying for many years. Unless otherwise indicated, any reference to lead arsenate refers to this form.

The use of a corrective will reduce arsenical injury. The zinc sulphate-lime mixture (see Section 33) should always be used with lead arsenate when applied on peaches and plums. The zinc sulphate-lime mixture when used experimentally on apples as recommended in the apple schedule has not caused russetting which would lower the commercial quality of the fruit.

Basic lead arsenate has been introduced into Michigan for use on peaches, which are susceptible to arsenical injury.

Basic lead arsenate, while less likely to cause injury, is less effective. Three pounds of basic lead arsenate are commonly used to replace two pounds of acid lead arsenate. Basic lead arsenate is used without correctives, and observations during 1939 indicated the 3-pound dosage to be effective against curculio.

14. Zinc Arsenate. Seven years' tests with zinc arsenate without a sticker have shown this material slightly less effective than lead arsenate. With a sticker zinc arsenate has been as effective as lead

arsenate without a sticker. The use of zinc arsenate eliminates lead residue but apples sprayed with it are above the tolerance for arsenic. Zinc sulphate-lime (see Section 33) used as a corrective has been found satisfactory with this material.

15. Nicotine Sulphate. The standard commercial form of nicotine used for orchard spraying is nicotine sulphate. This should contain 40 per cent of actual nicotine, and all recommendations made in this bulletin are based on this concentration. Nicotine sulphate appears on the market under several trade names. Any of them should give satisfactory results in the orchard if diluted so as to give the required amount of actual nicotine.

Formerly home-made nicotine sprays have been recommended, but their use has never become general. Their nicotine content and, consequently, their insecticidal value vary greatly so that uniform results cannot be expected from their use. Because of difficulties in making, and uncertainty of results following the use of home-made nicotine extracts, the standard commercial products are recommended for general use.

16. Fixed Nicotine. Several materials containing nicotine in "fixed" form are marketed. These compounds apparently retain the poisonous principles over a longer period than other nicotine compounds. When used according to manufacturers' directions these materials give excellent control of codling moth without leaving such residues as would make washing necessary.

17. Sodium Dinitro Cresylate. This is a recently introduced water-soluble dormant material which kills aphid eggs and San Jose scale. It should be applied in the dormant period only.

OIL SPRAYS

18. The two general classes of oil sprays are miscible oils and oil emulsions. In general, the miscible oils are factory-made products, while the emulsions are often home-made, although several commercially-made emulsions are now available. Some of the factory-made products contain additional toxicants such as various nitric acid derivatives of phenol and cresol rhodanates and nicotine. An oil emulsion consists of oil that has been mixed with water and some emulsifying agent and then treated mechanically to break the oil into fine globules or particles that remain in suspension in the water. The stock emulsions with which fruit growers are familiar contain oil, emulsifier, and water. These emulsions, before being applied to the tree, are diluted in the sprayer tank with water.

A miscible oil is generally a mineral oil combined with some material that makes it miscible or mixable with water. The preparation usually appears much like oil alone. It usually contains little, if any, water. A properly made miscible oil, when added to water, mixes readily and forms a milky white emulsion. There are certain advantages and disadvantages inherent to both classes of oil sprays (see Section 23).

It is of course necessary to determine first if oil is necessary for the control of the pests in question. Growers should study the specific instructions for each fruit to determine if an oil spray is needed. Oils are recommended specifically or optionally for the control of pear psylla, scale insects, fruit tree-leaf-roller, European red mite, clover mite, cherry casebearer, raspberry mite, codling moth and certain grape insects. The type of oil used as the base of miscible oils and oil emulsions should be determined by whether the spray is to be applied during the dormant or growing season.

19. **Dormant Oils.** Oils used for making miscible oils and oil emulsions for use in the dormant period may vary considerably in their properties. For dormant spraying, the oil should have a viscosity of at least 100 seconds (Saybolt at 100° F.) and 60 to 70 per cent unsulphonated residue. Oils used for pear psylla control should have a viscosity from 170 to 250 seconds. These specifications apply to oils used for home-made emulsions and to the oils which are the basis of factory-made products. The recommendations are not absolute, for there are commercial products available that have given satisfaction, although they do not meet these specifications in all respects. Oils used for home-made emulsions for dormant spraying are usually of the type ordinarily called lubricating oils. Oils for use in gasoline engines and automobile motors are not recommended. If desired, more specific information will be furnished on request.

20. **"D N Oils".** Dormant oils containing as added toxicants nitric acid derivatives of phenol and cresol have proved effective against aphid eggs and San Jose scale. Oils containing these materials are commonly referred to as "D N oils" and should be applied only in the dormant period.

21. **Miscible Oils.** The miscible oils are comparatively permanent, that is, they can be kept for reasonably long periods before diluting, without any separation of the ingredients. They are not likely to be broken down by freezing and are relatively simple to use. They are stable in all ordinary kinds of water. Most of them are not compatible with lime-sulphur, and, with these, serious difficulties will follow if any lime-sulphur is present in the sprayer. The manufacturer's instructions should always be carefully followed, especially in regard to protection and freezing and mixing with other materials. The miscible oils are generally effective for scale and red mite, but, for special purposes, such as pear psylla, there is considerable variation between the different brands. Their cost is higher than that of home-made emulsions, but the final cost is determined by the price per gallon and the rate of dilution.

22. **Oil Emulsions.** The emulsions commonly used are of two types, the soap emulsions and the cold-pumped or cold-mixed emulsions. Directions for preparing the home-made cold-pumped emulsions will be found in Sections 24-25. The properties of these two classes of emulsions vary considerably.

Comparing the home-made emulsions with the proprietary oils, the home-made emulsions are effective and much cheaper. They are less convenient to use and store, and greater care is necessary when dilut-

ing them to avoid the release of free oil. It may also be necessary to clean the sprayer tank at intervals to remove any accumulation of oily sludge. The choice between proprietary oils and home-made emulsions is largely a question of balancing cost against convenience.

23. Precautions in the Use of Dormant Oil Sprays. Applications of oil sprays have been safely made under many conditions, but, at other times with conditions apparently very similar, serious injury has followed. In order to avoid possible spray injury or failure to control pests certain precautions should be observed.

Peaches and pears should not be sprayed with oil in the fall and there seems to be no occasion, under Michigan conditions, to spray apples or any other fruit at that time.

Early spring dormant applications of some miscible oils have caused injury to peach trees.

Do not apply oil when rain or snow is likely to follow quickly, or when the temperature is below 40° F. or is likely to drop to the freezing point before the spray has thoroughly dried.

Follow carefully the instructions of the manufacturer in respect to the use of oil sprays in combination with lime-sulphur, other sulphur sprays or bordeaux and where the use of lime-sulphur precedes or follows an application of oil. The cold-pumped emulsions are relatively safe in this respect but it is not definitely established that injury never follows.

Dormant oil sprays, properly diluted, are generally safe when used in the dormant period, and it is recommended that the use of all oil sprays of this type should be confined to this period. Oils at the concentration necessary for the control of San Jose scale, red mites and pear psylla have not been observed to cause any injury from spring dormant applications. Precautions concerning the use of higher concentrations are stated in Section 46.

24. Cold-pumped Emulsions. For growers who care to make their own emulsions, the cold-pumped or cold-mixed emulsions are generally more satisfactory. Copper sulphate and lime, casein spreader and other materials may be used as emulsifying agents.

25. Bordeaux Emulsions. The combination of copper sulphate and lime is very satisfactory as an emulsifier. The formula and method of preparation follow:

Prepare the copper sulphate and lime as stock solutions. Convenient proportions for this purpose are "1 pound to 1 gallon" for the copper sulphate and "1½ pounds to 1 gallon" for the hydrated lime.

For each 100 gallons of a given concentration, proceed as follows: (Use stock solutions of the strength indicated in the preceding paragraph.)

Materials	For each 100 gal. of spray with actual oil content of		
	3 per cent	6 per cent	8 per cent
Place in sprayer in this order			
1. Water.....	$\frac{3}{4}$ gal.	1½ gal.	2 gal.
2. Copper sulphate (stock solution).....	3 pt.	3 qt.	1 gal.
3. Hydrated lime (stock solution).....	3 pt.	3 qt.	1 gal.
4. Oil.....	3 gal.	6 gal.	8 gal.

If these quantities are insufficient to permit good agitation add more water.

For a 200-gallon tank use twice the amounts indicated, for a 300-gallon tank use three times and for a 400-gallon tank use four times the indicated amounts. The procedure, step by step, follows:

1. Place the indicated amount of water in the empty sprayer tank. Have the agitator in operation.

2. Add the copper sulphate stock solution.

3. Add the hydrated lime stock solution (always stir before taking from the container).

4. Add the oil.

5. Emulsify by pumping at high pressure (at least 250 pounds) through spray gun or nozzle back into the tank. Continue until the emulsion is creamy in consistency and there is no evidence of free oil.

6. Add water to fill the tank and apply. Keep agitator in operation until tank is empty. **MAKE CERTAIN THAT THE CONCENTRATED EMULSION IS ALL OUT OF THE HOSE BEFORE ANY SPRAY IS APPLIED TO TREES.**

This emulsion must be continuously agitated. If through lack of agitation there is an appearance of free oil, discard the emulsion and start over.

If a large quantity is to be made up at a central mixing plant to supply several sprayers, the following formula for stock emulsion may be used:

Formula for Stock Emulsion of Bordeaux-oil-emulsion

Materials (Add to sprayer in this order)	Amount
1. Water.....	7½ gal.
2. Copper sulphate (stock solution).....	3¾ gal.
3. Hydrated lime (stock solution).....	3¾ gal.
4. Oil.....	30 gal.

To dilute this stock emulsion, fill the sprayer about one-fourth full of water, and, with agitator in motion, add the stock emulsion. The amount to use can be determined by reference to Section 26. When thoroughly mixed, fill the tank with water and apply, keeping agitator

in motion until the tank is empty. It is not advisable to make up more stock emulsion than will be used the day it is made.

26. Diluting and Using Emulsions. Emulsions prepared according to this formula contain approximately $66\frac{2}{3}$ per cent oil. Some commercial emulsions contain about the same amount. To dilute such emulsions, the general rule is that for each 100 gallons of spray the number of gallons of stock emulsion is one-half greater than the stated percentage of oil. A tabular statement of dilutions follows:

Table of Dilutions for Emulsions Containing Approximately $66\frac{2}{3}$ Per Cent of Oil

Amount of dilute spray	Amount of stock emulsion to use to make actual oil content of				
	2 per cent	3 per cent	$4\frac{1}{2}$ per cent	6 per cent	8 per cent
100 gal.....	3 gal.	$4\frac{1}{2}$ gal.	6 gal.	9 gal.	12 gal.
200 gal.....	6 gal.	9 gal.	12 gal.	18 gal.	24 gal.
300 gal.....	9 gal.	$13\frac{1}{2}$ gal.	18 gal.	27 gal.	36 gal.
400 gal.....	12 gal.	18 gal.	24 gal.	36 gal.	48 gal.

To make certain that the oil is properly emulsified, mix a pint of the finished emulsion in a bucket of water. If free oil appears on the top within 5 minutes, discard the entire mix.

27. Tar, and Tar and Oil Sprays. Tar sprays consist of certain liquid fractions obtained in the distillation of coal-tar treated to render them miscible with water. These sprays were developed for dormant use to control aphids. Certain disadvantages of the tar sprays led to the development of the tar and oil sprays, which in many cases consist of the tar products referred to, combined with petroleum oil and an emulsifier. The tar sprays kill aphid eggs and case-bearers on contact. Tar and oil sprays, chiefly because of the oil content, will control scale and mite, in addition to aphid and case-bearers. Tar, and tar and oil sprays will kill some bud-moth larvae. Directions for the use of tar, and tar and oil sprays are furnished by the manufacturer. **TAR, AND TAR AND OILS ARE TO BE APPLIED ONLY DURING THE DORMANT PERIOD.** Tar, and tar and oil sprays burn the face and hands. When these materials are being applied, horses should be protected from injury as well as the operator.

28. Summer Oils. Oils used for applications during the growing period should be much more highly refined than those for dormant spraying. Viscosity and unsulphonated residue should be within well defined limits. The limits for viscosity are 75 to 85 seconds (Saybolt at 100° F.) and 92 to 100 per cent for unsulphonated residue. Numerous brands of summer oils having those specifications are offered for sale. The manufacturer's instructions should be carefully read before attempting to dilute any summer oil spray.

ACCESSORY MATERIALS

29. **Spraying Lime.** Hydrated lime is the only form of lime generally available for spraying purposes in Michigan. There are several grades of hydrated lime, mason's hydrate, finishing hydrate, agricultural lime, chemical hydrate lime, and spraying lime. The first three mentioned grades are nearly always undesirable for spraying purposes. Special spraying or chemical hydrate lime should be used. Brands vary in fineness and physical properties. Finely ground limes with the least amount of grit or coarse material are most desirable. Limes vary in their chemical composition as well as their physical properties. Lime made from limestone composed almost entirely of calcium carbonate is called high-calcium lime and lime made from limestone containing a mixture of calcium and magnesium carbonates is called dolomitic lime. High-calcium limes have been generally recommended for spraying purposes in the past. Three years' results on the use of bordeaux for leaf-spot control on sour cherries show that bordeaux prepared from dolomitic lime is equally as good or better than bordeaux prepared from high-calcium lime. It caused less injury to the foliage, less dwarfing of fruits and was equally effective in leaf-spot control. No significant differences were found between high-calcium lime and dolomitic lime when used in the zinc sulphate-lime and iron sulphate-lime mixtures as a corrective for arsenical injury on peaches. Any high grade spraying lime appears to be satisfactory for this purpose.

Stickers, Spreaders, Wetting Agents, and Correctives

30. The use of stickers with wettable sulphurs and low-soluble copper materials is still in the experimental stage. The value of stickers and spreaders other than oils when used with lead arsenate for the control of codling moth and plum curculio has not been established. Oil stickers increase the efficiency of lead arsenate but render residue removal difficult.

Spreaders or wetting agents, such as soaps, are helpful in increasing the effectiveness of such spray materials as nicotine sulphate. In the control of aphids and leafhoppers, wetting of the insects is necessary.

Soaps, fish oil, soybean flour, soybean oil, summer oils, and materials containing casein and lime are common materials used as spreaders. Several commercial "spreaders" and "stickers" are sold under various trade names and are recommended by spray material companies to be used with their products.

31. **Precautions in the Use of Spreaders and Stickers.** Spreaders and stickers should be used only with materials with which they are compatible. Only a small amount is necessary of some spreaders. **Adding more than the required amount may cause excessive runoff.** Some spreaders are injurious to plants when used at too high concentrations.

Correctives

32. **Iron Sulphate-lime Mixture.** For each 100 gallons of spray use 4 pounds iron sulphate, 4 pounds hydrated lime, and 2 pounds acid lead arsenate: mix as follows:

1. Begin filling the sprayer with water with agitator running.
2. Sift or shake in gradually the "sugar" iron sulphate, which will dissolve in 1 or 2 minutes. If the crystalline form is used pour in the stock solution which has been prepared previously.

3. Continue to add water with agitation and add the hydrated lime in any convenient way.

4. Add the acid lead arsenate. Fill sprayer with water and apply.

When wettable sulphur is used with this mixture add the sulphur after the acid lead arsenate. It is not known how bentonite sulphur will combine with this mixture. **The use of iron sulphate-lime mixture has proved satisfactory for peaches but not for apples because it interferes with color.**

33. **Zinc Sulphate-lime Mixture.** A 1-4-100 zinc sulphate-lime mixture is recommended to prevent arsenical injury on apple; a 4-4-100 zinc sulphate-lime mixture to prevent arsenical injury on peach and plum; an 8-8-100 zinc sulphate-lime mixture for bacterial spot of peach.

It is a poor policy to use arsenicals indiscriminately just because the residue tolerance has been raised. If arsenicals are used on Jonathan, King, Rhode Island Greening, Ben Davis, or other varieties susceptible to arsenical injury, the zinc sulphate-lime mixture added to the spray will reduce the amount of injury. This material should be used, beginning with the second cover application.

Zinc sulphate-lime mixture is prepared as follows:

1. Begin filling the spray tank with water.
2. With the agitator running, add the required amount of previously dissolved zinc sulphate to the water in the tank. Fill until two-thirds full.
3. Wash the required amount of lime through the strainer or make it into a thin paste and pour into the sprayer.
4. Finish filling the tank and agitate a few minutes before adding lead arsenate.
5. Add lead arsenate, or sulphur if required.

There are three forms or grades of zinc sulphate on the market. They vary in amount of zinc and water present. The first grade contains $22\frac{1}{4}$ per cent zinc and is the crystal form; the second contains $25\frac{1}{2}$ per cent zinc and is the flake form; and the third contains 36 per cent zinc and is the powdered form. The $25\frac{1}{2}$ per cent grade is the one used in Michigan State College experimental work and on which recommendations are based. If one of the other grades of zinc sulphate is used, the amount should be in proportion to the percentage of zinc present. For example, in the standard 4-4-100 mixture, 4 pounds of the $25\frac{1}{2}$ per cent zinc sulphate and 4 pounds of lime are recommended. If the 36-per cent grade is used, then slightly less than 3 pounds of the zinc sulphate should be added to 4 pounds of lime. Zinc sulphate-lime mixture is an excellent corrective for use with all arsenates when applied to apples.

When lime-sulphur or wettable sulphurs are used with this mixture the sulphur should be added after the arsenate. Zinc sulphate should never be used without lime when applied to peach, apple, plum, or cherry trees. The zinc sulphate-lime mixture or the iron sulphate-lime mixture should always be used on peach and Japanese plums when acid lead arsenate is applied.

Compatibility of Spray Materials for Summer Use

34. Compatibility is the property of two or more spray materials of mixing without undergoing any reaction which will materially reduce their effectiveness for disease and insect control or increase their injurious effect on the plant.

In general, the following combinations are recommended. It is to be remembered that weather conditions, vigor of tree, variety, kind of fruit, method of application, amount of infection, all influence the effectiveness of disease and insect control and amount of injury to the host by any combination of spray materials.

Lime-sulphur. Liquid lime-sulphur, or dry lime-sulphur when used at concentrations stronger than 1 gallon of the liquid or 4 pounds of the dry may be used with lead or zinc arsenate under most conditions. Nicotine sulphate, and wettable sulphurs are safe to use with lime-sulphur. Lime-sulphur should never be mixed with oils, copper fungicides or soap.

Wettable Sulphurs. Wettable sulphurs may be combined with lime-sulphur, copper fungicides, acid or basic lead arsenate, zinc arsenate, nicotine sulphate, fixed nicotine, or soaps. They should not be used with oils or calcium arsenate.

Acid Lead Arsenate. Acid lead arsenate may be safely used with most materials. It should not be combined with weak concentrations of lime-sulphur (less than 1 gallon of lime-sulphur in 100 gallons of water or 4 pounds of dry lime-sulphur) or certain soap compounds.

Basic Lead Arsenate. Basic lead arsenate is compatible with all spray materials.

Bordeaux. Bordeaux may be added to wettable sulphur, lead arsenate, zinc arsenate, calcium arsenate, oils, nicotine sulphate, and the proprietary copper compounds. It should not be used with lime-sulphur, fixed nicotines, or soaps.

Calcium Arsenate. Calcium arsenate is compatible with sulphur, lime-sulphur and bordeaux, but is recommended only for use on grapes.

Proprietary Copper Compounds. Proprietary copper materials are compatible with bordeaux, wettable sulphur, nicotine sulphate, lead arsenate. Some are compatible with fixed nicotines. **They should not be mixed with lime-sulphur.**

Summer Oil Sprays. Summer oils may be mixed with bordeaux, proprietary copper compounds, lead or zinc arsenate, nicotine sulphate, and fixed nicotine. They are not safe to use with any of the sulphur materials nor should oils be used preceding or following a sulphur spray unless 10 days have elapsed between applications. Oil sprays for summer use such as miscible oils, fish oils, and soybean oil when used with lead or zinc arsenate, increase the deposit of poison and make it difficult to remove. For this reason, oils are not recommended in combination with arsenicals except in seriously infested orchards where the grower is equipped to wash.

Nicotine Sulphate. Nicotine sulphate is compatible with all spray materials. For best results in heavy infestations of aphids or leaf-hoppers, a special application of nicotine sulphate plus a soap or other activator is advisable.

Fixed Nicotine. Fixed nicotines may be used with oils, some of the proprietary materials, wettable sulphur, nicotine sulphate, and acid lead arsenate. High-alkaline materials liberate the nicotine and therefore are not effective when used with lime-sulphur, bordeaux, lime or soaps. Sulphur is dangerous when used immediately preceding or immediately following oil.

Lime. Lime aids in delaying arsenical injury, and is sometimes used with lead or zinc arsenate especially in the cover sprays on apples. It is recommended with proprietary copper compounds to reduce copper injury to cherry foliage. It tends to reduce the effectiveness of arsenicals and proprietary copper materials, but the decrease in disease and insect control is usually not so serious as early injury and defoliation which may result in some seasons. Lime is not recommended with fixed nicotine sprays or with oils.




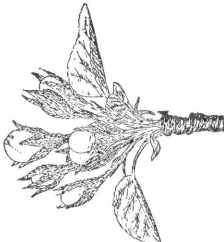
SUPPLEMENTARY DIRECTIONS FOR CONTROL OF APPLE DISEASES

35. **Apple Scab.** Apple scab may be a factor of importance in nearly every one of the early growing season applications. It is impossible to name any one application that is most important in all seasons or in all districts in any particular season. The most important applications vary from year to year, according to the weather, which is difficult to predict accurately. The spores of the apple scab fungus develop over winter in the old leaves on the ground. These spores produce the first or primary infections. These spores are usually ripe at the time of the green tip stage of the fruit buds and may be discharged by degrees during rains, from the green tip stage until several weeks after petal fall.

Spores are discharged only during rain and can germinate and infect only following rain and periods of wet foliage. Infection occurs following rain when the foliage has been wet four hours at 68° F. A somewhat longer period of wet foliage is necessary at lower or higher temperatures. The infections do not become visible until 8 to 21 days have elapsed. For best results the trees should be covered with spray before rains. Almost any fungicide, either dust or spray, will stop scab if applied within a 24-hour period after infection has occurred. Liquid lime-sulphur is more efficient in this regard and stops scab infection within 48 to 72 hours after infection has occurred. If rains occur during the night on unprotected foliage a dust or wettable sulphur spray applied the next day should prevent infection. Lime-sulphur applied within the next two and sometimes three days should accomplish the same results. Primary spore discharges and infections may occur during only a few rainy periods or over a long series of rainy periods, varying with the seasons.

Pre-blossom applications are usually the key to successful control

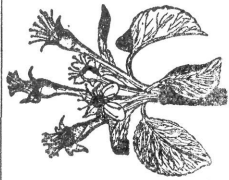
APPLES

STAGE OF GROWTH	APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
	1. DORMANT. Complete before green tips appear.	Lime-sulphur, 12½ gal. in 100, tar and oil or an oil spray. Refer to sections 6 and 18 to 28 for specific instructions.	Scale insects, mites and leaf rollers. Lime-sulphur will control scale. Oils will control scales, mites and leaf rollers. Tar sprays and D N sprays will control aphids. Tar and oil, and D N and oil will control aphids, mites and scales.	The dormant application of oil is necessary for the control of mites and leaf-rollers and will also control scale. Lime-sulphur may be used if scale only is to be controlled. Refer to sections 18 to 28 for specific instructions.
	2. DELAYED DORMANT. Apply in a well developed greentip stage, when leaf tips are ¼ to ½ inch in length.	Lime-sulphur, 2½ gal., lead arsenate,† 3 lb., nicotine sulphate, 1 pt., and water to make 100 gallons.	Scab, aphid, and bud moth. Omit the nicotine sulphate if a dormant application of *D N or tar and oil has been made.	This is the best period for the control of aphids, if this has not been effected by dormant applications. If aphids are present, include nicotine with the lime-sulphur that is necessary to prevent early infection of apple scab. Lead arsenate is partially effective against bud moth. Refer to sections 47 and 48 for special instructions for the control of aphids.
	2a. PRE-PINK. Begin soon after the delayed dormant condition and complete as soon as possible.	Lime-sulphur, 2½ gal., lead arsenate,† 3 lb., and water to make 100 gallons.	Scab, curculio, and bud moth. If aphids have not been controlled by this time nicotine should be added as satisfactory aphid control cannot be expected later than the pre-pink application.	Apply the pre-pink on the more susceptible varieties and on all varieties when conditions seem very favorable for scab development, or in seasons when bud development is spread over a long period. Still another application for scab control between the pre-pink and pink applications may be desirable under extreme conditions.
	3. PINK. Begin to apply as soon as most of the buds have separated in the clusters and complete before the blossoms open.	Lime-sulphur, 2 gal., lead arsenate, 3 lb.,† and water to make 100 gallons.	Apple scab, curculio and other chewing insects.	This application is important for scab control. The lead arsenate is of value for the control of chewing insects, as well as increasing the fungicidal value of the lime sulphur. Do not use lead arsenate after the blossoms begin to open. Bees may be poisoned and pollination of early bloom reduced.

THIS SCHEDULE WILL MAKE RESIDUE REMOVAL NECESSARY.

*D N. See sections 17 and 20.

†The use of lead arsenate is unnecessary in all pre-blossom applications, but at least one spray of lead arsenate prior to calyx is advisable.

	<p>4. PETAL-FALL (CALYX). Should be made when most of the petals have dropped and after bees have quit working in the bloom.</p>	<p>Lime-sulphur, 1½ gal., lead arsenate, 2 lb., nicotine sulphate, 1 pt., and water to make 100 gallons.</p> <p>Nicotine sulphate may be omitted if red bug is not prevalent.</p>	<p>These are the important applications for codling moth control.</p>	<p>Scab, codling moth, curculio, other chewing insects and red bug.</p> <p>Wettable sulphur may be substituted for lime-sulphur at this time.</p>	<p>Spraying should not begin until most of the petals are off and there are no bees working in the trees, but should be completed as soon as possible. Refer to Sec. 49 for the control of red bug.</p>
	<p>5. FIRST COVER. Seven to ten days after petal-fall.</p>	<p>Wettable sulphur, 4 to 6 lb., lead arsenate, 3 lb., and water to make 100 gallons.</p>		<p>Codling moth, curculio, lesser apple worm and scab.</p>	
	<p>*5a. SECOND COVER. Seven to ten days after application 5.</p>	<p>Lead arsenate, 4 lb., zinc sulphate-lime (see Sec. 33), wettable sulphur, 4-6 lb. (see Sec. 35) and water to make 100 gal.</p>		<p>Codling moth, curculio, lesser apple worm and scab. If apple scab is prevalent, the use of wettable sulphur may be advisable at this time.</p>	<p>WARNING. IMPORTANT</p> <p>Govern use of lead arsenate during the summer by the prevalence of codling moth. Read carefully sections 4 and 41.</p>
	<p>*5b. THIRD COVER. Ten to fourteen days after 5a.</p>	<p>Lead arsenate, 3 lb., zinc sulphate-lime (see Sec. 33), and water to make 100 gal.</p>		<p>Codling moth, lesser apple worm and curculio.</p>	<p>If fruit is not to be washed, refer to Sec. 42.</p>
	<p>*5c. FOURTH COVER. Two weeks after 5b.</p>	<p>Lead arsenate, 3 lb., zinc sulphate-lime (see Sec. 33), and water to make 100 gal.</p>		<p>Codling moth, lesser apple worm and curculio.</p>	
	<p>*6. SUMMER GENERATION. Exact time to be determined each year, usually about Aug. 1.</p>	<p>Lead arsenate, 3 lb., zinc sulphate-lime (see Sec. 33), and water to make 100 gal. Add wettable sulphur 4 to 6 lb. if needed for scab control.</p>		<p>Codling moth, curculio and scab.</p>	<p>The exact time of this application is determined by the Entomology Department and announcement is made through county agents.</p>
	<p>7. Two weeks after Application 6 and if necessary make one or two more applications at two week intervals.</p>	<p>Lead arsenate, 3 lb., zinc sulphate-lime (see Sec. 35), water to make 100 gal.</p>		<p>Codling moth and curculio.</p>	

IF FRUIT IS NOT TO BE WASHED, REFER TO SEC. 42.

*If conditions have been especially favorable for development of apple scab and it has not been controlled a fungicide may be applied in any of the cover sprays. Read Sec. 35.

and should be made regularly as recommended. This does not mean that later applications are of less importance, but it does mean that if the peak of infection occurs during the early period, successful control is almost impossible if the pre-blossom treatment has not been thorough. Successful scab control involves thorough coverage and timely applications. To be protected, keep the young leaves covered before infections occur. The apple scab schedule as recommended is devised to give the greatest margin of safety for the majority of growers for the control of this disease in epidemic years. Even more frequent applications may be necessary under unusual conditions. It is recognized that it is possible and even desirable for many growers to make radical departures from the so-called standard recommendations. These departures may consist of lower concentrations of liquid lime-sulphur or dry lime-sulphur in part or all of the applications; of the substitution of some other material such as wettable sulphur in part or all of the applications; the omission of sprays during long dry spells, providing adequate attention is given to weather reports and if equipment is available to cover quickly. Growers using weaker materials are usually prepared to spray oftener during critical periods. These changes are made solely for the purpose of reducing injury to foliage and fruit.

Caution: Weak concentrations of liquid lime-sulphur with lead arsenate sometimes cause considerable foliage injury, especially where less than one gallon of liquid lime-sulphur or four pounds of dry lime-sulphur are used in combination.

A full bloom spray of wettable sulphur may be of value when the blooming period is unduly prolonged and wet. Arsenate of lead should not be included while the trees are in blossom and the bees are working. Experience indicates that wettable sulphur is sometimes of advantage in the second cover if primary spore discharges continue late. Due consideration must be given to the use of oil following an application of sulphur (see Section 34).

If good scab control is obtained up to the application of the first cover spray no further fungicidal sprays are usually necessary. If scab is prevalent on fruit and foliage, however, a fungicide should be included in the second cover. Do not use two applications of liquid lime-sulphur at close intervals at this period (see Section 2). It is preferable to "sandwich in" a wettable sulphur spray between two liquid lime-sulphur sprays after bloom. Lime-sulphurs and wettable sulphurs are also more likely to injure with approaching warm weather, and copper sprays may russet the fruit at this time. Late fungicide applications especially complicate a fixed nicotine program. Sulphurs are incompatible with the oils commonly used with nicotine sprays. Alkaline materials such as lime-sulphur, lime, or bordeaux liberate nictines rapidly, thus destroying the residual effect necessary for codling moth control. Because of those reasons, control scab before the first cover spray.

Summer Sprays for Apple Scab

When the early season program has controlled scab, late summer applications of fungicides are unnecessary. Only in exceptional seasons are conditions favorable for the spread of scab in late summer. Fruit and leaves are more resistant at that time and about three days of con-

tinuous moisture are necessary for infection. Late infections which may appear as storage scab are occasionally troublesome on R. I. Greening, McIntosh, and Winter Banana. For some situations a late summer fungicide is advisable, but in general the benefits from summer application are doubtful. A summer spray about August 1, using paste sulphur 8 to 12 pounds in 100; or dry wettable sulphur, 6 to 8 pounds in 100; or weak bordeaux, about 2-6-100 or proprietary copper compounds with lime will control late summer infection but will not "burn out" established scab.

Lime sulphur will "burn" fruit and foliage during warm weather. All sulphur sprays are unsafe preceding or following oil sprays. Bordeaux or proprietary coppers may be used with or following oil and have not caused injury when used as a late summer spray. Summer fungicides are considered unnecessary in Michigan in most years if early control has been thorough.

36. Fireblight. The bacteria causing this disease gain entrance through open blossoms, young leaves or fresh insect wounds. They may also be spread during the growing season by pruning tools. The bacteria live over in hold-over cankers. The most effective time to treat cankers is during the dormant season. At this time the bark is removed for 3 inches above and below, and one inch around the sides of any visible signs of the canker. Blighted twigs and branches are also best pruned out at this time. There is little danger of spreading the disease with pruning tools during the winter months.

A 2-6-100 bordeaux spray applied when one-fourth to one-half of the blossoms are open is valuable as a blight preventative and should be applied on susceptible varieties when the disease is persistent. This spray also has considerable value in preventing scab infection during the full bloom period.

Summer cutting of fireblight is not recommended as a good practice on bearing trees but water sprouts on main limbs should be rubbed off by hand, using leather gloves for protection. This is to prevent the disease from getting into the large limbs and trunks. Blight infections should, however, be cut out in young trees during the summer. Tools should be disinfected after each cut when working with blight during the growing season.

Special instructions for the control of fireblight will be sent by the Botany Department upon request.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF INSECTS ON APPLES

37. Codling Moth. Fruit growers have, for a long time, put virtually all their fighting strength against the codling moth into a spraying program. In many orchards, this gives such good control that there cannot be the slightest doubt that an adequate spraying program provides a dependable means of fighting this pest, especially since it can be combined with the sprays for fungous diseases. It becomes increasingly apparent, however, that with the residue situation and a large codling moth population, growers in some localities are not getting enough apples free from codling moth injury. **Codling moth con-**

trol depends entirely on success in fighting the first brood. Control of the first brood is brought about by the systematic practice of supplementary measures followed by thorough and timely applications of effective spraying materials. Effectiveness of any material for codling moth control can be increased readily by shortening the interval between sprays to seven days during June.

Supplementary Measures. The proper disposal of culls and drops, elimination of orchard trash, destruction of larvae about packing-houses and equipment, and the scraping and banding of trees have been successfully employed against the codling moth under conditions of heavy infestation. Before the advent of spraying for control of codling moth in 1878, these so-called supplementary measures were relied upon for the production of clean apples. The only comparatively new idea about those mentioned is the use of a material to impregnate the bands, and even this has several years of successful use. None of these supplementary measures requires any large outlay of time or cash. Moreover, most of the operations can be completed in the off-season.

38. **Banding.** Codling moth banding consists of placing about the trunk of the tree, which previously has been scraped, a band 2 inches wide. The larvae seek shelter beneath the band when preparing to pupate, or to winter. The bands should be upon the trees by the time

Control the First Brood. Stop codling moth by scraping, banding, care of crates, packing and storage rooms, cull piles and by frequent and thorough early spraying.

larvae start leaving the apples—mid-June in southern Michigan and proportionately later in more northern counties. The bands are usually placed about two feet from the ground but may be placed at any convenient height. There are two kinds, treated and untreated. The band which was formerly used in greatest quantity was made of untreated burlap and necessitated visits every two weeks for the purpose of killing the larvae. These visits must be made or untreated bands are worse than no bands at all.

Refrain from banding smooth-barked trees or limbs, with chemically treated bands and place bands at a different place each year on any tree. Failure to observe these precautions has resulted in injury to trees.

Treated bands may be purchased or made at home. Instructions for making bands will be sent by the Entomology Department, Michigan State College, East Lansing, upon request.

Control the First Brood. Five wormy apples in one tree in July may be followed by an epidemic of "stung" and wormy apples before harvest.

39. **Scraping.** Careful scraping consists in the removal and destruction of all the bark flakes on the trunk and larger limbs. This can be done with a hoe, but a triangular tool, such as a mowing-machine section mounted on a stout handle, or some similar device, must be employed to get into the crevices. Do not leave scrapings about the base of the tree, because codling moth larvae on such scrapings will survive in large numbers. Many growers make an apron of burlap or other handy material, which is placed on the ground about the base of the tree before beginning to scrape. This automatically collects the scrapings, which can be kept in baskets for burning. Special care must be exercised in scraping the trunk at the ground line, and just below, as these are favorite winter places for codling moth larvae. The best results will be obtained if scraping is completed before blooming time.

40. **Spraying Methods.** Success from spraying for codling moth depends largely upon the thoroughness with which the material is applied. That is true with any effective material. The spraying should be done in such a manner that all surfaces of every leaf and apple in all parts of the tree will be covered with spraying material. To accomplish this will usually require that the inside portion of all trees be sprayed from the ground. Spray should be directed also from the top of the sprayer or from a tower to insure complete coverage on the outer portions and tops of the trees. This practice should start with the First Cover application and should be continued with all succeeding codling moth sprays. The use of lime-sulphur in this manner is likely to be followed by excessive injury and for that reason a wettable sulphur is recommended for the First Cover application. If a fungicide is needed later than this, a wettable sulphur may be used.

Control the First Brood. One per cent of wormy apples in July is too much.

41. **Spray Residue.** The amount of spray residue present on fruit at harvest is governed by many factors. The relationship of some of these factors is not well known, but it is certain that there is a definite correlation between the amount of poisonous residue at harvest and **the use of insecticides containing lead, arsenic, and fluorine during mid- and late summer.** The frequency and timing of such applications should be determined largely by the prevalence of codling moth. Growers, therefore, should study carefully the status of codling moth in their orchards and spray accordingly.

In many orchards it is possible, because of a low population of codling moth, to control this insect with a small number of applications and with little or no danger of excessive residue. In some districts, however, codling moth control is a serious problem and frequent and heavy applications during mid- and late summer may be necessary. Growers are advised to spray to the extent that is necessary to give satisfactory control. This practice may make necessary removal of the excessive residue which is likely to be present, but any effort to

avoid excessive residue by limiting the use of effective materials in heavily infested orchards is likely to result in wormy apples.

Schedule to Avoid Excessive Residue

42. Although there may be occasional exceptions, available analyses indicate that usually lead arsenate may be used on winter varieties in the petal-fall and first and second cover applications and zinc or calcium arsenate in the calyx and first and second and third cover applications without resulting in residues beyond present tolerances.

The only materials which have proved effective for the remainder of the season without excess residue and other complications are the nicotine compounds. Oil-nicotine sulphate has been recommended in THE SPRAYING CALENDAR for several years. It is effective, but the necessity for and cost of applications of oil (2 quarts) and nicotine sulphate ($\frac{3}{4}$ pint) at 8-day intervals have discouraged many people from using it.

The fixed nicotine compounds developed during the last few years and tested extensively in Michigan and other apple-growing areas apparently meet most of the requirements as a replacement for lead arsenate and washing. Factory-processed fixed nicotines have given consistently good results over the last four seasons without visible or illegal residues, and **without injury** and at a cost strictly comparable with lead arsenate plus washing costs.

Fixed nicotines when used at 10-day intervals in experimental plats and by many growers have given as good control as did lead arsenate at 10-day intervals.

Fixed nicotines are incompatible with lime-sulphur.

Fixed nicotines are compatible with some fixed copper compounds. Some brands are compatible with wettable sulphurs except when oil is used. If in doubt, consult your county agricultural agent. The foregoing points become doubly important when it is realized that dilute lime-sulphur and other sulphurs are used generally for scab control in Michigan and that the fixed nicotines are more effective when used with oil. The incompatibility of oils with sulphur necessitates scab control prior to the second cover for the best results with fixed nicotine-oil sprays. **If planning to use fixed nicotines and oil, every effort should be made to control scab prior to beginning the fixed nicotine-oil program.** During 1935 and 1937, bad scab years, McIntosh trees in the fixed nicotine tests which had no fungicide after the first cover showed no scab on fruit or foliage at harvest or afterward, control being effected by timely and thorough applications preceding the first cover.

The following combination arsenical and fixed nicotine schedule for codling moth control is suggested for Yellow Transparent, Duchess, and other early ripening varieties:

Petal-fall—lead or zinc arsenate 2 pounds with lime-sulphur $1\frac{1}{2}$ gal.

First cover—10 days after petal-fall, lead or zinc arsenate 3 pounds plus 4-6 pounds wettable sulphur.

Second cover—seven days after first cover—lead or zinc arsenate 3 pounds plus 4-6 pounds wettable sulphur or fixed nicotine, using material according to manufacturer's recommendation. Oil in this application may cause burning.

Third cover—seven days after second cover. Fixed nicotine according to manufacturer's recommendation, and may include oil.

Fourth and fifth covers may be applied according to circumstances at 7-10 intervals and may include oil.

The value of the seven-day interval in the second and third covers lies in maintaining coverage during the period of the fruit's **most rapid growth**.

Fungicides may be included but consult your county agricultural agent if in doubt as to the proper material to use.

For standard varieties of apples the following schedule of arsenical and fixed nicotine sprays is suggested:

Petal-fall—lead, calcium, or zinc arsenate plus lime-sulphur 1½ gallon.

First cover, 10 days after petal-fall—lead or zinc arsenate (see Sections 3 and 33) plus 4-6 pounds wettable or flotation sulphur.

Second cover, 7 days after first cover—lead or zinc arsenate 4 pounds plus 4-6 pounds wettable sulphur, or fixed nicotine according to manufacturer's recommendation. Remember that oil on foliage covered with sulphur may cause burning.

Third cover, 7 days after second cover—fixed nicotine according to manufacturer's recommendation. Oil may be used in this application and all subsequent sprays safely.

Spray at 10-day intervals after the third cover until first brood activity ceases. Usually two sprays of fixed nicotine for second brood with the deposit built by the sprays for first brood will protect the crop, although in heavily infested orchards or in long seasons an additional spray may be necessary.

The object of the 7-day interval between the first and second cover is to prevent early entries from which a second brood may develop. At the time these sprays are applied the fruit surfaces may **double** between applications at 7-day intervals. Every effort must be made **to cover the tops of the trees**, for it has been shown many times that the upper portions of the trees usually contain a greater percentage of wormy apples than the lower parts.

43. **Dormant Spraying.** The necessity for the dormant application should be determined by the prevalence of insects that may be controlled at that period. Dormant treatment is recommended for the control of the European red mite and the fruit tree leaf-roller. Treatment for scale insects should be made in the dormant period if oil is used, but lime-sulphur may be used for scale insects in either the dormant or delayed-dormant. If the European red mite is to be controlled, an application of an oil spray, which at the same time, will control scale insects, is recommended. The serious prevalence of the fruit tree leaf-roller requires treatment with an oil spray, which of course will satisfactorily control the mites and scale. Each grower should study his conditions in order to know what insects are prevalent in serious numbers and then use the minimum concentration necessary to give satisfactory results. Refer to the succeeding sections for specific recommendations. Growers desiring to control rosy aphids on apples and black cherry aphids on cherry in the dormant period may use a tar, tar and oil, nitro-phenol or nitro-cresylate spray. Tar and oil sprays

also control scale and mites but are not recommended for leaf-roller (see sections 19 and 28). Nitro phenols when combined with oils control scale and mites when used in sufficient concentration.

44. San Jose and Oystershell Scales. The San Jose scale is more numerous at present than for years. A close search should be made for it during the winter or early spring. The Department of Entomology will identify specimens upon request.

Oystershell scale is not so commonly a pest in orchards as is the San Jose scale but is of local importance at times.

Lime-sulphur, $12\frac{1}{2}$ gallons in 100 gallons of spray applied late in the dormant or in the delayed-dormant period will control San Jose scale. Dry lime-sulphur is not recommended for scale control. The same result is obtainable through the use of a dormant oil spray containing 3 per cent of actual oil. Oystershell scale can be controlled by the use of oil sprays containing 4 per cent of actual oil. (See sections 18 to 29 for a full discussion of oil sprays.) Use commercial oils at dilutions recommended by the makers. Tar and oil sprays will also control scale insects (see Sec. 27).

45. Fruit Mites and Clover Mites. Three species of mites, and perhaps more, attack apples and other fruits in Michigan: the common red spider, the clover mite, and the European red-mite. Fortunately, the spraying treatment for the red mite and clover mite is identical, and therefore it is not imperative that the grower distinguish between them except to remember that the European red mite is the one most capable of damaging trees. All Michigan fruit trees are subject to attack by one or all of these extremely tiny eight-legged pests. Warm, dry weather is favorable to the mites, while cold dashing rains help to keep them in check.

The most successful attempts at control have followed the application of oil sprays during the late dormant period and consist of one of the commercial spraying oils or of home-made lubricating oil emulsions. Use the home-made emulsions with 3 per cent of oil (see sections 24, 25 and 26). If a commercial spraying oil is used, follow the recommendations of the makers. Tar and oil sprays will control red mites (see Section 27). Spray with extreme care so that each tiny twig will be coated, especially on the under side, as well as the limbs and trunk. Observe precautions noted elsewhere under the caption of oil sprays, (refer to Sec. 23). The dormant spray is intended as a destroyer of the eggs.

Summer infestations of mites on foliage are controllable although the difficulties of covering all the foliage thoroughly enough to take care of the difficulty should be kept constantly in mind. The possibility of foliage injury must also be remembered in selecting materials.

An application of one per cent summer oil emulsion, repeated if necessary in 5-7 days, is perhaps the cheapest summer control for red mite, however, oil and sulphur in all forms are incompatible. If sulphur sprays are being used, or will be necessary immediately after a mite control spray, a rotenone spray with a good spreader or a D N spray for summer application may be applied.

No summer treatment for mites will succeed unless special efforts are made to cover every leaf.

46. **Leaf-roller.** The leaf-roller is an active, naked caterpillar, which rolls the leaves of the apple and other fruits, lives in this shelter, and feeds on the leaves and fruit. The winter is passed in the egg stage on the bark, and these eggs may be killed most easily by an application of an oil-emulsion late in the dormant period. Use home-made oil emulsion, diluted to give 6 per cent actual oil in the spray (see sections 24, 25 and 26). This oil must be applied while the trees are dormant. If commercial oils are used, follow the makers' recommendations. Refer to sections 18 to 27, inclusive, for a full discussion of oil sprays. Some miscible oils do not give satisfactory results, and definite information should be obtained about any particular brand before using it.

There are marked varietal differences in susceptibility to injury from the high concentration of oil necessary to control leaf-roller. Northern Spy is known to be more easily affected than others and the susceptibility increases as the season advances. It seems advisable, therefore, to make this application on Spy trees as an early spring dormant application. There are also marked differences in the effect of home-made and certain proprietary oil sprays. Information is not complete regarding varietal susceptibility, but normal Baldwin trees are apparently little affected by any dormant application of oil.

Very thorough coverage is necessary. The operator should spray from the ground so as to enable him to direct the spray to the under sides of all branches. With large trees, it is desirable for a second operator to spray from the top of the sprayer or from a tower. It is imperative that all high branches in the center of the trees be covered because the greatest number of eggs are found there.

Avoid Over-spraying.

The use of lead arsenate in the pre-blossom applications is a valuable supplement to the oil treatment, for it will kill cankerworms and other leaf-feeding insects which are sometimes present. All wood which is pruned from the trees before spraying should be gathered and burned before the spray is applied, and Tanglefoot bands may be placed around the trunks of the trees as an added precaution to prevent larvae from pruned twigs on the ground from crawling up into the trees. Tar and tar-oil sprays are not recommended for leaf-roller control.

47. **Aphids.** Three common aphids, in addition to the woolly-aphid, work in the tops of apple trees—the bud-aphid, the rosy aphid, and the green apple-aphid. All these pests winter as eggs on the trees. Aphids may be controlled while in the egg stage by a dormant application or in the delayed dormant after they hatch. The bud-aphid hatches first but most of the eggs of all three aphids are hatched by the time that the trees reach the delayed dormant stage. The critical time for aphid control, after the insects have hatched, is at the delayed dormant period before the aphids have increased in numbers through new generations and when they have the minimum of protection from foliage and blossoms. Spray as indicated in the apple schedule for the delayed-dormant application. If scale insects are to be sprayed for at this time, increase the amount of lime-sulphur to 12½ gallons. If for any reason the aphid treatment is not made in the dormant or delayed dormant period, it should be applied not later than the pre-pink. Spraying later than the

pre-pink is unsatisfactory for the control of the rosy aphid and the early broods of the green aphid.

The method of application, when spraying for aphids with nicotine, is important. **Complete each tree, or at least each row, as a unit, before going to the next.** Large trees with dense low-hanging limbs can be covered only when part of the spraying is done from the ground. Use high pressure and a good volume of delivery. Complete and thorough coverage is required. Favorable spraying weather often does not prevail at this period but best results are obtained on the more quiet and warm days.

Since it is impossible to predict the seriousness of aphid infestation, which is strongly influenced by weather conditions, spraying for the control of the rosy aphid and the early broods of the green aphid in the dormant or delayed dormant should be considered as a part of the annual spraying program on varieties susceptible to aphid attack. Because aphids do not cause serious injury every year in all parts of the state, or in any particular orchard, growers become lax in their control operations; the result is that orchards not sprayed regularly every year for aphids almost invariably suffer badly when conditions become favorable for aphid development and injury. Because of those conditions, it seems unwise for the operator of a productive orchard of susceptible varieties to omit aphid control measures.

Tar, tar and oil, or D N (dinitro-ortho-cyclo-hexylphenol), sodium dinitro-phenol, sodium-dinitro cresylate sprays may be used for aphid control but the application should be made while the trees are strictly dormant (see sections 17-20).

48. **Summer Infestation of Aphids.** The treatment just outlined, if properly made, should insure satisfactory control of rosy aphids for the season and of green aphids for the early part of the season. In case green aphids become troublesome during the summer, spray with nicotine sulphate added to one of the regular summer sprays or as a special application. Use nicotine sulphate, 1 pint to 100 gallons of spray with the addition of one of the following: 4 pounds hydrated lime; 4 pounds laundry or potash fish-oil soap or one of the special nicotine activators now available. If it is desirable to use a fungicide at the same time, a wettable sulphur may be added. Unsightly deposits resulting from summer infestations of green apple-aphids may be removed by including 25 pounds of hydrated lime in 100 gallons of spray.

Freshly mixed nicotine dust containing 2 per cent of actual nicotine is preferred by some growers. If factory-mixed dust is used, 3 per cent of nicotine is desirable. Repeated applications of fixed nicotine as used for codling moth control seemingly control summer infestations of aphids.

49. **Redbug.** Two species of redbug infest apples in Michigan. Both pass through the winter buried in the bark in the egg stage. Nicotine sulphate applied just after the eggs hatch serves best to control both species. The petal-fall spray is the best time for this application.

50. **Apple Maggot.** This insect is becoming more common. The maggots leave the apples after they fall to the ground. **The removal and destruction of all infested apples must be done if permanent re-**

duction in the number of apple maggots is desired. Gather all drops from summer varieties twice a week, from fall varieties weekly, and from winter varieties once every two weeks after July 15, and destroy them at once. Feeding the apples to livestock, putting the apples in sacks and submerging them in water or burying them at least 2 feet deep, are some of the ways of disposal. Pouring used crankcase oil over infested drops at the rate of 1 gallon to 10 square feet of pile surface will also prevent the adult emergence. The pile should not be under a tree and the oil may be applied any time before June 1 of the following year. Apply arsenical sprays with or without a fungicide on the dates determined annually by the Department of Entomology. These dates may be obtained from the county agricultural agent. The destruction of neglected apple and thornapple trees in the vicinity of orchards will help in controlling apple maggot.

51. **Curculio.** The well known plum curculio, which is responsible for the tiny dot and crescent-shaped scars on our tree fruits, hibernates under fallen leaves and trash. The destruction of all trash after cold weather arrives disposes of very many of these insects, and the liberal use of lead arsenate in the early routine sprays, beginning with the pre-pink application, will accomplish much toward their control. The curculio feeds, in early spring, on opening buds and on developing foliage.

The development of the curculio in the infested fruits continues after the fruits have dropped or have been removed by thinning. Hence, the disposal of "drops" and "thinnings" by feeding to livestock, crushing or burial beneath at least 18 inches of well-packed soil will reduce the infestation and consequent loss.

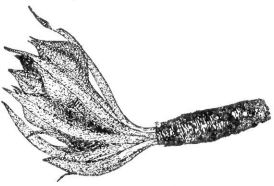

52. **Leafhoppers.** Leafhoppers are pests in many orchards. The typically discolored fruit and leaves and curled edges of the leaves associated with leafhopper injury are readily apparent only with heavy infestations, which may also result in stunting of new growth. The damage is caused by the feeding habits of these small insects, which are commonly seen rising in clouds from the trees when disturbed. Because these insects have sucking mouth parts the damage is caused by their feeding on the internal portions of the leaves. No arsenical spray affects them. They usually make their appearance during the month of May and the indications are usually such that the magnitude of the infestation can be judged by the first of June. If indications are such as to denote heavy infestation, the insects can be controlled by thoroughly spraying with nicotine sulphate (1 pt. in 100 gal.) in Application 5.

53. **Climbing Cutworms.** Refer to special instructions in Section 97.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF DISEASES ON PEARS

54. **Pear Scab.** Bordeaux is recommended for general use on pears because it has certain marked advantages over other materials. It does not injure the leaves and there is no apparent interference with their functioning. There are also definite indications that orchards regularly

PEARS

STAGE OF GROWTH	APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
	1. DORMANT. Apply with the first good spraying weather in March or early April.	Oil emulsion, 3% heavy oil, or a commercial oil spray.	Psylla, scale insects and mites.	For the control of pear psylla use an oil spray as an early spring application before egg laying begins. Apply with the first good spraying weather. Refer to Sec. 56 for specific instructions.
	2. DELAYED DORMANT, or PRE-PINK. Latter stage is shown at left.	Bordeaux, 3-8-100. Refer to sections 9 and 10 for instructions for making bordeaux.	Scab, leaf-blight, and curculio.	This application is good insurance on all susceptible varieties.
	3. PINK. Apply when the buds have separated in the clusters but before the blossoms have opened.	Bordeaux, 3-8-100 and lead arsenate, 3 lb. in each 100 gallons. Refer to sections 9 and 10 for instructions for making bordeaux.	Scab, leaf-blight, curculio, and bud moth.	This application should always be made in districts where scab is prevalent and everywhere on varieties such as Flemish Beauty. In many parts of the state, however, scab is seldom serious on most varieties. In such cases measures for its control may not be necessary.
	4. PETAL-FALL, or CALYX. Apply when most of the petals have dropped and after bees have quit working in the bloom.	Bordeaux, 2-8-100 and lead arsenate, 3 lb. in each 100 gallons of spray. See sections 9 and 10.	Scab, leaf-blight, codling moth, curculio and other chewing insects.	

THIS SCHEDULE WILL MAKE RESIDUE REMOVAL NECESSARY. IF FRUIT IS NOT TO BE WASHED, REFER TO SECTIONS 41, 42 AND 55.

	5. FIRST COVER. Two weeks after petals fall.	Bordeaux 2-8-100, and lead arsenate, 3 lb. in each 100 gallons of spray.	Codling moth, curculio, and other chewing insects, scab and leaf-blight.	Bordeaux may be omitted if scab and leaf-blight are not present. Refer to Sec. 56 for the summer treatment of psylla.
	5a. SECOND COVER. Two weeks after Application 5.	Lead arsenate, 3 lb. and water to make 100 gallons.	Codling moth and curculio.	<p style="text-align: center;">WARNING. IMPORTANT.</p> <p>Govern the use of lead arsenate during the summer by the prevalence of codling moth. Read carefully Sec. 55.</p>
	5b. THIRD COVER. Two weeks after Application 5a.	Lead arsenate, 3 lb. and water to make 100 gallons.	Codling moth and curculio.	
	6. SUMMER GENERAL COVER. Time determined the same as for apples.	Lead arsenate, 3 lb. and water to make 100 gallons.	Codling moth and curculio.	

See Sec. 54 for possible variations in materials for scab control.

sprayed with bordeaux do not suffer so severely from fire-blight as those in which bordeaux is not used. A definite disadvantage of bordeaux, with some varieties at least, is the fact that it causes russetting of the fruit. This is undesirable on Bartlett and possibly other smooth-skinned varieties but is probably an advantage with Bosc and possibly other varieties.

Lime-sulphur has been generally used in certain parts of the state apparently with satisfactory results, but the use of this material in the after-blossom applications does not seem to be the best procedure. For those who prefer that material, it is suggested that they use lime-sulphur at the rate of $2\frac{1}{2}$ gallons or preferably 2 gallons with water to make 100 gallons in the pre-blossom applications and to reduce the concentration in the after-blossom applications somewhat, or if scab is believed to be well under control to substitute one of the less injurious sulphur sprays in the after-blossom applications.

If lime-sulphur or other sulphur material is used during the summer, an application of "summer oil" for psylla should not follow a sulphur application within two weeks, nor be followed by one of sulphur until a similar period has elapsed. Because of this complication, every effort should be made to bring scab under control by the early sprays so as to avoid the use of a fungicide during mid- and late summer if oil sprays are to be employed.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF INSECTS ON PEARS

55. **Codling Moth and Spray Residue on Pears.** Codling moth is generally not so serious a problem with pears as with apples, and in most parts of the state it usually may be controlled without danger of excessive residue. Information regarding residue on pears is very meager, but it is believed that lead arsenate may be used in the petal-fall and first cover applications without causing excessive residue. If the codling moth infestation is such that further spraying is necessary and the fruit is to be washed, the schedule outlined on pages 32 and 33 should be followed. If, however, washing equipment is not available or it seems desirable to avoid washing, summer oil emulsion and nicotine sulphate or fixed nicotine should be used (see sections 15-16 and 42). To obtain with oil and nicotine the degree of protection afforded by the indicated schedule of lead arsenate, will require from six to eight applications beginning with Application 5A. The oil and nicotine application remains effective only for seven or eight days. The number of applications should be determined by the prevalence of codling moth, but should be held to as few as possible because of the cost and danger of injury to the trees. Summer oil emulsion, $\frac{1}{2}$ gallon, and nicotine sulphate, $\frac{3}{4}$ pint, with water to make 100 gallons, is the recommended strength. This treatment should also control pear psylla.

56. **Pear Psylla.** For the control of pear psylla, use a dormant early spring application of home-made oil emulsion containing 3 per cent of actual oil. This oil should have a viscosity of 175 to 250 seconds

QUINCES

APPLICATION	MATERIALS	TO CONTROL
DORMANT APPLICATION. If scale insects, mites, or leaf-rollers are prevalent, spray as indicated for these insects under apples.		
1. PRE-BLOSSOM. After leaves are well started.	Bordeaux, 3-5-100 and lead arsenate, 3 lb. in each 100 gallons.	Black-spot, curculio, codling moth and other chewing insects.
2. PETAL-FALL. Just after petals fall.	Bordeaux, 3-5-100, and lead arsenate, 3 lb. in each 100 gallons.	Black-spot, curculio, codling moth and other chewing insects.
3. Two weeks after Application 2.	Bordeaux, 3-5-100, and lead arsenate, 3 lb. in each 100 gallons.	Black-spot, curculio, codling moth and other chewing insects.
4. Two weeks after Application 3, and repeat in 8 days if codling moth infestation is heavy.	Summer oil emulsion, $\frac{3}{4}$ gal, nicotine sulphate, $\frac{3}{4}$ pt., and water to make 100 gallons. Refer to sections 28, 4 and 41.	Curculio, codling moth and other chewing insects.
5. SECOND GENERATION. Spray at the time recommended for the second generation of codling moth on apples, and repeat at 8 day intervals as long as necessary.	Summer oil emulsion, $\frac{3}{4}$ gal, nicotine sulphate, $\frac{3}{4}$ pt., and water to make 100 gallons. Refer to sections 28, 4 and 41.	Curculio, codling moth and other chewing insects.

Oriental fruit moth is a serious pest of quinces. It can be controlled by spraying thoroughly at weekly intervals with summer oil emulsion $\frac{3}{4}$ gallon and nicotine sulphate $\frac{1}{4}$ pint in 100 gallons of spray. Begin with the calyx spray and continue until harvest.

(Saybolt at 100° F.). Home-made oils can be emulsified either with bordeaux or other suitable emulsifier. Refer to sections 18 to 27 inclusive, for specific information about the making and use of oil emulsion. Bordeaux is most frequently used as the emulsifying agent. Several miscible oils and prepared oil emulsions are available and, in some instances, have given satisfactory results. Most of these preparations, however, are made from oils of lower viscosity than are desirable for best results. Dilute these materials according to the maker's instructions.

This application should be made in the early spring just before the adult psyllas have begun to lay eggs on the pear trees. In order to be sure of covering the branches before egg laying begins, apply the oil spray with the first suitable weather in March or early April, regardless of the number of psylla on the trees. In the southern counties of the state, the oil will usually need to be on in March, and further north as early as weather permits.

It is imperative that all parts of the trees be covered and this is accomplished best when the spraying is done from the ground as well as from the tank. Spray all shoots or suckers from the crown or roots, or, better still, cut and remove them from the orchard. It is also advisable to spray all interplanted and adjacent fruit trees of other kinds.

The use of oil-nicotine sprays, as recommended for codling moth control (refer to sections 15, 16, 42) should also control infestations of pear psylla.

57. **Pear-leaf Blister-mite.** This pest is best controlled by an application of lime-sulphur after the buds have begun to swell. Fairly good control can be obtained with the same material in the delayed dormant period. If scale insects are also to be controlled (which will not be necessary if the early application of oil has been used for psylla) dilute 12½ gallons of lime-sulphur with water to make 100 gallons. If scale is not present, the concentration may be reduced to 10 gallons of lime-sulphur with water to make 100 gallons. If applied in the delayed dormant period, the treatment will also be effective against pear scab and may be substituted in lieu of bordeaux at that time. A thorough treatment is usually effective for two or three or more years.

58. **Climbing Cutworms.** Refer to special instructions in Section 97.

59. **Fire-blight.** Upon request, special instructions for the control of fire-blight will be sent by the Botany Department, Michigan State College (see Section 36).

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF DISEASES ON CHERRIES

60. **Special Application for Brown-rot.** An application of sulphur on sweet cherries, one week or ten days before harvest, will prevent brown-rot, allow a longer harvesting season and protect the fruit during shipment. A dust is preferable because it leaves no noticeable residue on the fruit. Use sulphur with 5 to 10 per cent of hydrated lime or other "fluffer".

Sprays at this time, especially liquid lime-sulphur or copper materials with lime may stain the fruit. Wettable sulphur sprays are the least objectionable and are advised if a duster is not available. Wettable sulphurs are used at the rate of 5 to 8 pounds in 100 gallons of water.

61. Cherry Leaf Spot. Cherry leaf spot is caused by a fungus which lives over winter in old leaves on the ground. About the time of petal fall the spores developing in the old leaves become mature. During early rains these spores are discharged and carried by air currents to the young foliage on the trees. Under favorable conditions, such as rainy weather, the spores germinate and grow into the leaf tissue causing infection from which additional spores are produced. This disease can be controlled by spraying.

Proprietary copper materials (see Section 11) or a weak bordeaux (see Section 63) is recommended for the control of leaf spot on sour cherry in preference to liquid lime-sulphur. Experimental work in the last five years has shown that the proprietary copper materials are more effective in leaf spot control than lime-sulphur and do not dwarf the fruit as does strong bordeaux. **The same thoroughness and timeliness of application are necessary when using copper materials as when using lime-sulphur.** Following the instructions in the spraying calendar and applying the first and second cover sprays at intervals not longer than 14 days are important in the control of this disease. The addition of an equal amount of lime to most of the proprietary copper materials containing 25 per cent copper or less is recommended and double the amount of lime to those materials containing more than 25 per cent copper.

62. Lime-sulphur Sprays for Sour Cherries. Where lime-sulphur is consistently applied with thoroughness and timeliness so that overwintering disease inoculum is reduced to a minimum, it is possible for some growers to obtain satisfactory control. To control with lime-sulphur, it may be advisable to apply an extra pre-bloom spray, shorten the interval between applications to 10 days and include four or five sprays before harvest, depending on weather conditions. The after-harvest spray should be applied as soon as possible. **Never apply lime-sulphur on foliage which has had a previous copper spray because severe injury is certain to result.** Wettable sulphurs are not recommended for control of cherry leaf-spot.

63. Bordeaux Sprays for Sour Cherries. Bordeaux will control leaf-spot better than any other known spray material. It has, however, caused serious injury and dwarfing of fruit when used at concentrations of 4-6-100 or stronger in a four-spray schedule, especially in dry seasons. Since weather conditions cannot be predicted, the high concentrations are not safe under Michigan conditions. Recent experimental work tends to show that a 3-4-100 bordeaux is the maximum strength necessary to use on sour cherries for leaf-spot control in Michigan.

Bordeaux 2-3-100 seems to control leaf-spot as well as the recommended concentrations of proprietary copper materials. It has caused no significant dwarfing of fruit and little injury except in years of drouth. All bordeaux sprays may cause serious defoliation in late summer under drouth conditions, consequently they should not be used on trees growing in soils that are subject to drouth. If for any reason,

SOUR CHERRIES

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT.	Oil or tar sprays (refer to sections 18 to 28.)	Oil will control leaf-roller and case-bearer. Tar sprays will control case-bearer.	Instructions for control will be found in Section 69 for case-bearer and Section 46 for leaf-roller.
2. PETAL-FALL. When most of the petals have dropped.	Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lb., and water to make 100 gallons. See sections 11 and 63.	Leaf-spot, brown-rot, curculio, and slugs.	In years when blossoming is irregular or unduly prolonged, do not delay the application of the petal-fall spray but begin as soon as pollination has occurred but omit lead arsenate if bees are working.
3. FIRST COVER. Should be completed within two weeks after petal-fall.	Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lb., and water to make 100 gallons. See sections 11 and 63.	Leaf-spot, brown-rot, curculio, and slugs.	Lead arsenate should not be used later than this before harvest except on fruit that will go to the canning factory and will be thoroughly washed.
4. SECOND COVER. Should be completed within two weeks after Application 3.	Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lb., and water to make 100 gallons. Omit lead arsenate unless fruit is going to canning factory or can be washed. See sections 11 and 63.	Leaf-spot, brown-rot, curculio, and slugs.	Omit lead arsenate unless fruit is to go to canning factory or can be washed.
4a. SPECIAL. For the control of cherry maggot.	Refer to Sec. 7 for information concerning a special application for the control of cherry maggot in canning cherries.		Watch for special announcement on cherry maggot. See Sec. 67.
5. AFTER HARVEST. Immediately after the fruit is harvested.	Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lb., and water to make 100 gallons. See sections 11 and 63.	Leaf-spot and slugs.	

SPECIAL. On young growing trees extra applications may be necessary until growth is completed. Refer to Sec. 67 for special information on maggot control.

RESIDUE REMOVAL. Instructions will be furnished on request to Department of Horticulture. DO NOT follow a copper spray with lime-sulphur for summer applications during the same year.

SWEET CHERRIES

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT.	Lime-sulphur, oil, tar, and oil, or *D N. See next column.	Scale insects, (see Sec. 44). Leaf-roller, (see Sec. 46). Case-bearer, (see Sec. 69). Aphid (see sections 17, 20 and 27.)	
2. PETAL-FALL. Just after petals have fallen.	Lead arsenate 2 lb., 1 1/2 lb. 25% proprietary copper compound or 2 lb. of 12 1/2% proprietary copper compound plus 3 lb. of dry wettable sulphur plus 3 lb. lime. (See Sec. 64.)	Leaf-spot, brown-rot, curculio and slugs. (See Sec. 66 for aphid control.)	Important for control of leaf-spot and curculio.
3. TWO-WEEKS. Two weeks after Application 2.	Same as above.	Leaf-spot, brown-rot, curculio and slugs. (See Sec. 66 for aphid control.)	Lead arsenate should not be used later than this (before harvest) except on fruit that will go to the canning factory and will be thoroughly washed.
4. FOUR-WEEKS. Two weeks after Application 3.	Same as above. Omit lead arsenate unless fruit is to go to canning factory or can be washed.	Leaf-spot, brown-rot, curculio, slugs, and maggots. (See Sec. 66 for aphid control, and Sec. 67 for maggot control.)	Omit lead arsenate unless fruit is to go to canning factory or can be washed.
4a. SPECIAL. For the control of cherry maggot.	Refer to Sec. 67 for information concerning a special application for the control of cherry maggot in canning cherries.		
5. BROWN-ROT. About one week before picking.	Sulphur dust or spray of wettable sulphur.	Brown-rot.	See Section 60.

RESIDUE REMOVAL. Instructions will be furnished on request to the Department of Horticulture.
*D N. See sections 17 and 20.

the sprays have not been applied thoroughly and on time, an application of bordeaux 3-4-100 will be the most satisfactory one to check an established infection. It should be remembered that once a copper material has been applied it is not safe to resume use of lime-sulphur. Otherwise serious defoliation may follow.

64. Spraying Sweet Cherries. Experimental results the last three years have shown that a combination of proprietary copper compounds, wettable sulphur, and lime has given excellent control of leaf-spot and brown rot on sweet cherries and has caused much less foliage injury than the old lime-sulphur schedule. The concentrations used were $1\frac{1}{2}$ to 2 pounds of a copper compound, depending on copper content; 3 pounds of one of the standard brands of wettable sulphur, and 3 pounds of chemical hydrated lime. **Lime-sulphur cannot be substituted for wettable sulphur in this combination.** The appearance of the copper-sulphur-lime sprayed trees has been so much better that this combination for sweet cherries is recommended instead of liquid lime-sulphur.

65. The Green-vein Yellow Leaf Disease of Sour Cherries. The green-vein yellow leaf disease (physiological yellows) of sour cherries is sometimes mistaken for leaf-spot or for copper injury. This disease cannot be controlled by spraying. It has recently been shown to be of a virus nature. The symptoms of the disease are yellow foliage, large leaves, premature defoliation, a progressive reduction of spur growth, production of fruit on lateral buds and reduced yields of large size fruit. Defoliation may occur as early as two to three weeks after bloom and as late as after harvest. Most of the defoliation occurs during June and early July, and the first leaves formed are the first to fall. The fallen leaves vary in color from all green to all yellow. Most of the fallen leaves, however, are mottled green and yellow and an outstanding characteristic is yellow leaves with a definite green midrib and veins. Trees which are seriously defoliated show a progressive reduction in spur growth. The fruit is produced on lateral buds. This type of production results in long bare spaces on the twigs with the terminal bud the only growing point. Severely affected trees produce large leaves, light crops, and large fruit. The fallen leaves infected with yellow leaf disease differ from foliage attacked by leaf-spot in that they do not have any purple circular spots or brown dead areas. Defoliation occurs on individual trees scattered throughout the orchard while leaf-spot occurs more uniformly on all trees. Leaf-spot infected foliage is more of a uniform yellow color and does not have the green midrib and veins.

Copper-injured foliage differs from green-vein yellow leaf in that it occurs later in the season, especially after rainy or foggy periods. Copper-injured leaves are usually light yellow in color and have one or more large irregular dead areas in the leaf tissue. The veins on the under sides of the leaves are often purple in color.

Control: Growers should become acquainted with the symptoms of the disease so that they can distinguish it from leaf-spot, spray or drouth injury. Sprays, fertilizers, or cultural practices have no effect on the disease. The control measures adopted will depend upon the seriousness of the disease in the orchard. In orchards where the disease

is well established, the best plan, according to present knowledge, is to keep the orchard until it becomes unprofitable and then remove the entire orchard. If clean-up campaigns are considered, they should be on a local or district basis. The practice of removing only the seriously infected trees and replanting is not practical because the young trees may become diseased within a year or two. Where only a few trees in an orchard are diseased, they should be removed as soon as discovered. When planting new orchards purchase trees only from nurseries propagating from disease-free stock. The young orchard should be rogued once a week during the months of June and July and all diseased trees found removed immediately.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF INSECTS ON CHERRY

66. **Black Cherry Aphid.** This insect is often a serious pest on sweet cherries though of less importance to other groups. Activity starts with the new growth. The leaves are curled, growth is stunted, and the fruit may drop or become fouled with the honey-dew excreted. The curling of the leaves makes thorough spraying necessary. The information on control of black cherry aphid indicates that the best means of control, besides dormant sprays, is 1 pint of nicotine (see Section 15) plus 4 pounds of cheap soap or soap flakes in 100 gallons of water applied as a thorough drenching spray as soon as aphids are observed. The soap or soap flakes can be dissolved only in hot water and, unless dissolved, trouble will result from clogging the screens of the sprayer. Various liquid soaps and other nicotine activators which are very efficient for use with nicotine sprays are marketed. Black cherry aphid has been controlled repeatedly by nicotine dusts applied at first appearance of the insects.

The success of sprays or dusts applied for control of black cherry aphid depends upon getting the application on the trees before the leaves are badly curled. If the leaves become badly curled, it is almost impossible to eradicate the black cherry aphid.

A dormant application of tar, tar and oil or DN sprays (see sections 17 and 20) may be used to control black cherry aphids. If, for any reason, an infestation develops after such an application, it may be controlled by the previously outlined treatment with nicotine sulphate.

67. **Fruitflies.** There are two species of cherry fruitflies common in Michigan. These fruitflies produce footless and headless maggots, about one-fourth inch long, which feed inside the fruit. They are usually almost straight in form while the larvae of the plum curculio, which is even more commonly found in ripening cherries, has a small head and a body usually bent in a curve. The egg of the cherry fruitfly is laid in a slit cut in the young fruit in mid-June and early July. For canning cherries which are to be thoroughly washed, apply one or more applications of arsenate of lead, using 2 pounds to 100 gallons of spray. If necessary to control brown-rot or leaf-spot, include a fungicide as recommended in sections 60 and 61.

The exact spraying dates for cherry maggot are determined an-

nually by observations made by the Department of Entomology and supplied to county agricultural agents in the western cherry canning belt. Approximate dates can be supplied for other places if desired. Apply to your county agricultural agent for the observed dates.

68. **Climbing Cutworms.** Refer to special instructions in Section 97.

69. **Cherry Casebearer.** While the cherry casebearer is a minor pest, experimental work indicates that it can be controlled in the dormant season without injury to the trees. Proprietary oil and tar sprays used according to the manufacturers' recommendations and home-made oil emulsions at 8 per cent give excellent control of this pest. Most of the cherry casebearers spend the winter upon the twigs of the outer three or four feet of the branches. This makes it essential that this part of the tree be sprayed thoroughly, for only those insects hit will be killed. Great care should be exercised in spraying cherry trees with the heavy concentrations of oil necessary for control of the cherry casebearer, particular care being exercised to see that cherry trees are in the dormant stage when the spray is applied. It will be well also to observe the usual precautions regarding oil sprays (see Section 23).

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF DISEASES ON PEACH

70. **Brown Rot of Peach.** Brown rot may attack the fruit, blossoms or twigs. It may cause heavy losses in the orchard, considerable loss in transit, and disappointment to the consumer. This disease can be controlled by thorough spraying and sanitation.

Brown rot fungus lives over winter mostly on mummies (infected peaches which have dried) hanging on the tree and half-buried mummies on the ground. In the spring the mummies on the ground which are partially buried, produce small mushroom-like fruiting bodies which ripen and discharge their spores about peach blossom time. The mummies hanging on the trees also produce dusty masses of spores during wet spells at any time in the summer. For sanitary reasons knock all the mummies to the ground after the crop is harvested. Rake the rotted fruit far enough away from the trunk to reach the zone of cultivation. Disk or cultivate before bloom to disturb the half-buried mummies and prevent the formation of fruiting bodies.

71. **Control of Brown Rot by Spraying.** Standard varieties such as Hale, Elberta, and South Haven are somewhat resistant to blossom blight. Susceptible varieties such as Dewey, Prolific and Rochester should be given a special spray when the blossom buds show pink. To control fruit rot, curculio must be controlled first because rot follows heavy infestations of this insect. Fruit becomes increasingly susceptible as it approaches maturity. **The late sprays or dusts beginning one month before ripening and just previous to picking are very important in the control procedure.** Additional sprays or dusts sandwiched between these are necessary during wet, muggy weather occurring in the ripening period. Peach trees should be set at greater distances or

PEACHES

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT. Apply in early spring before growth starts.	Lime-sulphur, 5 gallons, and water to make 100 gallons for leaf-curl alone. If scale is present, increase lime-sulphur to 12½ gallons. If mites are present, use an oil spray with a fungicide. See Sec. 77.	Leaf-curl, scale insects and mites. If mites are present refer to Sec. 77.	To insure control of leaf-curl, this application should be made before growth starts. If mites are prevalent an oil spray is also necessary. See Sec. 77 for special instructions.
2. After the blossoms have dropped and the last of the "shucks" are falling.	DUST with arsenate of lead*lime dust containing 5% lead arsenate, or SPRAY with lead arsenate, 2 lb., in 100 gallons iron sulphate-lime or zinc sulphate-lime spray. See sections 3, 32 and 33.	Curculio. Refer also to sections 1 and 82.	If the arsenate of lead-lime dust is not available, an 80-5-15 sulphur-arsenate of lead-lime dust may be used, although the use of sulphur at this time is not essential. When spraying with acid lead arsenate on peaches, do not use more than 2 lb. in 100 gallons of spray.
3. About two weeks after No. 2.	DUST with 80-5-15 sulphur-arsenate of lead-lime dust, or SPRAY with wettable sulphur 4 to 6 lb., and lead arsenate, 2 lb., in 100 gallons of iron sulphate-lime or zinc sulphate-lime spray. See sections 3, 32 and 33 (nicotine sulphate 1 pt. See Sec. 76.)	Curculio, scab and brown-rot. Refer to sections 3, 32 and 33. Vectors of virus diseases. See Sec. 76.	This spray is important to check the early development of scab and brown-rot. Include nicotine to control sucking insects which transmit peach virus diseases, only if these diseases are present in the locality. See Sec. 76.
4. About one month before the fruit ripens.	DUST with sulphur (with fluffor), or SPRAY with wettable sulphur 4 to 6 lb. See Sec. 8.	Brown-rot and scab. See Sec. 70.	Do not use lead arsenate at this time unless absolutely necessary. This period is the most important time to control brown-rot.
4a. One week after No. 4.	Sulphur-oil-lime dust. See Sec. 78. Or spray with wettable sulphur, 4-6 lb.	Oriental fruit moth and brown-rot.	Sulphur sprays are especially important in brown-rot control if wet weather occurs.
4b. Two weeks after No. 4.	Sulphur-oil-lime dust. See Sec. 78. Or spray with wettable sulphur, 4-6 lb.	Oriental fruit moth and brown-rot.	
5. One week to ten days before the fruit ripens.	DUST with sulphur (with fluffor), or SPRAY with a wettable sulphur, 4 to 6 lb. See Sec. 8.	Brown-rot. See Sec. 70.	On many varieties this application is often important to retard rot development during or after harvest.

CAUTION. Study carefully Sec. 79. Use P. D. B. about September 15 for peach borer. See Sec. 79.

*Basic lead arsenate does not require a corrective on peaches. See Sec. 13.

pruned to allow room for the spraying or dusting machinery to go between trees at ripening time and allow for spray manipulations. In closely planted orchards a semi-portable stationary spray outfit may be the solution of this problem. Graders with brushes should be supplied with sulphur dusting equipment to protect the bruised fruit and prevent rot in transit. The wettable sulphur sprays or sulphur dusts will prevent brown rot if applied before infection occurs.

72. Bacterial Spot. This disease is most readily seen on leaves and fruit as small angular dark brown spots. It is distinguished from arsenical injury by the small size and rougher margin of the spots which do not fall out as readily as those of arsenical injury. Bacterial spot begins as a small water-soaked spot. Indications of bacterial exudate can frequently be found. This disease was serious in a few orchards in 1938 and 1939. Experiments by the United States Department of Agriculture have prompted recommendations of five or six sprays of zinc sulphate-lime, 8-8-100 (see Section 33) beginning with the petal-fall spray and repeated applications at 10- to 14-day intervals. This program is reported to prevent much of the injury but has not received experimental attention in Michigan because the disease has not been generally present. Vigorously growing trees are less severely attacked. Fertilization and tree vigor keeps the disease in check.

73. Coryneum Blight. Coryneum blight is serious in many orchards in certain areas in the state. On green shoots, leaves, and fruits, the characteristic circular lesions are readily identified by the red ring or margin surrounding the gray or cream-colored center. Defoliation and shot holing accompany severe cases. Death of individually affected buds and gumming usually accompany the lesions on twigs. Bordeaux 16-16-100 applied in the fall about October 15 or about the time of leaf fall has effectively controlled this disease. This application will also control leaf curl. A second bordeaux spray, 8-12-100, should also be applied in the spring late in the dormant period in serious cases of the disease.

74. Peach Canker. Peach canker is a fungous disease affecting the twigs, branches, and trunks of peach trees. Cankers may occur on any part of the twigs, branches, and trunk, and are common in the crotches.

The disease organism gains entrance to the host through winter-injured wood, pruning wounds, dead twigs, and brown rot cankers. Practices which will prevent winter injury, control brown rot and keep trees in a moderate growing condition, together with proper pruning methods, are steps in treating this disease.

PRUNING—

1. It is best to delay pruning until about March 1, and then the older trees should be pruned first, leaving the younger trees until last. Earlier pruning may spread the disease.

2. Prune young trees lightly. Older trees need heavier pruning, the amount depending on the crop prospects.

3. No stubs should be left in pruning.

4. It is important to remove all dead wood at pruning time. If

any is overlooked it should be removed not later than the end of June. This can be done at thinning time.

5. Remove all prunings from the orchard and burn as soon as possible.

6. Trim out cankers and coat exposed surfaces with an antiseptic.

WINTER INJURY—

Winter injury is more likely to occur most seriously on vigorous trees which were permitted to grow late in the season. Approximately 18 inches of terminal growth on young trees and 12 inches on bearing trees is satisfactory. Fertilize the trees so they will maintain the proper growth and no more. Stop cultivating and sow a cover crop in young orchards late in June, and in bearing orchards not later than July 15.

SPRAYING—

The brown rot organism which causes decay of the fruit often infects the twigs, and these lesions in turn may permit the entrance and development of canker. Spray carefully to control brown rot. Also, remove all fruits showing brown rot infection before the disease has a chance to spread to the twigs.

The results of experimental spraying to control peach canker are limited and inconclusive. No differences could be observed in any of the plots sprayed last season with several kinds of fungicides compared with plots of unsprayed trees.

TREATING CANKERS—

The cankers should be trimmed out to live healthy bark and the exposed areas painted with a mild disinfectant such as shellac, kolofog, or Corona wound dressing. The lower end of the wound should be trimmed to a point to help healing and avoid collection of moisture. The cankers will heal more readily if treated the latter part of May or in June when the wood is growing rapidly.

75. Leaf Curl. One application of strong fungicide during the dormant period controls leaf curl. This disease can be controlled by proper fall spraying. It is suggested to those who care to practice fall spraying that bordeaux, 8-12-100, be used after the leaves have dropped.

Bordeaux will not control scale insects, or red mite. Where oil is used to control San Jose scale or red mite in the dormant period, bordeaux can be included in this spray for the additional control of leaf curl (see Section 77). Lime-sulphur, 5 gallons in 100 gallons of spray or stronger, will control leaf curl and if used for that purpose should be applied in the spring before the buds swell. Leaf curl infections occur only during a limited period while the buds are opening in the spring. The disease must be controlled before infection occurs. Foliage applications are of no value after the disease becomes established.

76. Peach Virus Diseases. Virus diseases are caused by plant proteins or living organisms too small to be seen with the microscope. They are spread from plant to plant by sucking insects or by propagation of diseased trees. Some varieties mask the symptoms of virus infection. Certain varieties of plums may be symptomless carriers of

peach yellows and little peach. Wild chokecherry carries "X" disease of peach and also green-vein yellow leaf disease of cherry. Other wild cherries have been demonstrated to carry certain cherry virus diseases in the western states.

Viruses cannot be reached and killed with sprays but spray control of the insect vectors may be of value in reducing the spread of these diseases. Peach yellows, little peach and red suture are probably spread by one insect only. This insect is a leaf-hopper primarily found on plums and is known as *Macropsis trimaculata*. It has but one brood a year, and during early summer the insect is present in wingless form. This insect can be controlled by one spray of nicotine sulphate applied in mid-June. This spray appears advisable in orchards where peach yellows, little peach, or red suture is a serious problem.

Rosetted mosaic, a rather rare peach disease, is carried over in the soil. Infected peach trees should be removed. Do not replant for several years when this disease has been present.

"X" disease in peach orchards is unlikely if there are no chokecherries in the vicinity. Eradicate the chokecherries for a distance of 500 feet from the orchard by completely grubbing out the tree and all of its roots or by spraying with an eradicant spray in early July. Sodium chlorate with a deflagrating agent (sold under trade names such as "Atlacide") should be applied at the rate of $\frac{3}{4}$ pound to a gallon of water until the chokecherry leaves are thoroughly wet. Such a spray should completely kill the tree and prevent further sprouting from the roots.

The chokecherry is a low-growing shrub (rarely a small tree) and can be differentiated from the supposedly harmless large black cherry tree by the size of the tree, the character of the bark and the "teeth" on the leaves. Chokecherries have a dull gray-brown bark and more numerous and sharper points on the "teeth" of the leaves. Chokecherries blossom one week earlier than black cherries and are very readily located at blossoming time. Locate and mark the chokecherries when they are in full bloom. Eradicate them by sprays in early July. Eradication by sprays is more complete than by other methods.

It has been established by law that growers must remove trees showing evidences of harmful virus diseases. Inspection and quarantine for these diseases is under the control of the State Department of Agriculture.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF INSECTS ON PEACHES

77. European Red Mite. This pest overwinters in the egg stage (Section 45). If the minute red eggs of this mite are present, the application of an oil spray containing 3 per cent actual oil is necessary. A complete and thorough coverage is necessary if all eggs are to be killed. Since it is always good insurance to spray peaches for the control of leaf curl, it is desirable to combine a fungicide with the oil spray. The home-made bordeaux emulsion can be used with bordeaux (see Section 25). To make a 3-per cent oil spray with fungicidal value, add $4\frac{1}{2}$ gallons of home-made oil emulsion to 100 gallons of bordeaux

(8-12-100). This can best be accomplished by first making the emulsion in the sprayer and then pumping the emulsion into a separate container. Then make the bordeaux in the sprayer in the usual way (sections 9 and 10) and finally, when the tank is nearly full, add the oil emulsion. Keep agitator in operation at all times. This 3-per cent oil and bordeaux combination may be used in the dormant period to control red mite, San Jose scale and leaf curl in one spray application. Fungicides for the control of leaf curl may be added to proprietary oils according to the manufacturers' recommendations. Oil sprays or oil-fungicide combinations should be applied in the spring only.

78. Oriental Fruit Moth. This insect is most successfully fought by its parasites which have been introduced into most peach-growing sections and are being added to, each year by new introductions. Injury to the twigs is sometimes conspicuous but causes no permanent harm to the tree, although it provides a point of infection for peach canker. Oriental fruit moth has four generations in Michigan but it is usually the third generation before the fruit is attacked. This commonly occurs about the season of Elberta ripening. Peaches ripening after Elberta are likely to be infested.

Early cultivation reduces the population of oriental fruit moth as most of them go through the winter on mummies or on pieces of weeds beneath the tree. Treatment with paradichlorobenzene (P. D. B.) for peach borer kills some oriental moth.

Insecticidal treatments for oriental fruit moth have never been so effective as for curculio and other insects attacking peaches.

The best insecticidal treatment tried to date has been weekly applications of $\frac{1}{2}$ pound per tree of a dust consisting of 60 pounds sulphur, 5 pounds of oil, and 35 pounds of lime or talc. The treatment should begin about one month before picking. This dust may be mixed at home or purchased from one of several companies.

79. Peach Borers. These insects are larvae of moths. They tunnel between bark and wood of crown, trunk, and upper roots of peach and some other trees. Treatment with paradichlorobenzene (P. D. B.) is the accepted method of control. Prepare the ground by removing weeds, grass, and debris from near the crown of the tree. Do not loosen soil. Remove most of the gum which may be present. Distribute the crushed crystals in a narrow ring about the crown, not nearer than one inch, nor more than two inches away from the crown. Use one ounce on trees six years old or more, $\frac{3}{4}$ ounce on trees 5 years old and $\frac{1}{2}$ ounce on trees 4 years old. Do not use paradichlorobenzene on trees until they have been in the field for three years. Cover lightly with soil, being careful not to disturb the ring of crystals. Apply late in August or about the first of September. Paradichlorobenzene (P. D. B.) is only partially effective when the temperature of the soil at 4 inches depth is less than 60° F.

Heavy clay soils have a tendency to retain the fumes of paradichlorobenzene. With such soils, the mounds should be withdrawn in three or four weeks and the trees mounded again with fresh soil.

In case one does not wish to use paradichlorobenzene, he may dig out the larvae in spring or fall.

During the last 3 years, applications of paradichlorobenzene dis-

solved in a miscible oil and applied as a spray has been tried successfully on young trees. This is accomplished by dissolving 2 pounds of paradichlorobenzene in 1 gallon of miscible oil and diluting to 30 gallons and then spraying about the base of the young trees. Because at this dilution each gallon of solution contains approximately one ounce of paradichlorobenzene it is possible to apply small dosages easily. One to two quarts, depending upon the age of the tree, is the proper dosage. This treatment has not been so effective on older trees as the standard crystal treatment.

Ethylene dichloride emulsion has caused so much damage it cannot be recommended.

80. Lesser Peach Borer. The lesser peach borer, which is often confused with its relative, the peach borer, works in the trunk, crotch and large limbs of the peach tree. The presence of these insects in such locations is shown by masses of gum and frass which are often very noticeable because of their size and number. The application of paradichlorobenzene in raw cottonseed oil any time between September 1 and April 15 will control these pests. It should not be applied, however, when the temperature is 50° F., or below, for the material will crystallize. Painting the mixture upon the infested areas after removal of the gum will kill virtually all of the borers, while painting without removal of the gum will kill about 90 per cent. This mixture consists of 1 pound of paradichlorobenzene dissolved in 2 quarts of raw cottonseed oil.

81. Climbing Cutworms. Refer to special instructions in Section 97.

82. Curculio. In peach plantings where curculio is of importance as a pest, clean-up measures will aid materially in its control. The use of heavy arsenical applications on peach trees causes burning. Clean-up measures which can be applied to the peach orchard are the same as those described in Section 51 for apple orchards, with the addition of proper disposal of the thinnings, which normally include curculio-infested peaches. All things and drops should be thrown out into the space between the rows, so that the sun shines upon them. Then the heat of the sun will destroy most of the curculios which would otherwise develop.

83. Black Peach Aphid. This pest is a dark, shiny plant louse that works both in the tops and on the roots of peach. It starts out in localized areas in peach orchards. In the tops, it may be killed by the usual nicotine sprays. On the roots, it is very resistant and no satisfactory control method is now known. When "dead spots" due to this insect appear in the orchard, remove the trees from those areas and seed the land to clover for several years before resetting to peaches.

84. Rose Chafer. Rose chafers cause great annoyance and loss at times on all fruits. Attacks are usually in the vicinity of sandy quack grass sod where the insects spend their immature stages. The "hit-run" nature of their damage and their extreme toughness has made it difficult to devise a control. Whether to apply a special spray should be decided upon the basis of immediate value of the crop, or possible value of young trees, because the pyrethrum sprays used in controlling

rose chafers are very expensive. Wherever possible, the repellent lime spray should be used.

On grapes, the inclusion of 5 pounds of arsenical and 1 gallon of molasses in 100 gallons of one of the bordeaux sprays being applied at the time of attack has been the best treatment. This treatment causes injury on all other fruits.

On brambles and rosebushes, a 10 per cent pyrethrum dust when applied at frequent intervals has given excellent control. This treatment seems inadaptably to orchards.

On tree fruits, rose chafers have been controlled by spraying with a pyrethrum spray containing mannitol monolaurate* (1 pint in 100 gallons). This spray kills the rose chafers present, but others infest the trees in about 48 hours.

When the insects first appear, or to prevent reinfestation after a pyrethrum spray, a spray of 25 pounds of lime plus 4-6 pounds of wettable sulphur should be immediately applied on peaches.

Two sprays containing not more than 15 pounds of lime per 100 gallons, plus 4-6 pounds wettable sulphur, have been applied to cherries, apples, pears and plums without noticeable injury. Where this spray is also to protect against codling moth on apples, add 4 pounds lead arsenate.

The repellent sprays are especially necessary on young trees.

Pyrethrum if mixed with lime is not nearly so effective in killing rose chafers.

There is no use trying to out-guess rose chafers. **Do not spray in advance** but be on the alert for them, and as soon as they appear, spray. Fruit trees, especially sweet cherries and young apples, can be killed by repeated heavy applications of lime.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF DISEASES OF PLUM

85. **Sanitary Measures for Brown Rot Control.** Brown rot of plum, the same disease as found on the peach and cherry, is controlled primarily by spraying, but thinning of the fruit and certain sanitary measures will help greatly. The fruit should be thinned soon after the June drop so that the plums will not touch when ripe. Rot will spread more easily from one plum to another if they touch. All "mummied" fruits from the previous season should be removed from the tree, raked from the ground and destroyed. They are sources of reinfection. **Curculios must be controlled as brown rot follows their injury** (See sections 82, 51). See Section 71 for instructions on brown-rot sprays for stone fruits.

86. **Black Knot.** Plum or cherry orchards in which this disease is present should be inspected in the late fall or early spring before spore dissemination takes place, and all knots removed and burned. A single inspection and treatment each year will, in most cases, give control. If the disease is well established on a very susceptible variety, more frequent pruning of diseased parts may be necessary. A dormant spray

*This is sold under the trade names of NNOP and Pyrosread.

PLUMS

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT. Apply just before growth starts.	Lime-sulphur, 12½ gallons, and water to make 100 gallons, for scale insects, or 3 % oil for mites or scale.	Scale insects and mites.	Whether or not this application is necessary will depend on the prevalence of mite eggs or scale.
2. PRE-BLOSSOM. Just as leaf buds burst and before blossoms open.	Lead arsenate*, 3 lb. plus corrective. (See sections 3 and 33) and water to make 100 gallons.	Curculio.	Curculio coming out from hibernation feed on the opening buds. This application is important.
3. PETAL-FALL. Just after the petals have fallen.	Wettable sulphur 4 to 6 lb. and lead arsenate, 3 lb. plus corrective. (See sections 3 and 33) in 100 gallons.	Curculio, leaf spot and brown rot.	This spray is important for leaf spot, brown rot, and curculio.
4. TWO-WEEKS. Ten days to two weeks after No. 3.	Wettable sulphur 4 to 6 lb. and lead arsenate, 3 lb. plus corrective. (See sections 3 and 33) in 100 gallons.	Curculio, leaf spot and brown rot.	The number of early summer applications necessary will depend on the prevalence of leaf spot and curculio. Leaf spot is not serious in some districts.
5. LATE SUMMER. About one month before harvest.	Wettable sulphur, 4 to 6 lb. in 100 gallons. See Sec. 8.	Brown rot and leaf spot.	This is an important application in the control of brown rot.
6. SPECIAL. One week to ten days before harvest.	Sulphur dust (with small percentage of a fluffer), or a non-staining spray. (See Sec. 8.)	Brown rot.	This application is very important to prevent the development of rot as the fruit ripens and during transit.

*Basic lead arsenate does not require a corrective. See Sec. 13.

of lime-sulphur or oil-bordeaux will eliminate many spores of black knot. The usual summer sprays also help check new infection. See Section 77 for instructions on oil-bordeaux.

87. **Bacterial Spot.** Refer to Section 72.

88. **Virus Diseases.** Peach yellows, little peach, and a new peach virus known as rosetted-mosaic can also affect plum trees. On some varieties these diseases may be present but the symptoms are masked. A plum leafhopper can transmit these diseases from plums to peaches. All plum trees in peach districts should be regarded with suspicion. Remove any unprofitable plum trees and plum thickets as a sanitary precaution. All remaining plum trees should be sprayed with nicotine sulphate, 1 pint in 100 gallons of water, about 3 weeks after petal-fall, or include this material in Application 4. This application will eliminate the leafhoppers. See Section 76.

SUPPLEMENTARY DIRECTIONS FOR CONTROL OF INSECTS ON PLUMS

89. **Red Mite.** Plums are frequently infested with red mites. The treatment is the same as that recommended for the apple. (Refer to Section 45.)

90. **Curculio.** In plum plantings where curculio is of importance as a pest, clean-up measures will aid materially in its control. Clean-up measures which can be applied in the plum orchard are the same as those described in Section 51 for apple orchards, with the addition of proper disposal of the thinnings, which normally include curculio-infested plums. All thinnings and drops should be thrown out into the space between the rows, so that the sun shines upon them. The heat of the sun will destroy most of the curculios which would otherwise develop.

91. **Aphids.** The foliage of plums, especially of the growing tips, is often seriously attacked by aphids. Their control can best be accomplished by spraying as indicated for cherry aphids in Section 66.

92. **Climbing Cutworms.** Refer to special instructions in Section 97.

SUPPLEMENTARY DIRECTIONS FOR GRAPES

93. **Black Rot.** This disease develops best in rather warm, rainy weather and usually becomes established early in the season in a seemingly insignificant way in the form of spots on the leaves. If weather conditions continue favorable, it spreads from there to the fruit and may cause heavy loss. Black rot does not develop in epidemic form every year and in the non-epidemic years grapes free from rot can be grown with the use of little or no bordeaux. This condition leads many growers to become lax in their spraying operations and they omit one or both of Applications 1 and 2, with the result that rot may develop seriously under favorable conditions if the primary or early infection

GRAPES

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. When shoots are 4 to 5 inches long.	Bordeaux, 8-8-100. Calcium arsenate, 3 lb. plus 3 qt. of summer oil in each 100 gallons of spray. See Sec. 9 and 10 for instructions for making bordeaux.	Black rot, downy mildew, berry moth and dead arm.	Applications 1 and 2 are usually very important for rot control in seasons when it develops in epidemic form. They should be made every year as insurance against rot. Refer to Sec. 93 for further discussion of black rot.
2. Just as the blossom buds are opening.	Same as above.	Black rot, berry moth, downy mildew, and rose chafer.	If rose chafer is present, use 5 lb. lead arsenate and perhaps a gallon of cheap molasses (See Sec. 84). This is a critical application for the control of berry moth.
3. Immediately after fruit sets.	Same as above.	Black rot, downy mildew, berry moth, See Sec. 95 and rose chafer. See Sec. 84.	This application is imperative for berry moth control.
4. Two weeks after full bloom.	Bordeaux, 8-8-100. Calcium arsenate 3 lb. plus 3 qt. of summer oil plus 1 pt. nicotine sulphate. See Sec. 9 and 10 for instructions for making bordeaux 3 lb. fixed nicotine (14%) plus ½ lb. rosin fish oil soap plus 3 lb. proprietary copper compound to each 100 gallons of spray.	Black rot, downy mildew, leaf hopper, berry moth and rose chafer. See Sec. 95.	If rose chafer is very bad or berry moth very plentiful, make this application four days earlier.
5. About the time the berries begin to touch, or just before first leaf hoppers acquire wings.	Fixed nicotine (14%) 3 lb. plus ½ lb. rosin fish oil soap, 3 lb. proprietary copper compound to 100 gallons of spray.	Black rot, downy mildew, leaf hopper, berry moth.	Better leaf hopper control follows inclusion of fixed nicotine in this spray.
6. Time determined by observations. Usually around August 15.	Fixed nicotine (14%) 3 lb. plus ½ lb. of rosin fish oil soap, to 100 gallons of spray.	Berry moth.	Particularly valuable in heavily infested vineyards.

has not been prevented. Some experienced growers feel they can predict whether rot will develop, and they govern their spraying operations accordingly. Experience has shown that such predictions are not always reliable. Therefore, there is only one safe general procedure to insure satisfactory control of black rot, and that is to make Applications 1 and 2 regularly every year. These applications also prevent many new infections of the dead-arm disease.

94. **Dead Arm.** This disease attacks the above ground parts of the vine, slowly killing the canes. Affected arms show dwarfed, yellow leaves in the early season, but later the vine appears to recover. Diseased vines are difficult to locate at pruning time. Mark the affected vines early in the season, remove them or cut them off well below the last visible sign of the dry heart rot in the trunk at pruning time, and allow a renewal sprout to replace the old trunk. **The first grape spray is important in preventing new infections of dead arm where this disease is prevalent.** It will not control established infections.

95. **Grape-berry Moth.** This insect has recently been especially destructive.

Thorough spraying in all applications is necessary for control of berry moth. The residue situation is such that the schedule is arranged to concentrate all arsenicals into the period when they will be most effective.

The alternative spray schedule using fixed nicotine beginning with Application 4 is designed to give control of both berry moth and leaf hopper. Experimentation has shown that the schedule outlined will give equal control of berry moth, better control of leaf hopper and less danger of injury than can be had for the same amount of money spent on the older treatment.

The use of a hooded boom will always give better control with any materials used on grapes.

The difficulty of spraying control places an added importance upon supplementary measures. Destruction of weeds, accumulations of leaves in the vicinity of woodlands, gullies, low places, hollows, and fence rows will aid in controlling berry moth.

The most important single clean-up measure that can be applied is to turn under all vineyard refuse as early in the spring as possible and leave it **undisturbed** except for very shallow cultivation until late June regardless of weed growth. Information at hand indicates that plowing to the vines is more effective than plowing from them.

96. **Grape Leafhopper.** Spray in exactly the same manner as outlined for the control of berry moth. It is necessary to coat the under sides of the leaves. Use nicotine sulphate with bordeaux, as indicated in Application 5; or, if bordeaux is not needed, use nicotine sulphate, one pint in 100 gallons of water, with $1\frac{1}{2}$ pounds of casein-lime. The use of fixed nicotine for grape-berry moth in the 4th and 5th recommended sprays of the grape schedule (page 52) also gives excellent control of leafhopper. If dust is preferred, use 2-per cent nicotine in hydrated lime. Apply dust at night while air is still. Use freshly mixed, hot dust. If cold dust is used, a higher percentage of nicotine is required. This application should be made just before the first nymphs acquire wings.

97. **Climbing Cutworms.** In common with ordinary cutworms, the species having the climbing habit feed at night and are most numerous in or near grass sod. All cutworms are likely to be more numerous during a cold, wet spring. The attack comes early in the season. The worms ascend the plants and feed on buds, young leaves, blossoms, or young fruits. In the case of trees, a narrow band of tree-tanglefoot spread with a paddle around a trunk or large limbs is all that is required. With grapes, the trunk and the wires on both sides of the posts should be treated with Tanglefoot.

In newly set plantings, the Tanglefoot should be applied to a strip of paper, which is wrapped around the trunk. Poison-bran bait should be scattered on the ground beneath the branches to supplement the bands and to prevent the worms from gnawing the bark just below the bands. About two handfuls scattered thinly about each plant in the evening will be sufficient. If scattered in such a way that no lumps are left, the danger to farm animals is negligible.

Formula for Bran Bait

For small scale baiting:

- 20 pounds wheat bran
- 1 pound white arsenic
- $\frac{1}{2}$ gallon molasses
- 2 ounces amyl acetate of good grade (banana oil)
- Water to moisten

Add molasses and poison to 5 or 6 quarts of water and stir all ingredients together and add enough more water to moisten thoroughly. Success depends largely on the thoroughness of the stirring.

For large scale baiting:

A greatly improved bait can be made by dissolving 3 pounds and 4 ounces of caustic soda (lye) in 7 pints of water and then stirring in and dissolving 10 pounds of white arsenic. This makes a stock solution of arsenite of soda containing approximately 8 pounds of arsenite to the gallon. In preparing bait, add 1 quart of the stock solution to 10 gallons of water and 2 gallons of cheap molasses; use this mixture to moisten 100 pounds of bran, and then stir in 3 ounces of banana oil.

98. **Flea Beetle.** The grape flea beetle formerly was a serious pest in this state but the regular routine sprays which are usually applied in Michigan vineyards have proved very effective in controlling it.

The beetles, which hibernates under rubbish, attack the opening buds. Later, the adults and larvae feed together on foliage and on fruit. When the beetles are especially plentiful, burn rubbish late in the fall, and spray the vines with 4 pounds of lead arsenate in 100 gallons of water or bordeaux just as the leaf-buds are bursting.

99. **Grape Rootworm.** The adult of the grape rootworm is a reddish brown beetle, covered with short gray hairs, and about one-fourth of an inch in length. This beetle eats chain-like holes in the upper surface of the leaves of grapes during June and July and later lays clusters of eggs in the loose bark of the cane. The larvae drop to the soil and work their way to the roots. At this time the larvae are tiny white grubs about two-fifths of an inch long. They pass through the winter as partially grown larvae and complete their growth in late May and early June in earthen cells under ground. Grapes which are

sprayed thoroughly for berry moth usually are not attacked. If chain-like punctures appear on the leaves, make a special arsenical application, spraying downward, since root injury is severe if adults escape poisoning.

SUPPLEMENTARY DIRECTIONS FOR CURRANTS AND GOOSEBERRIES

100. **Aphids.** Currants and gooseberries are often attacked by aphids which cause the leaves to curl and sometimes to turn red. Spray as directed in schedule.

101. **Witches'-broom.** One species known as the Houghton gooseberry aphid produces witches'-brooms or brushy-galls on gooseberry. This louse, whose work is not entirely confined to the Houghton gooseberry, nevertheless prefers that variety to others. The species overwinters on the gooseberry in the egg stage. The eggs hatch in April and May and a spray of nicotine sulphate as recommended in Application 2 is more effective than at any other time, for, while the witches'-brooms develop later in the season, the lice themselves are more plentiful on the currants just after the eggs hatch.

102. **Leaf Eating Insects.** The most common important leaf feeding insect on currants is the imported currant worm. This caterpillar-like larva and practically all others on currants and gooseberries can be killed by pyrethrum dusts or sprays used according to manufacturers' recommendations. If one desires to mix his own dust, shake together equal parts of flour, or talc, or powdered chalk and freshly ground pyrethrum and dust thoroughly. Rotenone dusts and sprays are also effective in controlling currant worms. These materials are effective but kill insects of the size of currant worms slowly. Either pyrethrum or rotenone may be used without danger of poisonous residue.

103. **Currant Borer.** The currant borer is a moth larva which burrows in the canes of the currants, eats out the pith, and leaves a blackened furrow which causes the death of the cane. The parent moths fly in June and deposit eggs that produce larvae which almost reach maturity by fall. They complete their growth in early spring, pupate in the burrows, and each one produces an adult moth. The infested canes usually start growth in the spring but soon die. Cut out the infested canes, which are indicated by the sickly foliage. Be sure to cut below the bottom of the burrow, and immediately burn all prunings.

RASPBERRIES, DEWBERRIES, AND BLACKBERRIES

104. Use vigorous disease-free plants. Every new planting should be started with vigorous plants which have come from plantings that have a minimum amount of mosaic, curl, streak, and orange rust. The best plants are usually obtained from young fields. Where possible, the plants should be taken directly from the mother plants to the new field.

CURRANTS AND GOOSEBERRIES

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT. Apply just before growth starts.	Lime-sulphur, 12½ gallons, and water to make 100 gallons, or oils containing *DN as recommended for scale on apples. See sections 17 and 20.	Scale insects and aphids.	Scale is seldom found on gooseberries, but is often present on currants. Inspect carefully and spray when necessary.
2. When terminal leaves are one-half to one inch in length.	Bordeaux, 8-12-100, (See sections 9 and 10), lead arsenate, 3 lb., and nicotine sulphate, 1 pint in each 100 gallons of spray.	Leaf spot, leaf-eating insects, aphids, and four-lined leaf-bug.	If DN has not been used in the dormant period this is a critical application for aphid control. Thorough spraying at this time is important. Spray the under sides of the leaves.
3. Soon after the blooming period.	Bordeaux, 4-6-100, (See sections 9 and 10.)	Leaf spot and mildew. See Section 102 for control of leaf-eating insects after blossoming period.	The number of summer applications should be governed by the prevalence of leaf spot and the susceptibility of the varieties grown. If aphids persist, add nicotine sulphate and spray very thoroughly.
4. Ten days or two weeks after No. 3.	Bordeaux, 4-6-100, See sections 9 and 10.)	Leaf-spot and mildew. See Section 102 for control of leaf-eating insects.	If currant worms appear refer to Section 102.
5. Just after the fruit is harvested.	Bordeaux, 8-12-100, (See sections 9 and 10.)	Leaf-spot and mildew.	This is desirable when leaf spot has not been well controlled in early summer.

*DN, See sections 17 and 20.

Remove the old canes, commonly called tails or handles, from black raspberry and dewberry tips before planting. Anthracnose is carried to the new field on the "tails". The removal of these and the covering of all parts of the tips with soil greatly reduces anthracnose in the new planting.

Plant black raspberries at a distance of at least 50 yards from red varieties. Red varieties, especially King and Latham, commonly act as carriers of mosaic viruses which do little damage to reds and may be masked but which cause severe stunting of blacks. Wild red raspberries in the immediate vicinity of black raspberry plantings are also a source of infection. The spread of mosaics to blacks from wild reds is sometimes very rapid, especially if the wild plants are in shaded locations where aphids are abundant.

Rogue older raspberry plantings if the percentage of disease is not too high. It is rarely profitable to rogue fields more than a year old and having more than 10 per cent mosaic, streak, and orange rust. If the percentage is lower, careful roguing may be of value. No field which is well rogued the first year should show more than one per cent of the plants diseased the second year. Usually, old fields having less than 2 per cent of these diseases can be successfully rogued.

105. **Anthracnose.** Spray black raspberries, King and Latham red raspberries and dewberries for anthracnose. Applications should be as follows:

1. Just as the buds show green. Use 10 gallons of lime-sulphur with water to make 100 gallons. The addition of 1 pound of casein spreader will improve the spray.

2. About one week before the blossoms open. Use bordeaux 4-6-100. (See sections 9 and 10 for instructions for making bordeaux.) Casein spreader, 1 pound in 100 gallons may be used as a spreader. Especial care should be taken to cover completely all new canes with this application.

Usually, red raspberries and blackberries are not sprayed, but they should be treated in the same way if anthracnose develops. Purple raspberries may be sprayed if anthracnose becomes severe.

106. **Borers, Girdlers, and Tree-crickets.** The borers, girdlers, and tree-crickets affecting raspberries over-winter in the canes. The removal of all mutilated or distorted canes in spring and their immediate destruction by fire will eliminate a large proportion of trouble from these pests the first year it is practiced. The continuation of this practice, together with the elimination of wild plants in the vicinity of cultivated raspberry plantings will, in a very few seasons, reduce the population of these insects to the point where they are no longer of importance.

Thinning the new canes except for the very weak ones should be delayed until the leaves appear in the spring. This will permit the removal of weakened canes and aid in getting rid of borers and still leave enough canes for profitable production.

107. **The American Raspberry Beetle.** The small grubs, or worms, occurring in raspberries are the larvae of a brown beetle, about $\frac{1}{8}$ inch in length, which first makes its appearance early in the spring

about the time the flower buds appear. If raspberries are inspected at this time, it is an easy matter to locate the pests. The best control of these insects to date has been brought about by the use of a dusting mixture of 1 part calcium arsenate with 19 parts of lime, although almost equally good results have been obtained with a mixture of 1 part lead arsenate and 9 parts of hydrated lime. Either material should be dusted upon the plants at the first appearance of the beetles, and the plants subsequently kept covered by dusting at intervals until blossoms appear. The inclusion of 3 pounds of lead arsenate in the early fungicidal sprays is also an effective treatment.

108. **Sawflies.** The sawflies affecting raspberries are ordinarily controlled by 3 pounds of lead arsenate to 100 gallons of water or of bordeaux going on at the time they appear. However, late infestations, coming after the fruit has set cannot be treated in this way, because of the danger of residue. Such infestations can be controlled by the use of rotenone or pyrethrum sprays or dusts used according to manufacturers' recommendations. Rotenone preparations are slow-acting poisons and a thorough application is required. Repeat in a week if all the larvae are not killed the first time.

109. **Raspberry Mites.** Injury by raspberry mites causes partial to complete defoliation and seriously disturbs the functioning of the remaining leaves. In addition to the adverse effect upon the crop from this damage attacks are made usually as berries are being picked. Berries covered with mites are not readily sold at a profitable figure. Raspberry mites can be controlled best by spraying, as soon as the leaves show green, with a summer oil emulsion (see Section 28). A series of three sprays containing one gallon of oil emulsion in 100 gallons of spray, 5 days apart are necessary because of resistant stages in the life history of the mites. If for any reason the early sprays have not been put on the mites can be stopped at any time by the treatment outlined, but it is wise to spray early if infestation has been present the previous year. Raspberries are tolerant to the recommended strength of oils.

There are many good rotenone sprays on the market which will control these mites. Thoroughness of application is absolutely essential.

The removal of spent canes and weeds from an infested patch immediately after harvest and then applying the recommended series of sprays will enable the young plants to make good growth for the next year's crop. Burn all spent canes and weeds as they are removed.

STRAWBERRIES

110. There are several diseases and insect pests that may be found on the strawberry, but, aside from the leaf-rollers and the leaf-spot diseases, spraying is unnecessary or not effective.

111. **Strawberry Leaf-roller.** This is a small greenish caterpillar with a brown head. It draws the leaflet together with the silken thread, feeds on it from within, and causes it to turn brown and die. The adult is a small moth that lays its eggs on the under surfaces of the leaves

in early spring. Spraying in early spring, using two pounds of lead arsenate in 50 gallons of spray will prove effective, if applied just before the larvae begin to fold the leaves. Spraying after the leaves are folded will do little or no good. Mowing and burning the leaves after the crop is harvested will destroy the larvae and pupae in the folded leaves. This treatment will also aid in the control of the leaf spots. Old beds that are to be abandoned should be plowed under immediately after the last picking.

If infestation develops when there is fruit upon the plants a rotenone or pyrethrum dust should be used, because of the possibility of residue from arsenicals.

In new plantings a fluosilicate compound applied at the rate of 4 pounds to 100 gallons with 1 quart of summer oil is very effective in controlling leaf-roller. This material, however, is not compatible with bordeaux.

112. Leaf Spots. These are diseases which are most common and conspicuous on the leaves. They also occur on leaf stalks and on the fruit stems. These diseases reduce the vigor of the plants and, in severe attacks, practically ruin the plantation. In fruiting plantations, spray with 8-12-100 bordeaux (refer to sections 9 and 10 for instructions for making bordeaux) before blossoming and repeat 10 days or two weeks later. Young plantations or those which are not producing fruit should be sprayed whenever necessary to keep the diseases under control. Mowing and burning the leaves after harvest, and the removal of diseased leaves before the plants are set, are also methods of control.

SPRAYING YOUNG NON-BEARING ORCHARDS

113. Young non-bearing fruit trees should be kept relatively free from disease and insect injury. It is important that the foliage remain in a good healthy condition if large, early-producing trees are to be grown. The kinds of pests present, the amount of infestation, kinds and varieties of fruit and weather conditions will influence the spray schedule.

114. Apples. As a rule young apple trees require less sprays than bearing trees. The common insects attacking young apple trees are scale, red mite, aphids, leafhoppers, canker worms, and climbing cutworms. Apple scab is the important disease to be controlled.

The following sprays are recommended for the average season.

1. Apply when trees are strictly dormant. Use a dormant oil spray (Section 19). Necessary only if scale or red mite are a problem. If aphid eggs are numerous on the trees a tar oil or D N oil emulsion or sodium dinitro-cresylate may be substituted for the oil spray. The tar oil, D N oil emulsions, or sodium dinitro-cresylate will aid in preventing early aphid injury but will not control later infestations. Apply dormant materials according to manufacturers' directions. (See sections 17, 18, 19, 20, 21.)

2. When the leaves are about $\frac{1}{4}$ inch long. For control of scab, aphids and chewing insects.

Apply bordeaux 3-4-100, lead arsenate 2 pounds, nicotine sulphate 1 pint to 100 gallons of spray. If aphids are not present the nicotine is unnecessary. (See sections 9 and 10 for preparation of bordeaux.) Bordeaux is preferred to lime-sulphur because it causes less dwarfing of foliage.

3. About 2 weeks after No. 2

Use same materials.

4. About 2 weeks after No. 3.

Use same materials.

5. If aphids or leafhoppers become numerous later in the season apply 1 pint nicotine sulphate, plus a good soap or spreader to 100 gallons of water (see sections 48, 15, 30).

115. Sour Cherries. Young cheery trees should be sprayed regularly for the control of leaf spot and slugs. Early defoliation of young trees by leaf spot will stunt the trees severely so that they will be short-lived and under-productive.

1. When trees are dormant. (See sections 17, 18, 19, 20, 21.)

For control of black cherry aphids and scale apply D N oil emulsion or sodium dinitro-cresylate. Follow manufacturers' recommendations. This spray is especially important on sweet cherry for the control of aphids. If this spray has been omitted, control of aphids can be obtained by spraying with nicotine and soap soon after the aphids appear. Thorough spraying is necessary.

2. When young leaves are about $\frac{1}{2}$ inch long (sections 9, 10, 11).

For control of leaf spot, leaf-eating insects and slugs, apply bordeaux 3-4-100, lead arsenate 2 pounds to 100 gallons. (See sections 9 and 10 for the preparation of bordeaux.)

3. Two weeks after No. 2. Use same materials as in No. 2.

4. Repeat application No. 3 at 2-week intervals until terminal growth has ceased.

115a. Sweet Cherries. Bordeaux is not safe to use on sweet cherry trees for the control of leaf spot because of copper injury. For this reason substitute the proprietary copper compound—wetttable sulphur-lime mixture described in Sec. 64. Follow the same spray schedule outlined in Sec. 115 for spraying sour cherry.

For the control of aphid and scale insects on sweet cherry follow the recommendations given in application 1 in Sec. 115.

116. Peaches. Young peach trees do not require much, if any, summer spraying because peach trees are attacked by few diseases and insects which are controlled by this method. The common diseases attacking peaches are peach leaf-curl, bacterial leaf-spot, canker, and virus diseases. The important insects are scale, red mite, Oriental fruit moth, and borers. Young peach trees should receive an annual dormant spray of bordeaux 8-12-100 or liquid lime sulphur 5 gallons in 100 gallons of spray for the control of leaf-curl. If scale or mites are present a dormant oil should be added to the bordeaux. This mixture should be applied only in early spring before the buds break (see Section 77).

If bacterial leaf-spot is a problem, applications at 2-week intervals beginning at petal-fall of an 8-8-100 zinc sulphate-lime mixture should

be applied. (See Section 33 for preparation of zinc sulphate-lime mixture.) Keep trees in good vigor to resist leaf spot attack.

Borers cause more damage to peach trees than any other pest. Special attention should be given to controlling this insect. See Sec. 79 for control of borers.

117. **Oriental Fruit Moth.** See Sec. 78 for the control of this insect.

118. **Peach Canker.** This disease has become a problem in the growing of young orchards. Planting disease-free trees, and growing them under the recommended cultural practices will aid in keeping the disease in check (see Section 74).

119. **Virus Diseases** can be controlled only by planting healthy stock. If virus diseases are suspected in the orchard, consult your county agricultural agent (see Section 88).

Young peach trees should not be sprayed with lead arsenate unless an arsenical corrective is added (see Section 33). Arsenicals applied without a corrective will cause serious defoliation and injury to twigs and branches.

120. **Pears.** Young pear orchards should be sprayed similarly to young apple trees. Pear psylla, a specific pest on pears, can be controlled with a dormant oil spray just before the buds break in the spring (see Section 56).

121. **Plums.** Young plum trees may be attacked by scale, red mite, leaf-eating insects, and aphids. Leaf spot and black knot are the common diseases (see sections 44, 45, 86 and 115).

Are You In Doubt—?

Regarding

- ***Spray materials?***
- ***The best combination of materials?***
- ***Timing of applications?***
- ***Methods of application?***

If you are, consult your County Agricultural Agent.

He is a trained and experienced agriculturist. He knows your spraying problems and their relation to profitable fruit production. He is an authorized representative of Michigan State College and the U. S. Department of Agriculture in your county. He is in a position to supply you with the best available information—free from any possible bias—and his recommendations are for your best interest.

The recommendations in this calendar are derived from a careful analysis of research conducted by Michigan State College over many years, substantiated by growers' experiences under Michigan conditions.

New materials, although satisfactory in other states, should be used only in a limited way until their value has been established under Michigan conditions.

Feel free to call upon your County Agricultural Agent for counsel regarding your fruit production problems.