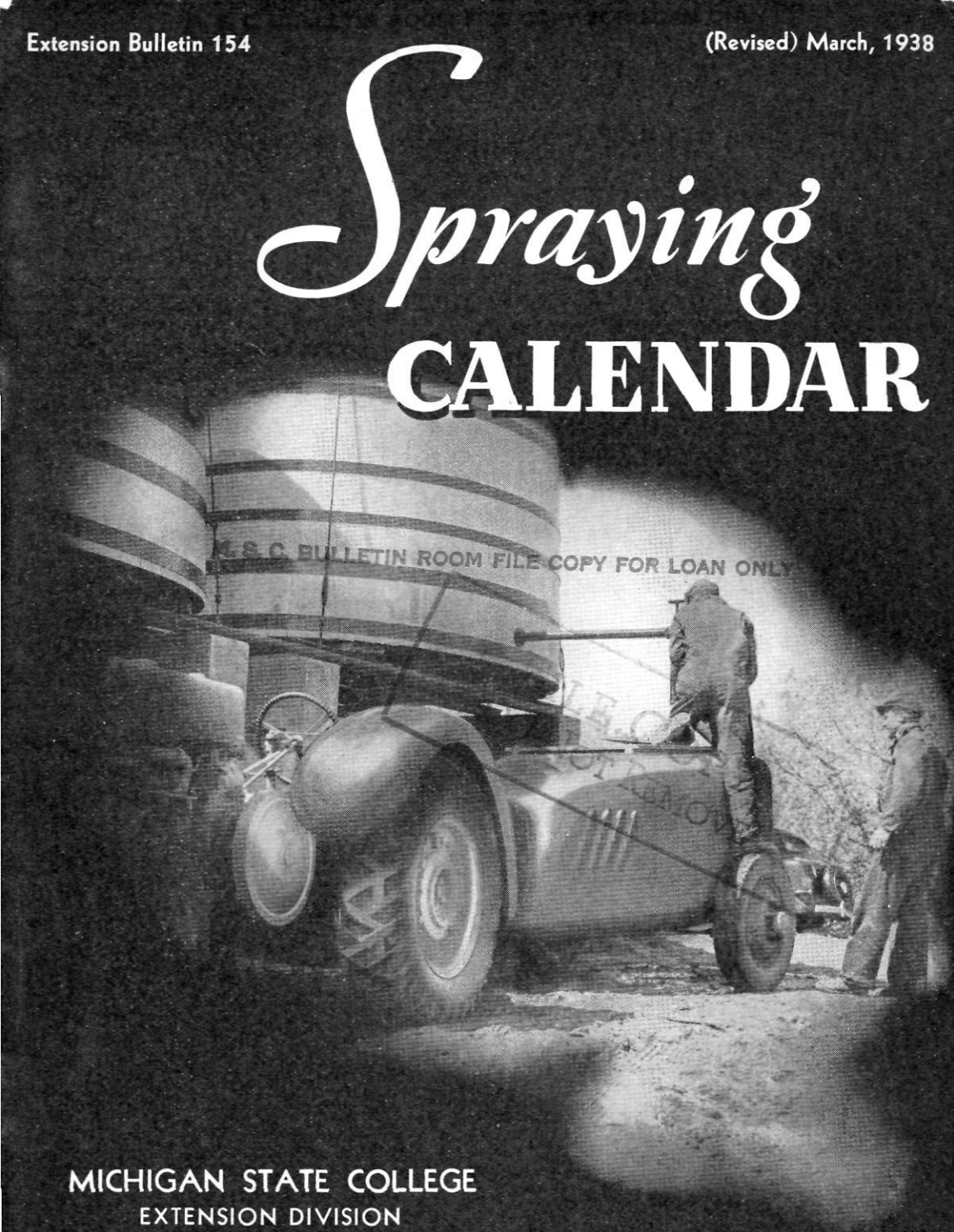
Extension Bulletin 154 (Revised) March, 1938

# Spraying CALENDAR




MICHIGAN STATE COLLEGE
EXTENSION DIVISION
R. J. BALDWIN, DIRECTOR

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# SPRAYING CALENDAR

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

1. The directions given in this publication are intended for dealing with moderately severe cases of insect or disease infestation. In special cases, more drastic measures than those recommended may be necessary. This situation may be met by making more applications, by increasing the concentration of the materials used, or by the use of a special material. In other instances, it may be possible because of special spraying methods, relatively light infestations, or relatively resistant varieties to reduce the number of applications or to lower the concentration of the materials or to make some changes in the selection of materials. However, it is suggested that any departures from these schedules be made only after a careful study of local

## 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 CALENDAR**

conditions has clearly indicated the advisability of the change. Such modification or adjustment of the spray schedules to meet particular conditions is necessarily something that must be determined by the individual grower.

2. *Spraying Is Insurance.* Spraying, in general, is insurance; insurance against loss from attack by insects and disease. It has been stated in Section 1 that modification in the spraying treatment may be possible and even desirable in some cases, but growers should realize that there is usually a minimum treatment which must be used regularly if satisfactory results are to be expected. Diseases, such as scab, leaf-spot, and rots do not develop in epidemic form every year, nor do aphis, psylla, leaf-rollers, berry moths, and other insects appear in really serious numbers each season. Some growers gain a feeling of false security because at such times it is usually possible to grow fruit without injury even though certain applications are omitted or delayed, the concentration of the materials lowered, or some materials left out. Disastrous results often follow the continuance of such practices, as it is impossible to predict accurately when most of the diseases will develop in epidemic form or when certain insects will appear in seriously injurious numbers. Each grower should determine what the minimum spray treatment should be for his special case. Factors to be considered are prevalence of insects and diseases, susceptibility of varieties, the productiveness of the orchard, and the final value of the crop.

Growers should realize also that the mere routine following of the spraying schedules given in this publication does not insure satisfactory results. The real responsibility lies with the grower himself, for success depends largely on correct timing of treatments and thoroughness of application, and the proper method of application for the particular insect or disease in question. The exercise of good judgment in modifying or increasing the treatments to meet local, varietal, or seasonal conditions is imperative, and the ability to do this successfully comes only from experience and careful study.

3. *Spray Injury.* Over-spraying, too frequent applications, a material used improperly, or even standard materials used in the regular way may cause injury. Severe injury may be just as serious as failure to control because of too little spraying. Spray injury may cause loss of foliage, excessive dropping of fruit, or dwarfing of fruit; or it may affect the color. 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. Some of these injuries may be evident only in the year during which they occur, others are likely, if severe, to affect the future vigor and productiveness of the tree. 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.

4. *Spray Residues.* The United States Department of Agriculture and the State Department of Agriculture have established tolerances for residues of arsenic, lead and fluorine on fruit that goes into inter-state shipment and there is also a tolerance on arsenic that must be met when fruit is exported. Residue removal is made more difficult by the inclusion of oil with lead arsenate in the cover sprays. A modified program will be necessary in those orchards where the fruit will not be washed. With other fruits, precautions may be necessary and the recommendations for each fruit should be studied carefully in this connection. No guarantee can be made that any recommended treatment will not cause excessive residue, but the information is the best available.

## Spraying Materials

5. *Lime-Sulphur.* Recommendations in this bulletin for the use of lime-sulphur always refer to the commercial concentrated solution. Most of the commercial products test 32 to 33 degree Baumé, and all dilutions recommended herein are based on that strength of concentrated solution.

6. *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 go to make up 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 the sulphur and sulphur bearing compounds in them 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 are approximately equal to 1 gallon of the liquid. To determine the amount of dry required, simply multiply the recommended number of gallons of liquid by 4 and the result will be the number of pounds of the dry necessary to give equivalent results. For further discussion of the concentrations of lime-sulphur to use, refer to Section 39. 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 is not recommended for scale control.

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 when the two are used at equivalent strengths.

7. *Lead Arsenate.* All recommendations in this bulletin for the use of lead arsenate refer to the powder or dry form of the ordinary or "acid" lead arsenate.

The use of a corrective will reduce arsenical injury. Either the zinc sulphate-lime or iron sulphate-lime mixture should always be used with lead arsenate when applied on peaches and plums. The zinc sulphate-lime mixture when used on apples as recommended in the apple schedule may cause some russeting but not enough to be of commercial significance.

8. *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, much injury is likely to occur.

9. *Zinc Arsenate.* A more recent introduction as a lead arsenate substitute is zinc arsenate. In appearance it is much like lead arsenate. It contains slightly more arsenic than lead arsenate and tests in Michigan indicate that it is about as effective in codling moth control as lead arsenate. It is desirable to use lime or a corrective with it.

10. *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 strength. 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.

In times past, 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.

11. *Mixing Combined Sprays of Lime-Sulphur, Lead Arsenate, and Nicotine Sulphate.* The method used in mixing these materials may have more or less effect on results, but it is not possible to lay down any rule that is best under all conditions. Where the water supply is in or adjacent to the orchard, mix the lead arsenate with water until in a milky condition, and pour into the tank which is partly filled with water; or, empty the dry lead arsenate on the tank strainer and wash through with water. The agitator should be in operation. When the tank is nearly full, add the lime-sulphur and lastly the nicotine sulphate if it is used. Always have the agitator in operation when adding lead arsenate and keep in operation until the tank is emptied.

If the sprayer must be drawn a considerable distance before spraying is begun, it is advisable to add the lead arsenate in the orchard just before spraying is started. The use of lead arsenate and lime-sulphur which have been mixed for 1 or 2 hours or longer is inadvisable.

12. *Wettable Sulphurs.* Wettable sulphurs are composed mostly of free sulphur, ground or chemically precipitated to a finely divided state and mechanically combined with some other material to make them "wettable" so that they can be mixed with water. A general but not absolute rule is that the effectiveness of a wettable or any sulphur is directly proportional to the fineness of the sulphur particles. The type of film in which sulphur is deposited probably is also important.

The full range of usefulness of wettable sulphurs has not been established in Michigan. Extensive trials indicate that 4 or 5 pounds of some of the dry wettable sulphurs or 8 to 10 pounds of paste flotation sulphur are approximately equivalent to one gallon of commercial liquid lime-sulphur in the control of apple scab, but others have definitely lower value for scab control.

Wettable sulphurs are much safer on foliage than lime-sulphur and for that reason only are they preferable to lime-sulphur for the control of apple and pear scab. However, the wettable sulphurs frequently cause serious injury under some conditions, particularly, in extremely hot weather. Some of the better wettable sulphurs are reliable for scab control if properly used, and less injury to the fruit and foliage may be expected. It is usually necessary with materials of this type, to spray somewhat more frequently than is the general practice of many growers.

No general rule can be offered for the substitution of wettable sulphurs for liquid or dry lime-sulphur, but growers should study the problem carefully before substituting for lime-sulphur in all applications. A better procedure is to use wettable sulphur in the first cover and possibly the petal fall application. They may be used advantageously on some of the varieties less susceptible to scab and subject to foliage injury and russeting of the

fruit. Apple and pear growers will do well to inform themselves concerning the merits of particular brands of wettable sulphurs before using them in their orchards. Sulphurs of this type do not "burn out" established scab lesions at ordinary temperatures.

Wettable sulphurs are not recommended for leaf-spot control on sour cherries but are valuable in the control of brown rot, especially on sweet cherries, plums and peaches.

Wettable sulphurs are generally satisfactory for summer applications on peaches. The requirements regarding to fungicidal efficiency are not so exacting as for apple scab control; consequently, many products that are unsatisfactory on apples are entirely satisfactory on peaches. An arsenical corrective, such as zinc sulphate-lime or iron sulphate-lime, should always be used when any of these sulphurs are combined with lead arsenate on peaches or Japanese plums and probably on prunes.

13. *Bentonite Sulphur.* Another of the newer materials is bentonite sulphur which is sulphur blended with bentonite (a clay-like material). This product has been tested extensively in Michigan and usually has not given satisfactory results in scab control, especially when used under severe conditions in the pre-blossom period. It has given better results in the after-blossom period, when lime-sulphur has been used early in the season. Its use in the pre-blossom period for apple or pear scab control is not advised, especially on susceptible varieties. If used in late summer an undesirable amount of residue is likely to be present at harvest. It probably can be used to advantage on stone fruits for brown-rot control provided application is not made so close to harvest that undesirable residue is present when the fruit is picked.

14. *Spraying Lime.* Hydrated lime is the only form generally available for spraying purposes in Michigan. There are several grades of hydrated lime. Mason's hydrate, finishing hydrate, agricultural lime, chemical hydrated 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 are called high calcium lime and those made from limestone containing a mixture of calcium and magnesium carbonates are 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 causes less injury to the foliage, less dwarfing of fruits and is 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.

15. *Low-soluble Copper Compounds as Substitutes for Bordeaux.* A number of new copper compounds are appearing on the market as substitutes for bordeaux and lime-sulphur. Several of these compounds have been extensively tested and found well adapted as cherry sprays for the control of leaf-spot. Owing to the failure of lime-sulphur to control this disease with a reasonable number of sprays, and to the uncertainty of bordeaux in

regard to injury, the new copper compounds are recommended for the cherry spray program. See Sec. 53.

While the new copper compounds may also be useful in controlling certain foliage diseases where bordeaux or lime-sulphur sprays are now indicated, they have had favorable tests only on cherries.

Spraying experiments in 1937 showed that these copper compounds were decidedly unsafe for the early season applications on most apple varieties because of serious russeting of the fruit. Russeting by copper sprays is not usually as serious beginning with the second cover spray but no unqualified recommendations can be made in this regard. Varieties most susceptible to copper injury are Jonathan, McIntosh, Grimes, and Ben Davis. Varieties least susceptible are Red Delicious and Stark. See Sec. 53.

16. *Bordeaux.* Bordeaux is made from copper sulphate (blue stone, 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.

Many grades of lime are undesirable for spraying purposes. Refer to Section 14 for a full discussion of lime.

17. *Preparation of Bordeaux.* There are many methods for making bordeaux, but two only will be given here. One method involves the use of stock solutions and the other, the "instant" method, requires powdered or "sugar" copper sulphate.

*Stock Solution Method.* When bordeaux is to be used in quantities, a stock solution of copper sulphate and possibly of lime should be prepared in advance. The copper sulphate is dissolved at the rate of 1 or 2 pounds per gallon of water. Fill a 50-gallon wooden barrel, preferably one with wooden hoops, nearly full of water. To make a "1 pound to 1 gallon" stock solution, suspend 50 pounds of copper sulphate in a clean gunny sack so that the bottom of the sack is in the water a few inches. The sulphate will usually dissolve in a few hours after which, fill the barrel with water to make a total of 50 gallons. Keep the barrel covered to prevent evaporation. To make a "2 pounds in 1 gallon" stock solution use 100 pounds of copper sulphate. This will require longer to dissolve but is more economical of storage space. If "quick" lime is used it should be slaked to a paste and covered with water in barrels or in troughs made for this purpose. It is essential to know how many pounds of lime are in each gallon of the paste. When hydrated lime is used it may be mixed with water a little in advance of the time to be used; or it may be emptied on the tank strainer and washed into the tank.

There are several satisfactory ways of combining the ingredients of bordeaux; a very satisfactory method is as follows:

Start filling the tank, then with the agitator running strain in the required amount of stock solution of lime. Next fill the tank nearly full and slowly add the stock solution of copper sulphate. Finish filling the tank. If lead arsenate is used it should be added when filling is completed. When nicotine sulphate is used it should be added last. Keep the agitator running until the material is sprayed out.

*"Instant Bordeaux" Method.* Another method used extensively recently involves the use of pulverized, powdered, or "sugar" copper sulphate. This does not have to be made up into a stock solution as it dissolves quickly, with agitation, in the sprayer tank. A satisfactory procedure follows:

1. Fill sprayer tank about one-fourth to one-third full with water.
2. Place hydrated lime on the tank strainer and wash through, or mix with water in pail or tub and pour through tank strainer.
3. With the agitator in operation, place the copper sulphate on the tank screen and wash through, and continue to add water until the tank is nearly full. Allow about 2 minutes for the copper sulphate to dissolve.
4. Add lead arsenate or nicotine sulphate at this time if either is to be used. Fill tank with water and apply. Keep agitator in operation continuously after copper sulphate is added.

## Oil Sprays

18. Much interest has been shown in the use of oil sprays of various kinds. There are two general classes of oil sprays;—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. 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.

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 case-bearer, raspberry mite, codling moth and certain grape insects. The type of oil used as the basis of miscible oils and oil emulsions should be determined by whether the spray is to be applied during dormant or growing season.

19. *Dormant Oils.* The 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 degrees F.) and 60 to 70 per cent unsulfonated residue. Oils used for pear psylla control should have a viscos-

ity from 175 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 as 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.

A dormant oil containing dinitro-ortho-cyclohexylphenol has proved effective against aphid eggs and San Jose scale. This material should be used in the dormant period only.

20. *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 from freezing and mixing with other materials. The miscible oils are generally effective for the common insects, but, for special purposes, 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.

21. *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 and 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 diluting 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.

22. *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.

A. 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.

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

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

D. Follow carefully the instructions of the manufacturers 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 ap-

plication of oil. The cold-pumped emulsions are relatively safe in this respect but it is not definitely established that injury never follows.

E. 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 36.

23. *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.

24. *Bordeaux Emulsion.* 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 as indicated in Section 17. 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 | | |
|---|---|---|---|
| Place in sprayer in this order | 3 per cent | 6 per cent | 8 per cent |
| 1. Water | ¾ gal. | 1½ gal. | 2 gal. |
| 2. Copper sulphate (stock solution) | 3 pts. | 3 qts. | 1 gal. |
| 3. Hydrated lime (stock solution) | 3 pts. | 3 qts. | 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.**

If a large quantity is to be made up at a central mixing plant to supply several sprayers, the formula for stock emulsion may be used. To dilute this stock emulsion, fill the sprayer about one-fourth full with 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 emulsion than will be used the day it is made.

**Formula for Stock Emulsion of Bordeaux 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. |

25. *Casein Emulsion.* Casein spreader is sometimes used as the emulsifier. For each 100 gallons of spray of a given concentration proceed as follows:

| Materials | For each 100 gal. of spray with actual oil content of | | |
|---|---|---|---|
| Add to sprayer in this order: | 3 per cent | 6 per cent | 8 per cent |
| 1. Water | 1½ gal. | 3 gal. | 4 gal. |
| 2. Casein spreader | 6 oz. | 12 oz. | 16 oz. |
| 3. Oil | 3 gal. | 6 gal. | 8 gal. |

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. Put the indicated amount of water in the sprayer tank.
2. With the agitator in operation, add the casein spreader and allow thorough mixing.
3. Add the oil.
4. Emulsify, dilute and apply as indicated for bordeaux emulsion (Section 24).

If a large quantity is to be made at a central mixing plant to supply several sprayers, the formula for stock emulsion may be used. To dilute this stock emulsion, fill the sprayer about one-fourth full with 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 emulsion than will be used the day it is made.

**Formula for Stock Emulsion of Casein Emulsion**

| Materials (Add to sprayer in this order) | Amount |
|---|---|
| 1. Water | 15 gal. |
| 2. Casein spreader | 4 lbs. |
| 3. Oil | 30 gal. |

26. *Diluting and Using Emulsions.* Emulsions prepared according to these formulae contain approximately 66⅔ 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 2/3 Per Cent of Oil**

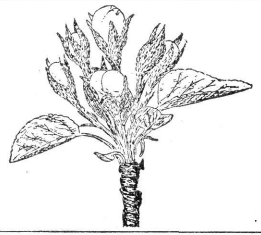
| Amount of Dilute Spray | Amount of stock emulsion to use to make actual oil content of | | | | |
|---|---|---|---|---|---|
| | 2 per cent | 3 per cent | 4 per cent | 6 per cent | 8 per cent |
| 100 gal. | 3 gal. | 4½ gal. | 6 gal. | 9 gal. | 12 gal. |
| 200 gal. | 6 gal. | 9 gal. | 12 gal. | 18 gal. | 24 gal. |
| 300 gal. | 9 gal. | 13½ gal. | 18 gal. | 27 gal. | 36 gal. |
| 400 gal. | 12 gal. | 18 gal. | 24 gal. | 36 gal. | 48 gal. |

To make sure 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. *Summer Oils.* Oils used for applications during the growing period should be much more highly refined than those for dormant spraying. Viscosity and unsulfonated residue should be within well defined limits. The limits for viscosity are 75 to 85 seconds (Saybolt at 100 degrees F.) and 92 to 100 per cent for unsulfonated residue. The manufacturer's instructions should be carefully read before attempting to dilute any summer oil spray.

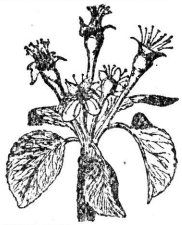
28. *Tar and Tar and Oil Sprays.* Tar sprays consist of certain liquid fractions obtained in the distillation of coal-tar treated to render them miscible with water. These sprays were developed for dormant use against aphis. Certain disadvantages of the tar sprays led to the development of the tar and oil sprays, which in many cases consist of the tar products referred to, combined with petroleum oil and an emulsifier. The tar sprays kill aphis eggs and case-bearer on contact. Tar and oil sprays, chiefly because of the oil content, will control scale and mite, in addition to aphis and case-bearer. 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

## APPLES

| STAGE OF GROWTH | APPLICATION | MATERIALS | | TO CONTROL | EXPLANATIONS |
|---|---|---|---|---|---|
|  | 1. DORMANT. Complete before green tips appear. | Lime-sulphur (dormant strength), tar and oil or an oil spray.<br><br>Refer to Sections 28 and 33 to 36 for specific instructions. | | Scale insects, mites and leaf-rollers. Lime-sulphur will control scale insects, but oil will also control scale and is necessary for mites and leaf-roller. Tar and oil will control aphid, scale and redmite. Oil containing *DNOCHP will control aphis and San Jose scale. | 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 33 to 36 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 gals., lead arsenate, 3 lbs., nicotine sulphate, 1 pt., and water to make 100 gallons. | These applications are the most important for scab control. | Scab, aphid, and bud moth. Omit the nicotine sulphate if a dormant application of *DNOCHP or tar and oil has been made. | This is the best period for the control of aphid, if this has not been effected by dormant applications, and the lime-sulphur that is necessary with the nicotine will prevent early infection of apple scab. Lead arsenate is partially effective against bud moth. Refer to Sections 37 and 38 for special instructions for the control of aphis. |
|  | 2a. PRE-PINK. Begin soon after the delayed dormant condition and complete as soon as possible. | Lime-sulphur, 2½ gals., lead arsenate, 3 lbs., 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 gals., lead arsenate, 3 lbs., 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.

*DNOCHP=Dinitro-ortho-cyclohexylphenol.

| | | | | |
|---|---|---|---|---|
|  | 4. PETAL-FALL (CALYX) Should be made when most of the petals have dropped and after bees have quit working in the bloom. | Lime-sulphur, 1½ gals., lead arsenate, 3 lbs., nicotine sulphate, 1 pt., and water to make 100 gallons.<br><br>Nicotine sulphate may be omitted if red bugs are not prevalent. | Scab, codling moth, curculio, other chewing insects and red bugs.<br><br>Wettable sulphur may be substituted at this time. | 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 Section 40 for the control of red bug. |
| | 5. FIRST COVER. Ten days after petal-fall. | Wettable or flotation sulphur, 4 to 6 lbs., lead arsenate, 3 lbs., and water to make 100 gallons. | Codling moth, curculio, lesser apple worm and scab. | |
| | *5a. SECOND COVER. Ten days after Application 5. | Lead arsenate, 3 lbs., zinc sulphate-lime (See Sec. 60), and water to make 100 gals. | Codling moth, curculio, lesser apple worm and scab. If apple scab is prevalent, the use of wettable sulphur may be advisable at this time. | WARNING. IMPORTANT<br><br>Govern use of lead arsenate during the summer by the prevalence of codling moths. Read carefully Section 31. |
| | *5b. THIRD COVER. Two weeks after 5a. | Lead arsenate, 3 lbs., zinc sulphate-lime (See Sec. 60), and water to make 100 gals. | Codling moth, lesser apple worm and curculio. | If fruit is not to be washed, refer to Section 31. |
| | *5c. FOURTH COVER. Two weeks after 5b. | Lead arsenate, 3 lbs., zinc sulphate-lime (See Sec. 60), and water to make 100 gals. | Codling moth, lesser apple worm and curculio. | |
| | *6. SUMMER GENERATION. Exact time to be determined each year, usually about Aug. 1. | Lead arsenate, 3 lbs., zinc sulphate-lime (See Sec. 60), and water to make 100 gals. Add flotation sulphur or other similar material if needed for scab control. | Codling moth, curculio and scab. | The exact time of this application is determined by the Entomology Department and announcement is made through county agents. |
| | 7. Two weeks after Application 6 and if necessary make one or two more applications at two weeks intervals. | Lead arsenate, 3 lbs. | Codling moth and curculio. | |

**These are the important applications for codling moth control.**

**IF FRUIT IS NOT TO BE WASHED, REFER TO SECTION 31.**

*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. 12.

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.

29. *Dusting.* The dusting method has many distinct advantages over spraying. The original investment for dusting equipment is much less, and the 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, ahead of 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. 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 temperature 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, leaf-hoppers, 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 have usually 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 drifts 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.

## Supplementary Directions for Apples

30. *Codling Moth.* Fruit growers have, for a long time, put practically 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 fungus 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 control 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, the destruction of larvae about packing-houses and equipment, and the scraping and banding of trees have been successfully employed against the codling moth under similar circumstances. Before the advent of spraying control for 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 require any large outlay of time or cash. Moreover, most of the operations can be completed in the off-season.

*Banding.* Codling moth banding consists in placing about the trunk of the tree, which previously has been scraped, a band two inches wide. The

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

larvae seek shelter beneath the band when preparing to pupate, or to winter. The bands should be upon the trees by the time 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 used in greatest quantity in former times 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; and place bands at a different place each year on any tree. Failure to observe these precautions has resulted in injury.

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

**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.

*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. Especial care must be exercised in scraping the trunk at the ground line, and just below, as these are favorite wintering-places for codling moth larvae. While mid-June is the proper time for banding in southern Michigan, the best results will be obtained if scraping is completed before blooming time.

*Spraying Methods.* Success from spraying for codling moth depends largely upon the thoroughness with which the material is applied. This 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 shall 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 also be directed 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 con-

tinued 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 wettable flotation sulphur, or other effective free sulphur material, is recommended for the First Cover application. If a fungicide is needed later than this, flotation sulphur or wettable sulphur may be used.

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

31. *Spray Residue.* The amount of spray residue present on fruit at harvest is governed by many factors. The relation of some of these factors is not well known, but it is certain that there is a definite relation 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.

There are many orchards in the state where it is possible, because of 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 the 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

Generally speaking, lead arsenate may be used on winter varieties in the petal-fall and first cover applications and zinc or calcium arsenate in the calyx, first and second cover applications without resulting in residues beyond present tolerances. There may be occasional exceptions to this, but available analyses indicate this to be the case.

The only materials which have proved effective for the remainder of the season without excess residue are the nicotine compounds. Oil-nicotine sulphate has been in the spraying calendar several years. It is effective, but the necessity for and cost of applications of oil (3 quarts) and nicotine sulphate (¾ pint) at 8-day intervals has kept 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 lead arsenate at 10-day intervals.

Fixed nicotines are incompatible with lime-sulphur.

Fixed nicotines are compatible with fixed copper compounds. Some brands are compatible with elemental sulphurs (wettable, flotation) except when oil is used. If in doubt, consult your county agent. The above 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 first cover for the best results with fixed nicotine-oil sprays. If planning to use fixed nicotines and oil, every effort should be bent toward scab control prior to beginning the 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 3 pounds with lime sulphur 1½ gal.

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

Second cover—7 days after first cover. Fixed nicotine, using material according to manufacturer's recommendation. Oil in this application may cause burning.

Third cover—7 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 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:

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

First cover 10 days after petal-fall—lead or zinc arsenate (Sec. 60) plus 4-6 pounds wettable or flotation sulphur.

Second cover 7 days after first cover—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.

32. *Spreaders and Stickers.* The value of spreaders and stickers other than oils, when used with lead arsenate for the control of codling moth has not been established. Furthermore, their use makes lead arsenate more persistent so that the danger of excessive residue is increased. Oil stickers increase the efficiency of lead arsenate but render residue removal difficult.

33. *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 calls for treatment with an oil spray, which will of course be satisfactory for 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 spray for aphids in the dormant period may use a tar or tar and oil spray. Tar and oil sprays also control scale and mites but are not recommended for leaf-roller. (See Sec. 19 and 28.)

34. *San Jose and Oyster Shell 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 determine specimens upon request.

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

Lime-sulphur, 12½ 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. Oyster shell scale can be controlled by the use of oil sprays containing 4 per cent of actual oil. See Sections 18 to 26 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 Section 28.)

35. *Fruit Mites and Clover Mites.* Three species of mites, and perhaps more, affect apples and other fruits in Michigan; the common red spider, the clover mite which has always been with us, 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 too critically except to remember that the European red-mite is the one most capable of damaging the trees. All of our 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 spring 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 Section 26). If a commercial spraying oil is used, follow the recommendations of the makers. Tar and oil sprays will control red-mites. See Section 28. 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 Section 22). The dormant spray is intended as a destroyer of the eggs. Summer applications of nicotine and dilute lime-sulphur are not so satisfactory and therefore the principal effort should be expended in making the dormant spray effective.

36. *Leaf-Roller.* The leaf-roller is an active, naked caterpillar, which rolls the leaves of the apple and other fruits, lives in their 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 Section 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 26 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 with regard to varietal susceptibility, but normal Baldwin trees are apparently little affected by any dormant application of oil.

Very thorough application 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. The use of lead arsenate in the pre-blossom applications is a valuable supplement to the oil treatment. 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.

37. *Aphids.* Three common aphids, aside from 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 out first but most of the eggs of all three are hatched by the time that the trees reach the delayed dormant. The critical time for aphid control, after they 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 aphis 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 brood 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 brood 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. The fact that aphids do not cause serious injury every year in all parts of the state, or in any particular orchard, tends to make growers lax in their control operations, with the result that orchards which are not sprayed regularly every year for aphids almost invariably suffer badly when conditions become favorable for aphid development and injury. Because of these conditions, it seems unwise for the operator of a productive orchard of susceptible varieties to omit aphid control measures.

Tar or tar and oil sprays may be used for aphid control but the application should be made while the trees are strictly dormant. See Sections 19 and 28.

38. *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 the 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: 25 pounds hydrated lime; 4 pounds of 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, the nicotine sulphate, 1 pint in 100 gallons, may be added to bordeaux, 3-5-100, or to lime-sulphur. The lime in the bordeaux when used with nicotine sulphate, could be advantageously increased to 25 pounds and the same amount of lime could be used with the lime-sulphur. The bordeaux should not be used earlier than four weeks after petal-fall, because of danger of russeting. Very heavy application is essential to success in the control of summer infestations of aphids and for that reason lime-sulphur in such sprays is probably the least desirable combination because of the danger of injury to foliage during midsummer, especially when the trees are heavily sprayed and the temperature high.

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.

39. *Apple Scab.* Apple scab may be a factor of importance in nearly every one of the growing-season applications. It is impossible to name any

**Control Scab Early.** Simplify scab control by preventing early infection.

one application that is most important in all seasons or in all orchards. Initial infection begins during the first soaking rain after the spores are mature in the dead leaves on the ground. Spore discharge may occur at any time from the delayed dormant to the first cover spray depending on the season. Spore discharge and infection may occur during only a few rainy periods or over a long series of rainy periods. Pre-blossom applications are the key to successful control in most seasons and they should be made regularly as recommended. This does not mean that later applications are of less importance as they are often as essential as the earlier ones, but it does mean that if the peak of infection occurs in the early period, that successful control is almost impossible if the pre-blossom treatment has not been thorough. Successful scab spraying involves thorough coverage and timely applications. To be protected, the young leaves should be covered with a fungicide before spore discharge occurs. "Keep Covered" is the slogan for fighting apple scab.

**Control Scab Early.** Pre-blossom applications are the key to successful apple scab control.

The apple 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 on susceptible varieties. 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 the use of lower concentrations of lime-sulphur in part or all of the applications; of the substitution of some other material in part or all of the sprays or of the omission of the fungicides in some of the mid- and late-summer treatments. These changes are usually made mainly for the purpose of reducing injury to foliage and fruit.

Wettable sulphur, bentonite sulphur, and sulphur dust are materials that have been successfully used in this way. Dry lime-sulphur, in low concentrations, has been used. The use of a combination spray of weak liquid lime-sulphur and wettable sulphur with lead arsenate has sometimes caused considerable foliage injury especially where less than one gallon of liquid lime-sulphur is used in the combination. Weak concentrations of dry lime-sulphur, wettable sulphur and lead arsenate may also cause serious foliage injury. More experimental evidence is necessary before such combinations can be recommended.

**Control Scab Early.** Foliage injury is unavoidable if lime-sulphur is used heavily in the cover sprays.

## 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 lbs. 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 lbs. 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 lbs. 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, ¾ gal., nicotine sulphate, ¾ pt., and water to make 100 gallons. Refer to Section 27 and 31. | 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, ¾ gal., nicotine sulphate, ¾ pt., and water to make 100 gallons. Refer to Section 27 and 31. | Curculio, codling moth and other chewing insects. 2 lbs. only of lead arsenate should be used at this time. |

## 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 Section 47 for specific instructions. |
| | 2. DELAYED DORMANT, or PRE-PINK. Latter stage is shown at left. | Bordeaux, 3-8-100 and lead arsenate 3 lbs. in each 100 gallons. Refer to Sections 16 and 17 for instructions for making bordeaux. | Scab, leaf-blight, curculio, and bud moth. | This is good insurance against scab on any susceptible variety and should everywhere be made on Flemish Beauty or other similarly 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 lbs. in each 100 gallons. Refer to Sections 16 and 17 for instructions for making bordeaux. | Scab, leaf-blight, curculio, and bud moth. | This 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. Just as the petals are falling. | Bordeaux, 2-8-100 and lead arsenate, 3 lbs. in each 100 gallons of spray. | 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 SECTION 31.

| | | | | |
|---|---|---|---|---|
| | 5. FIRST COVER. Two weeks after petals fall. | Bordeaux 2-8-100, and lead arsenate, 3 lbs. in each 100 gallons of spray. | Codling moth, curculio, other chewing insects, scab and leaf-blight. | Bordeaux may be omitted if scab and leaf-blight are not present. Refer to Section 47 for the summer treatment of psylla. |
| | 5a. SECOND COVER. Two weeks after Application 5. | Lead arsenate, 3 lbs. and water to make 100 gallons. | Codling moth and curculio. | WARNING. IMPORTANT<br>Govern the use of lead arsenate during the summer by the prevalence of codling moth. Read carefully Section 46. |
| | 5b. THIRD COVER. Two weeks after Application 5a. | Lead arsenate, 3 lbs. and water to make 100 gallons. | Codling moth and curculio. | |
| | 6. SUMMER GENERATION. Time determined the same as for apples. | Lead arsenate, 3 lbs. and water to make 100 gallons. | Codling moth and curculio. | Bordeaux may be used at this time on varieties very susceptible to scab. Read carefully Section 46. |

See Section 49 for possible variations in materials for scab control.

**General recommendations for the adoption of the suggested modifications are not possible as changes must be made by each grower after determining the conditions in his orchard. In case of doubt, it is suggested that the so-called standard recommendations be followed.**

41. *Red-Bug.* Two species of red-bug 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.

41a. *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 carried on if permanent reduction in the numbers of apple maggots is desired.** Pick up all drops from summer varieties twice a week, from fall varieties weekly, and from winter varieties once in two weeks after July 15th, 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 two feet deep, are some of the ways of disposing of them. 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 lime-sulphur on the dates determined annually by the Department of Entomology. These dates can be obtained through the county agricultural agent. The destruction of neglected apple and thornapple trees in the vicinity of orchards will help in controlling apple maggot.

42. *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 sets in disposes of very many of these insects, and the liberal use of lead arsenate in the early routine sprays, beginning with the delayed dormant application, will accomplish much toward their control. The curulio 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.

43. *Leaf-Hoppers.* Leaf-hoppers are a pest in many orchards. The typically discolored fruit and leaves and curled edges of the leaves associated with leaf-hopper 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. Since 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 they can be controlled by thoroughly spraying with nicotine sulphate (1 pt. in 100 gals.) in Application 5.

44. *Climbing Cutworms.* Refer to special instructions in Section 81.

45. *Fire-Blight.* Special instructions for the control of fire-blight will be sent on request by the Botany Department.

## Supplementary Directions for Pears

46. *Spray Residue on Pears.* Codling moth is generally not as 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 excesssive 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 26 and 27 should be followed. If, however, washing equipment is not available, or it seems desirable to avoid washing, summer oil emulsion and nicotine sulphate should be used.[2] 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. Oil and nicotine 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 the lowest number possible because of the cost and danger of injury to the trees. Summer oil emulsion, ¾ gallon, and nicotine sulphate, ¾ pint, with water to make 100 gallons, is the recommended strength. This treatment should also control pear psylla.

47. *Pear Psylla.* For the control of pear psylla, use a home-made oil emulsion containing 3 per cent of actual oil. This oil should have a viscosity of 175 to 250 seconds (Saybolt at 100° F.). It may be emulsified either with casein spreader, bordeaux, or other suitable emulsifier. Refer to Sections 18 to 26 inclusive, for specific information about the making and use of oil emulsion. Casein spreader and bordeaux are most frequently used as the emulsifying agents. 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 makers' 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 psyllas 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 Section 46) should also control infestations of pear psylla.

48. *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

[2]See Sec. 31.

## SOUR CHERRIES

| APPLICATION | MATERIALS | TO CONTROL | EXPLANATIONS |
|---|---|---|---|
| 1. DORMANT. | Oil, or tar sprays (refer to Section 57). | Oil will control leaf-roller and case-bearer.<br>Tar sprays will control case-bearer. | Instructions for control will be found in Section 57 for case-bearer and Section 36 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 lbs., and water to make 100 gallons. See Section 53. | Leaf-spot, brown-rot, curculio, and slugs. | This application is important in checking the first infections of leaf-spot. |
| 3. TWO-WEEKS. Should be completed within two weeks after petal-fall. | Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lbs., and water to make 100 gallons. See Section 53. | 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. FOUR-WEEKS. Should be completed within two weeks after application 3. | Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lbs., and water to make 100 gallons. Omit lead arsenate unless fruit is going to canning factory or can be washed. See Section 53. | Leaf-spot, brown-rot, curculio, and slugs. | Omit lead arsenate unless fruit is to go to canning factory or can be washed. |
| 5. AFTER HARVEST. Just after the fruit is harvested. | Approved proprietary copper compounds (Use according to manufacturer's recommendation); lead arsenate, 2 lbs., and water to make 100 gallons. See Section 53. | Leaf-spot and slugs. | |

SPECIAL. On young growing trees extra applications may be necessary until growth is completed.
Refer to Section 55 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 oil-*DNOCHP. See next column. | Scale insects, (see Section 34). Leaf-roller, (see Section 36). Case-bearer, (see Section 57.) Aphid (see Section 19 and 28.) | |
| 2. PETAL-FALL. Just after petals have fallen. | Lime-aulphur, 2 gallons, lead arsenate, 2 lbs., and water to make 100 gallons. | Leaf-spot, brown-rot, curculio and slugs. (See Section 54 for aphid control.) | Avoid spraying sweet cherries during periods of high humidity and high temperature. |
| 3. TWO-WEEKS. Two weeks after Application 2. | Lime-sulphur, 2 gallons, lead arsenate, 2 lbs., and water to make 100 gallons. | Leaf-spot, brown-rot, curculio and slugs. (See Section 54 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. | Lime-sulphur, 2 gallons, lead arsenate, 2 lbs., and water to make 100 gallons. Omit lead arsenate unless fruit is to go to canning factory or can be washed. | Leaf-spot, brown-rot, curculio, slugs, and maggots. (See Section 54 for aphid control, and Section 55 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 Section 55 for information concerning a special application for the control of cherry maggot on canning cherries. | | |
| 5. BROWN-ROT. About one week before picking. | Sulphur dust or spray of wettable sulphur. | Brown-rot. | See Section 52. |

**RESIDUE REMOVAL.** Instructions will be furnished on request to the Department of Horticulture.
*DNOCHP=Dinitro-ortho-cyclohexylphenol.

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.

49. *Other Materials for Scab Control.* 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 the functioning of the leaf. There are also definite indications that orchards regularly sprayed with bordeaux do not suffer as 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 russeting 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 rather 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 this material, it is suggested that they use it at the rate of 2½ 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 one of sulphur 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 when oil sprays are to be employed.

50. *Climbing Cutworms.* Refer to special instructions in Section 81.

51. *Fire-blight.* Special instructions for the control of fire-blight will be sent upon request by the Botany Department.

### Supplementary Directions for Cherries

52. *Special Application for Brown-rot.* An application of sulphur dust made on sweet cherries, one week or ten days before harvest will prevent brown-rot on the tree, allow a longer harvesting season and protect the fruit during shipment. Use sulphur with 5 to 10 per cent of hydrated lime or other fluffer.

Sprays at this time may stain the fruit but the least objectionable are "wettable" sulphur sprays and these are usually advisable if a duster is not available.

53. *Copper Compounds for the Control of Cherry Leaf-spot.* Because of the general failure of liquid lime-sulphur for cherry leaf-spot control in past years, and because of the excellent results and superiority displayed by some of the new copper compounds for the control of cherry leaf-spot in extensive experiments, it seems advisable to change the previously recommended spray schedule for cherries. The new copper compounds are recommended because they are effective over a longer period of time than lime-sulphur and have not shown the tendency of bordeaux to dwarf the fruit.

It is not possible to classify any one compound as being the best from every standpoint of control, injury or cost. The following compounds avail-

able on the market, seem to show superiority and from our experiments and observations appear safe for recommendation at the proposed strengths. Listed alphabetically there are:—Basicop, 3-8-100 (Basicop, 3 lbs., lime, 8 lbs.); Bordow, 6-100; Coposil, 3-100; Cupro K, 3-100; and Grasselli copper compound A, 1½ to 2 lbs. plus ½ pt. of Grasselli sticker-spreader.

It is suggested that these compounds be used with the same timeliness and thoroughness previously accorded to lime-sulphur. Four sprays as recommended should be adequate for any season.

The advisability of using copper sprays on sweet cherries has not been determined. Some of these materials used at a reduced strength and with a small amount of lime added have shown promise. In general, however, lime-sulphur is still considered adequate for sweet cherries.

These compounds are not recommended for apples, pears, or other fruits. See Section 15.

53A. *Lime-sulphur for the Control of Cherry Leaf-spot.* Where lime-sulphur is consistently applied with thoroughness and timeliness so that overwintering disease inoculuum 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 sprays 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 AS SEVERE INJURY IS CERTAIN TO RESULT.

54. *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 aside from or 5 pounds of cheap soap or soap flakes in 100 gallons of water applied as a they are seen on the cherry trees. Nicotine sulphate, 1 pint, combined with 4 or 5 pounds of cheap soap or soap flakes in 100 gallons of water applied as a thoroughly drenching spray as soon as they are observed will kill all aphids hit. The soap or soap flakes can only be dissolved in hot water and unless dissolved trouble will result from clogging the screens of the sprayer. There are upon the market various liquid soaps and other nicotine activators which are very efficient for use with nicotine sprays. 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 get rid of this aphid.

A dormant application of tar or tar and oil (See Sec. 19 and 28) may be used for the control of black cherry aphid. If, for any reason, an infestation develops after such an application, it may be controlled by the previously outlined treatment with nicotine sulphate.

55. *Fruit Flies.* There are two species of cherry fruit-flies common in Michigan. These fruit-flies produce footless and headless maggots, about one-quarter inch long, which feed inside the fruit. They are usually almost

## 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 Section 58. | Leaf-curl, scale insects and mites. If mites are present refer to Section 58. | 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 Section 58 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 lbs., in 100 gallons iron sulphate-lime or zinc sulphate-lime spray. See Section 60. | Curculio. Refer also to Section 60 and 67. | 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 lead arsenate on peaches, do not use more than 2 lbs. 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 and lead arsenate, 2 lbs., in 100 gallons of iron sulphate-lime or zinc sulphate-lime spray. See Section 60. | Curculio, scab and brown-rot. Refer to Section 60. | This is important to check the early development of scab and brown-rot. |
| 4. About one month before the fruit ripens. | DUST with sulphur (with fluffer), or SPRAY with wettable sulphur. See Sections 12 to 15. | Brown-rot and scab. | Do not use lead arsenate at this time unless absolutely necessary. |
| 4a. One week after No. 4. | Sulphur-oil-lime dust. See Section 58a. | Oriental fruit moth. | |
| 4b. Two weeks after No. 4. | Sulphur-oil-lime dust. See Section 58a. | Oriental fruit moth. | |
| 5. One week to ten days before the fruit ripens. | DUST with sulphur (with fluffer), or SPRAY with a wettable sulphur. See Sections 12 to 15. | Brown-rot. | On many varieties this application is often important to retard rot development during or after harvest. |

CAUTION. Study carefully Section 61. Use P. D. B. about September 15 for peach borer. See Section 61.

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 fruit-fly 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, put on 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 2½ gallons of lime-sulphur for sour cherries or 2 gallons for sweet cherries.

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

56. *Climbing Cutworms.* Refer to special instructions in Section 81.

57. *Cherry Case-bearer.* While the cherry case-bearer is a comparatively new 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 case-bearers 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, as 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 case-bearer, 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 22).

## Supplementary Directions for Peaches

58. *European Red-mite.* This pest overwinters in the egg stage (Section 32). If the minute red eggs of this mite are present, the application of an oil spray containing 3 per cent actual oil is indicated. A complete and thorough coverage is necessary if all eggs are to be killed. Since it is always desirable to spray peaches for the control of leaf-curl, it is desirable to combine a fungicide with the oil spray. The home-made casein and bordeaux emulsions can be used with bordeaux. To make a 3-per cent oil spray with fungicidal value, add 4½ 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 (Sections 24-25) and then pumping it into a separate container. Then make the bordeaux in the sprayer in the usual way (Sections 16 and 17) 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.

58A. *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. Oriental fruit moth has four or five 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 cuts down the population of oriental fruit moth as most of them go through the winter on mummies, pieces of weeds, beneath the tree. Treatment with P. D. B. for peach borer kills some oriental moth.

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

The best insecticidal treatment tried to date has been weekly applications of ½ pound per tree of a dust consisting of 60 pounds sulphur and 5 pounds of oil, 35 pounds lime or talc. This may be mixed at home or purchased from one of several companies.

59. *Fall Spraying for Leaf-curl.* Leaf-curl can be controlled by proper fall spraying and it is believed that enough experience has been obtained here and elsewhere to indicate that this practice can be followed with safety. It is suggested to those who care to practice fall spraying that bordeaux, 8-12-100, be used after the leaves have dropped.

60. *Arsenical Injury.* Peaches and certain varieties of 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 this and other states have developed 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 lead arsenate or lead arsenate and a sulphur spray. One of these should be used whenever lead arsenate is present in a peach spray. Iron sulphate is somewhat cheaper and dissolves more readily than zinc sulphate.

### Iron Sulphate-Lime[3]

*With Lead Arsenate Alone.* For each 100 gallons of spray use iron sulphate, 4 pounds, hydrated lime, 4 pounds (use high calcium spraying or chemical hydrated lime) and 2 pounds lead arsenate and 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 made previously.
3. Continue to add water and with agitation add the hydrated lime in any convenient way.
4. Add the lead arsenate. Fill sprayer with water and apply.

*With Lead Arsenate and Sulphur.* When wettable sulphur or sulphur paste which does not contain lime is used with lead arsenate proceed as with lead arsenate alone, adding the sulphur material after the lead arsenate. It is not known how bentonite sulphur will combine with this mixture.

### Zinc Sulphate-Lime[3]

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 22¼

[3]Iron sulphate-lime and zinc sulphate-lime are excellent correctives for use with zinc and calcium arsenates.

per cent zinc and is in a crystal form; the second contains 25½ per cent zinc and is the flake form; and the third contains 36 per cent zinc and is the powdered form. The 25½ per cent grade is the one used in our 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 per cent of zinc present. For example, in the standard 4-4-10 mixture, 4 pounds of the 25½ 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 should be added to 4 pounds of lime.

61. *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 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 to a well grown tree. Do not use paradichlorobenzene on trees until they have been in the field for three years. Use less on a tree under six years old and a half-ounce on smaller stock. Cover lightly with soil, being careful not to disturb the ring of crystals. Apply late in August or about the first of September. Paradichlorobenzene does not work well when the temperature of the soil at four inches depth falls below 60 degrees Fahrenheit.

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, dig out the larvae in spring or fall.

During the last 3 years, application of paradichlorobenzene dissolved 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. Since 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 worked so efficiently on older trees as the standard crystal treatment.

62. *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 15th will control these pests. It should not be applied, however, when the temperature is 50° F., or below, as the material will crystallize. Painting the mixture upon the infested areas after removal of the gum will kill practically all of the borers, while painting without removal of the gum will kill about 90 per cent. This mixture consists of one pound of paradichlorobenzene dissolved in two quarts of raw cottonseed oil.

63. *Bacterial Spot.* This bacterial disease is most readily seen on leaves and fruit as small, angular or jagged dark brown spots. It is distinguished from arsenical injury by the small size and rougher margin of the spots

## 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 scale or mite eggs. |
| 2. PRE-BLOSSOM. Just as leaf buds burst and before lossoms open. | Lead arsenate, 3 lbs. plus corrective. (See Section 60) and water to make 100 gallons. | Curculio. | Beetles coming out from hibernation feed on the opening buds. This application is important. |
| 3. PETAL-FALL. Just after the petals have fallen. | Wettable or flotation sulphur and lead arsenate, 3 lbs. plus corrective. (See Section 60) in 100 gallons. | Curculio, leaf-spot and brown-rot. | |
| 4. TWO-WEEKS. Ten days to two weeks after No. 3. | Wettable or flotation sulphur and lead arsenate, 3 lbs. plus corrective (See Section 60) 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 or flotation sulphur, 4-6 lbs., in 100 gallons. See Section 12. | 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 Sections 12 and 13.) | Brown-rot. | This application is very important to prevent the development of rot as the fruit ripens and during transit. |

which do not fall out as readily as those of arsenical injury. Very little of the disease has been noticed in the state during the past few years. If bacterial spot is suspected, send leaf samples to the Botany Department, for determination. Directions for spray control will be forwarded if diagnosis is substantiated.

64. *Coryneum Blight.* Coryneum blight has been serious in only relatively few orchards in spotted localities 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 accompanies the lesions on twigs. Bordeaux 16-24-100 applied in the fall about Oct. 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, applied in the spring, late in the dormant period would also be of value. A leaflet describing this disease and its control may be obtained from the Botany Department.

65. *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 these areas and seed the land to clover for several years before resetting to peaches.

66. *Climbing Cutworms.* Refer to special instructions in Section 81.

67. *Curculio.* In peach plantings where curculio is of importance as a pest, clean-up measures will aid materially in its control, since 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 43 for apple orchards, with the addition of proper disposal of the thinnings, which normally include curculio-infested peaches. 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 in the peaches on the ground.

68. *Virus Diseases.* Trees having peach yellows, little peach or red suture should be removed when the symptoms are recognized. Circular Bulletin 146 describes these diseases. In most peach districts these trees are located and ordered removed by township inspectors. Recent investigation shows that these diseases can be transmitted by a plum leaf-hopper. Plums can have these diseases without showing the symptoms. Old, uncared for, unprofitable and unwanted plum trees should be destroyed. Plum trees should be sprayed with nicotine sulphate, 1 pint in 100 gallons about three weeks after petal-fall to control the leaf-hoppers, or include the nicotine sulphate in Application 4.

### Supplementary Directions for Plums

69. *Red-mite.* Plums are frequently infested with red-mites. The treatment is the same as recommended for the apple. Refer to Section 35.

70. *Sanitary Measures for Rot Control.* Brown-rot 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 from one plum to

## GRAPES

| APPLICATION | MATERIALS | TO CONTROL | EXPLANATIONS |
|---|---|---|---|
| 1. When shoots are 8 to 10 inches long. | Bordeaux, 8-12-100. Lead arsenate, 3 lbs. plus 3 qts. summer oil. See Sections 16 and 17 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 Section 77 for further discussion of black-rot. |
| 2. Just as the blossom buds are opening. | Bordeaux, 8-12-100, and calcium or lead arsenate, 2 lbs. plus 3 qts. summer oil in each 100 gallons of spray. (Refer to Sections 16 and 17 for instructions for making bordeaux). Use casein-lime or casein-bentonite spreader. | Black-rot, berry-moth, downy mildew and rose-chafer. | If rose chafer is present, use 5 lbs. lead arsenate and perhaps a gallon of cheap molasses. This is a critical application for the control of berry moth. |
| 3. Immediately after fruit sets. | Bordeaux, 8-12-100, and calcium arsenate, 2 lbs. in each 100 gallons of spray. Use casein-lime or casein-bentonite spreader. | Black-rot, downy mildew, berry-moth and rose-chafer. | If rose chafer is very bad or berry moth very plentiful, make this application four days earlier. |
| 4. Two weeks after full bloom. | Bordeaux, 8-12-100, and calcium arsenate, 2 lbs., in each 100 gallons of spray. Use casein-lime or casein-bentonite spreader. | Black-rot, downy mildew and berry-moth (See Section 79). | This application is imperative for berry moth control, as the use of an arsenical at a later date, as formerly advised, no longer seems justified because of danger of excessive residue. |
| 5. About the time the berries begin to touch, or just before first leaf-hoppers acquire wings. | Bordeaux, 4-6-100, and nicotine sulphate, 1 pint, with casein-lime as a spreader. | Black-rot, downy mildew, and leaf-hopper. | This application should be made if black-rot and mildew threaten. Usually the first application for leaf-hopper control may be made at this time. (See Section 80). Omit the nicotine sulphate if hoppers are not present in injurious numbers. |

another if they touch. All "mummied" fruits from the previous season should be removed from the tree and raked up from the ground and destroyed by being buried under two feet of compacted soil. They are sources of reinfection. **Curculios must be controlled as brown-rot follows their injury.**

71. *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 of lime-sulphur or oil-bordeaux will eliminate many spores of black-knot. The usual summer sprays also help check new infection. See Section 58 for instructions on oil-bordeaux.

72. *Climbing Cutworms.* Refer to special instructions in Section 81.

73. *Bacterial Spot.* Refer to Section 63.

74. *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 42 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 in the plums on the ground.

75. *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 54.

76. *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 leaf-hoppers.

### Supplementary Directions for Grapes

77. *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 to become slack in their spraying operations and they omit one or both of Applications 1 and 2 with the result that rot many develop seriously under favorable conditions if the primary or early infection 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.

78. *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.

79. *Grape Berry-moth.* This insect was especially destructive during 1937. Unless control measures are applied conscientiously, losses will be greater in 1938 because large numbers of these insects are now in winter quarters.

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

The danger of residue places an added importance upon supplementary measures. Destruction of weeds, accumulations of leaves, in the vicinity of woodland, 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 or July regardless of weed growth. Information at hand indicates that plowing to the vine is more effective than plowing from them.

80. *Grape Leaf-hopper.* Spray in exactly the same manner as outlined above for the control of berry-moth. It is necessary to hit 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 one and one-half pounds of casein-lime. If dust is preferred, use 2-per cent nicotine in hydrated lime. Apply dust at night while air is not stirring. 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.

81. *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 the 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 a double handful 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 other animals is negligible.

## FORMULA FOR BRAN-BAIT

20 pounds wheat bran
1 pound white arsenic
½ 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.

A greatly improved bait can be made by dissolving 32 pounds of caustic soda (lye) in 8½ gallons of water and then stirring in and dissolving 100 pounds of white arsenic. This makes a stock solution of arsenite of soda containing eight pounds of arsenic to the gallon. In preparing bait, add two quarts 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.

82. *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 keeping it down.

The beetles, which hibernate 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.

83. *Grape Root-worm.* The adult of the grape root-worm 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 from above downward, since root injury is severe if adults escape poisoning.

### Supplementary Directions for Currants and Gooseberries

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

85. *Witches'-broom.* One species known as the Houghton gooseberry aphis 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.

## 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 *DNOCHP as recommended for scale on apples. See Sections 34 and 19. | 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 16 and 17), lead arsenate, 3 lbs., and nicotine sulphate, 1 pint in each 100 gallons of spray. | Leaf-spot, leaf-eating insects, aphids, and four-lined leaf-bug. | This is the critical application for aphid control and thorough work at this time is important. Spray the under sides of the leaves. |
| 3. Soon after the blooming period. | Bordeaux, 4-6-100, (See Sections 16 and 17). | Leaf-spot and mildew. See Section 86 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 aphis persists, add nicotine sulphate and spray very thoroughly. |
| 4. Ten days or two weeks after No. 3. | Bordeaux, 4-6-100, (See Sections 16 and 17). | Leaf-spot and mildew. See Section 86 for control of leaf-eating insects. | If currant worms appear refer to Section 86. |
| 5. Just after the fruit is harvested. | Bordeaux, 8-12-100, (See Sections 16 and 17). | Leaf-spot and mildew. | This is desirable when leaf-spot has not been well controlled in early summer. |

*DNOCHP=Dinitro-ortho-cyclohexylphenol.

86. *Leaf Eating Insects.* The commonest and most 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 you desire to mix your own dust shake together equal parts of flour, talc, or powdered chalk and freshly ground pyrethrum and dust thoroughly. Hellebore, 2 ounces in each gallon of spray or 1 part hellebore with 4 parts flour as a dust will kill leaf feeding insects on currants. These materials are effective but kill slowly insects the size of currant worms. Either may be used without danger of poisonous residue.

87. *Currant Borer.* The currant borer is a moth larva which burrows in the smaller canes of the currants, eats out the pith, and leaves a blackened burrow 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 pruned out pieces of canes.

## Raspberries, Dewberries, and Blackberries

88. 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, orange rust, and streak. 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.

Remove the old canes 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 but which cause severe stunting of blacks. Wild red raspberries in the immediate vicinity of black 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 aphis are abundant.

Rogue older raspberry plantings if the percentage of disease is not too high. Fields more than a year old and having more than 10 per cent mosaic, streak, and orange rust rarely pay for rogueing. If the percentage is lower, careful rogueing 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 two per cent of these diseases can be successfully rogued.

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

1. When 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 16 and 17 for instructions for making bordeaux.) Casein

spreader, 1 pound in each 100 gallons, may be used. Especial care should be taken to completely cover 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.

90. *Borers, Girdlers, and Tree-crickets.* The borers, girdlers, and tree-crickets affecting raspberries over-winter in the canes. The removal of all multilated 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.

91. *The American Raspberry Beetle.* The small grubs, or worms, occurring in raspberries are the larvae of a brown beetle, about an eighth of an 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 one part calcium arsenate with 19 parts of lime, although almost equally good results have been obtained with a mixture of one 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.

92. *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 derris or pyrethrum sprays used according to manufacturers' recommendations. Derris 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.

93. *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 (made from oils of 75-85 seconds viscosity Saybolt and at least 92 per cent unsulphonated residue). 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. 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

94. 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.

95. *Strawberry Leaf-roller.* This is a small greenish caterpillar with a brown head. It draws the leaflet together with a 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.

96. *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 16 and 17 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 old leaves after harvest, the removal of diseased leaves before the plants are set, and the planting of resistant varieties are also methods of control.

## Spraying Young Non-bearing Orchards

97. Young orchards, in general, do not require as much spraying as bearing trees, but a certain amount of attention is necessary to insure proper protection from insects and diseases. Treatment should depend largely upon the prevalence of insects and the susceptibility of the foliage to injury by fungi.

CLIMBING CUT-WORMS. Climbing cut-worms are one of the most important pests of young trees. Read and follow instructions in Section 81 to avoid injury by these pests.

APPLES. Young apple trees should be kept free from scale insects. Should scale be found, the dormant spray, as recommended for bearing trees, should be applied. If aphids have been prevalent, make the delayed dormant application (Application 2) instead, using lime-sulphur and nicotine sulphate as recommended in the apple schedule. Aphids may cause serious injury to young apple trees by attacking the new growth and by spreading fireblight. Summer applications are desirable to keep the foliage free from scab and to kill leaf-eating insects. Two applications of lime-sulphur and lead arsenate, one soon after the leaves are well started and another two or three weeks later, are usually sufficient. Bordeaux can be used in place of lime-sulphur on non-bearing trees.

CHERRIES. Young cherry trees should be sprayed regularly for the control of leaf-spot and slugs. Heavy defoliation of young trees by leaf-spot may stunt the trees seriously so that they will be short-lived and un-

productive. Follow the same schedule as recommended for bearing cherry orchards, or see Section 53. If aphids are prevalent, spray as indicated in Section 54. This is more often necessary with sweet than with sour cherries.

PEACHES. Young peach trees should receive the dormant application as recommended in the peach schedule. Close attention should also be given to peach borers and mites. Failure to control borers, mites and curl will seriously impair the vigor of the trees.

PEARS. Young pear orchards should be examined every year for the presence of scale. If present, make the dormant application. Psylla seldom attack seriously, young, open plantings of pears, but, if they should appear, spray as directed for bearing orchards. If slugs appear in the summer, they may be easily controlled by an application of lead arsenate.

PLUMS. Young plum orchards should receive the dormant application if they become infested with scale. Summer applications are usually not necessary unless leaf-spot is prevalent. Spray as directed in the plum schedule if necessary to control this disease. Keep on the alert during the summer for leaf-eating insects and aphis. (Sections 75 and 54.)

CURRANTS AND GOOSEBERRIES. Young plantings of these fruits will require about the same attention as bearing plants. Requirements will vary somewhat according to variety and conditions.

GRAPES. Non-bearing grapes will usually require little or no spraying further than to make sure that they do not serve as breeding places for the leaf-hopper or root-worm. See Section 81 for measures against climbing-cutworms.



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