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TAR DISTILLATE EMULSIONS FOR THE CONTROL OF THE ROSY APHID AND OTHER FRUIT INSECTS

F. Z. HARTZELL AND P. J. PARROTT

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TAR DISTILLATE EMULSIONS FOR THE CONTROL OF THE ROSY APHID AND OTHER FRUIT INSECTS

F. Z. HARTZELL AND P. J. PARROTT

ABSTRACT

Tar distillate emulsions represent a new type of insecticide which are as yet little utilized by the orchard industry of this State. The principal constituent is refined creosote oil which is rendered miscible in water by various emulsifying agents. The claim of these preparations for recognition rests primarily on their greater effectiveness against the overwintering stages of a number of important injurious insects of fruit trees as compared with other insecticides.

The experimental activities under review were undertaken to secure information relative to the efficiency of tar distillate emulsions, particularly against various aphids and scale insects, the bud moth, and certain associated species. The effect of such treatment on the vigor and productiveness of fruit trees was also considered.

The progress of the work during the past 5 years along these two lines is briefly summarized, with the inclusion of data to show the general trend of control against the foregoing species as well as of records on the influence of the various treatments on buds and wood. It is pointed out that the tar distillate emulsions have shown a high degree of efficiency, notably against the rosy apple aphid, the black cherry aphid, and the bud moth. When applied under the conditions specified, there have been no indications of harmful effects on buds or wood. With respect to these three pests it would appear that the new spray materials should serve a useful purpose for many orchardists.

To avoid risk of injury to trees, particularly the buds, treatment is restricted to the period in the spring when buds are dormant. The limitation of applications to such a brief period may entail greater difficulties for the New York fruit grower.
than for those in other fruit growing areas. The actual number of days associated with dormancy of buds when temperature and soil conditions are suitable for spray operations and when there is freedom from high winds and rains are, generally speaking, rather few. In New York, it not infrequently happens that with the cessation of hard winter weather temperatures may rise rapidly, suggesting summer conditions, and as a result the buds develop quickly. Careful planning will be required to utilize days that present optimum conditions for the treatment of the trees.

INTRODUCTION

During the past 5 years the merits of coal tar distillate sprays for combating various destructive insects have been considered by this Station. In pursuing this study many tests were conducted under laboratory and field conditions.\(^1\) A number of these efforts have consistently shown a high degree of control and it is believed that the facts gained from certain of these activities are of sufficient practical importance that they should be brought to the attention of the fruit industry. Since interest in these new spray materials is being displayed by increasing numbers of orchardists and nurserymen each year, the purpose of this bulletin\(^2\) is to serve as a guide to those who desire to use tar oil emulsions for controlling certain insect pests.

In directing attention to this new class of insecticidal materials, it should be pointed out that further investigations are desirable and that they will be continued, particularly with reference to the efficiencies of the different important constituents of tar oil emulsions. Knowledge of the value of the principal elements should prove useful in compounding preparations for specific purposes and in promoting better standardization of this class of spray materials.

So far, we have no means of determining the attitude that the

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\(^1\) The authors are indebted to the following growers for the use of orchards and other facilities: J. R. Stevenson, Cayuga; C. S. Wilson and B. R. Jones, Hall; Collamer Brothers, Hilton; F. E. Pease, Lockport; W. R. Clarke, Milton; J. S. Beckwith and Clark Anderson, New Haven; George Catchpole and O. A. Skutt, North Rose; L. J. Salisbury, Phelps; B. J. Case and J. G. Case, Sodus; H. P. King, Trumansburg; W. P. Rogers, Williamson; F. H. Hammond, A. G. Lewis, A. L. Sanford and C. K. Scoon, Geneva.

\(^2\) A more complete presentation of data will be given in a series of bulletins which is now in course of preparation.
fruit industry is likely to display relative to the usefulness of these preparations. Individual growers who have cooperated with the Station have, with few exceptions, expressed great satisfaction with the degree of protection secured against various species of insects. Nevertheless, there is need of more information than is now available relative to growers’ reactions generally towards these new spray materials, particularly as regards the safeness of treatments to fruit trees and the ability of owners of plantings to find suitable weather and soil conditions that will permit satisfactory spraying of orchards when buds are dormant. The experience of growers with respect to the responses of fruit trees to treatment and in securing favorable conditions for spray operations will determine to a large extent the part that tar distillate sprays will play eventually in the spray program of the fruit industry in this State.

In beginning the investigations relative to tar oil sprays the primary considerations were (1) to find the safety limits of tar washes on different varieties of fruit trees; (2) to determine the effectiveness of such materials on the more important fruit insects; (3) to ascertain whether American tar oil would produce as effective and safe washes as foreign tar distillates; and (4) to determine whether or not a home-made tar distillate spray was feasible and practical.

As thereafter various American concerns began to place on the market brands consisting of domestic materials and varying in accordance with the specifications of each manufacturer, the investigational project was enlarged to include new aspects; namely, the comparative effectiveness and safety of various foreign and domestic brands and chemical analyses to ascertain the constituents of the different preparations. The information gained along these lines should prove of much value in guiding growers in their spray practices.

COMPOSITION OF TAR DISTILLATE SPRAYS

The chief constituent of tar washes is refined creosote oil obtained from the distillation of coal tar. This material (coal tar) is formed during the manufacture of coke and illuminating gas. For their preparation bituminous coal is heated to 1100°C in a by-product coke oven. The vapors coming from the oven are cooled and the material that condenses is known as coal tar. For the manufacture of creosote the tar is placed in large steel stills and heated at
gradually increasing temperatures. After the water has been driven off the fractions that distill below 200°C are removed, since they contain xylols and other valuable chemicals. Some of these chemical constituents are believed to be injurious to trees. The portion that distills from 200°C on up is known as crude creosote oil, or sometimes simply as tar oil. The highest temperature to which the distillation is carried depends upon the use that is to be made of the pitch that collects in the still. If a soft pitch is desired the process is stopped at a temperature approximating 360°C, but if a hard pitch is required the heating may continue until a temperature of 400°C is reached. The fraction of creosote utilized for the preparation of tar distillate emulsions is a refined portion that is obtained by redistilling the creosote to remove light boiling materials, as well as the heavy end portion. This selected fraction is then chilled to 5°C and put thru a filter press to remove crystalline materials that would otherwise settle out with the first cold weather and cause trouble in the spraying process.

The expression “tar” associated with these new sprays frequently suggests to those unacquainted with the emulsions a wrong impression as to their appearance and physical properties. Except that tar distillate oils are considerably darker, they resemble somewhat in general appearance ordinary lubricating oils; altho their physical properties are different. The emulsions of each type of oil when diluted with water show a striking resemblance as regards color.

Tar oil sprays are made by emulsifying the creosote oil to make it miscible with water. In the first commercial brands produced in Holland resin fish oil soap was used for the emulsifier. Later, workers at the Long Ashton Station, England, employed a high grade of sulfonated castor oil and caustic soda as the emulsifier for a type of tar distillate spray to which was given the name Long Ashton Wash. At the present time the different foreign and domestic brands of tar washes contain various materials as emulsifiers. Since there seems to be no indication that the kind of emulsifier affects appreciably the insecticidal properties of the washes so


far tested, no effort has been made to determine the character of these ingredients.

The Long Ashton Wash and certain foreign brands do not contain any petroleum oil. Other foreign brands and all the domestic brands tested, except one that is not yet on the market, contained petroleum oil, the proportion varying in the several brands from 10 to 38 per cent. It is believed that the incorporation of petroleum oil enhances the durability of the emulsions which is a desirable requisite if preparations are kept in storage for more or less extensive periods. Petroleum is also being used with the expectancy that tar distillate sprays can be made effective against a large number of destructive insects.

English workers at the Long Ashton Station have investigated coal tar oils with the aim of determining the fractions of greatest insecticidal properties and of ascertaining their effect on the health of trees. They regard tar acids as undesirable constituents of the washes. This position seems to be corroborated by experiments at this Station. These workers also assert that the most valuable elements of neutral tar oils, at least for certain European insects, are contained in the fraction distilling between 260° and 360°C after the anthracene has been removed. This claim does not seem to have been substantiated by other English workers nor by this Station. However, certain results secured here may possibly be explained on this basis. Tests of various fractions of tar oil on the eggs of the green apple aphid (Aphis pomi) indicate that even the fraction distilling between 200° and 270°C is very toxic to the eggs of this species. Further experimentation, especially as regards other insects, is necessary to settle this question. The refined neutral fractions boiling between 280° and 360°C, emulsified by Agral W B (a refined sulphonated castor oil) and an alkali, constitutes the Long Ashton Tar Distillate Wash which is marketed both as a “one-solution” and a “two-solution” spray material by several English firms. The fractions of tar distillates in the various commercial brands of tar washes range from straight-run tar oils boiling between 200° and 360°C thru those distilling from 240° to 360°C to material boiling from

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280° to 360°C, the last being the fraction used in the Long Ashton Wash. In addition to different proportions of petroleum oil, there is a variation in tar acid content from almost 0 to 9 per cent. Thus it will be seen that these sprays have not been standardized.

Despite this lack of uniformity in composition, with few exceptions fairly consistent results have been secured in controlling various species of aphids, oystershell scale, scurfy scale, and eye-spotted bud moth. The following brands have been used in field tests: Carbokrimp (made in Holland); Imperial Tar Wash, Metro, Mor- tegg, Ovicide, Dormoil, and Long Ashton Tar Wash furnished by Solignum Ltd. (all made in England); Arbo, Barko, Tarolene, Tar- zol, and an unnamed mixture manufactured by the Koppers Company in 1932 (all made in America). Several brands were tested on fruit trees for 4 years, others for two years, and some for only a single season.

HOME-MADE TAR DISTILLATE EMULSIONS

At the present time domestic concentrated tar distillate emulsions containing from 79 to 83 per cent active ingredients, including both tar distillate and petroleum oil, are being sold at from 35 to 40 cents per gallon. Thus, a 5 per cent\(^5\) spray mixture would cost from 1.75 to 2 cents per gallon as applied to the tree. Other concentrations would be in proportion. Because of freight and tariff charges, foreign brands of tar distillate sprays are expensive and their high cost, according to our experience, prohibits their use by the average grower.

Tar distillate sprays had their origin in Europe, and for a number of years the only available materials of this character were a few brands compounded by foreign manufacturers. Reports of control of various insects by these materials led workers of this Station to

\(^5\) Throughout this bulletin the concentrations stated in percentages refer to the number of gallons of concentrated emulsion used in 100 gallons of the spray mixture. It would be more definite to state the percentage of tar distillates in the diluted mixture, but until more is known regarding the effect on insects of the petroleum oil in the combination it seems that the method used gives the best picture of the amount of ingredients involved and does no injustice to the various brands. The fact that, notwithstanding the great variation in tar distillate and petroleum oil in the several brands, similar results were generally secured by different brands is another reason for specifying the strength of the spray mixture in terms of the number of gallons of stock emulsion used rather than on the basis of the tar distillate or petroleum oil content.
import several of the leading brands for experimental tests. Owing to freight charges and tariff duties, the materials proved expensive and it was soon recognized that any advantages which tar washes might possess for combating certain insect pests would be overshadowed by the high cost of the treatment per tree, especially if such concentrations as 8 to 10 gallons of emulsion per 100 gallons of spray mixture was used, as is the custom in England.

At the beginning of this study the question arose, Why could not tar washes be made from American tar oils? Accordingly, in 1930 a commercial unrefined creosote oil was secured thru the courtesy of the Rochester Gas and Electric Company, a nearby plant that distilled tar commercially. This oil contained 49.4 per cent of residue that became coke above 355°C, so in reality only one-half the material was tar oil. Considering the tar oil content alone, 47.2 per cent distilled between 200° to 270°C; 23.7 per cent between 270° to 315°C, and 29.1 per cent between 315° to 355°C. Moreover, the creosote oil contained 12.5 per cent tar acids. It is to be noted that, altho this was a straight run creosote oil, the lowest boiling fraction contained nearly one-half of the entire tar oil.

The crude creosote oil was emulsified by mixing 9 parts with 1 part of Agral W B. The material was then put in the spray tank with about three times as much water. With the agitator running and the spray-gun directed on the mass a saturated solution of caustic soda was slowly added until a fine emulsion resulted, after which the remaining volume of water was added. It required about 3 pints of the soda solution to emulsify 5 gallons of the combined creosote-Agral mixture. Tests with the 5 per cent spray during four seasons showed that it possessed a killing efficiency against the rosy aphid about equal to that of the commercial preparations at the same concentration. At the prices then prevailing a good grade of sulfonated castor oil cost $1.50 per gallon, while the crude tar oil sold for about 15 cents per gallon in 50-gallon drums f. o. b. shipping point.

Owing to the high cost of sulfonated castor oil, attempts were made to find a more economical substitute. Menhaden oil seemed to be a promising raw material since it was available in large quantities at a relatively low cost. This was successfully sulfonated by one of the writers in 1931 and it was found to emulsify tar oil when used with either caustic soda or sodium metasilicate. Later, sulfonated cod oil was found to emulsify tar oil when used with either
of these alkalies. Even at the present time sulfonated menhaden oil is not a commercial commodity. Sulfonated cod oil is a standard product because it is made in large quantities for the tanning industry, and at present costs about 50 cents per gallon in barrel lots.

The commercial tar emulsions contain about 80 per cent of active ingredients and, as stated previously, are sold at from 35 to 40 cents per gallon; so a 5 per cent mixture of any of the commercial tar distillate emulsions would cost approximately $1.75 to $2.00 per 100 gallons. With these figures as a basis, it is of interest to note the items of expense for materials used in the preparation of a homemade tar distillate spray of equal concentration, as follows:

<table>
<thead>
<tr>
<th></th>
<th>Refined</th>
<th>Refined</th>
<th>Crude</th>
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<tbody>
<tr>
<td></td>
<td>tar oil at 37c</td>
<td>tar oil at 50c</td>
<td>tar oil at 15c</td>
</tr>
<tr>
<td>3.25 gallons tar oil</td>
<td>$1.20</td>
<td>$1.63</td>
<td>$0.49</td>
</tr>
<tr>
<td>0.75 gallon lubricating (petroleum) oil @ 20c</td>
<td>.15</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td>0.4 gallon sulfonated cod oil @ 50c</td>
<td>.20</td>
<td>.20</td>
<td>.20</td>
</tr>
<tr>
<td>2.50 pounds caustic soda @ 3c</td>
<td>.08</td>
<td>.08</td>
<td>.08</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td><strong>$1.63</strong></td>
<td><strong>$2.06</strong></td>
<td><strong>$0.92</strong></td>
</tr>
</tbody>
</table>

Thus it will be noted that if a grower makes his own emulsion from refined tar oil, some saving in cost of materials alone might be possible but the amount is not large. If the ingredients were purchased in large quantities, the cost could doubtless be reduced below the figures mentioned. However, it should be noted that these estimates make no allowance for such items of expense as labor, equipment, or waste of materials due to inability to make stable emulsions. In our experience, while no great difficulties have been encountered in making tar distillate concentrates, nevertheless petroleum oils on an average have proved to be more readily emulsified than tar oils.

One may wonder why home-made tar distillates cannot be compounded at a smaller cost. The situation in this case is probably no different than that which exists with arsenate of lead and lime-sulfur solution. Possibly with these materials some economies could be effected by the use of home-made preparations. However, considering all factors that are involved in such an undertaking, the actual saving is probably not large in most instances. This fact, coupled with the convenience and sense of satisfaction derived from using standardized products, probably explains why most growers prefer commercial brands. So with tar distillate sprays, the pur-
chase of tar oil in tank car lots, the use of cheaper emulsifiers which are practical with special mixing machinery, and quantity production under technical supervision are advantages associated with large industrial enterprises. It is these factors which, for the most part, make possible the production of commercial tar distillate emulsions at present prices. If these new sprays should hereafter be used extensively, it would seem that prices might be lower as a result of competition by manufacturers.

It will also be noted that the crude tar oil is considerably less expensive than the refined material. The specifications for the most suitable crudes have not been established as regards their insecticidal properties. The crude tar oils vary considerably, especially from different manufacturing plants, and with present information it is not known if their use will be practical. If crude tar oils of certain specifications are required, their cost will doubtless be higher than for the unstandardized products.

The foregoing considerations are of two-fold interest; viz., that in the preparation of home-made tar oil emulsions, more information is needed than is now available relative to the sources of supply as well as to the qualities of the materials that can be used by growers for the preparation of such sprays; and that the experimental data relative to the actual utility of tar oil sprays that can be compounded by the grower on his own premises is, comparatively speaking, very meager. Doubtless future years will witness considerable activity along these lines; but for the present at least, prudence dictates that in selecting a tar distillate spray chief reliance be placed in commercial brands which are preferred by the leading growers in one's locality.

TIME OF APPLICATION

On the basis of our experience with tar distillate emulsions, growers should adopt the rule of applying these sprays on apples during early spring while the buds are strictly dormant, that is, before there is any evidence of gray color on the tips of the more advanced buds. In all of the experiments made by the writers, including large orchard spray demonstrations with cooperating growers, treatments applied at the period designated have, in the main, not only given satisfactory control of several important pests, but in no instance has there been any evidence of appreciable injury when the spray mixture contained no more than 7½ gallons of the
stock tar distillate emulsion with water enough to make a volume of 100 gallons. On the other hand, some injury to buds has occurred when the applications were made at the time that the buds were in the gray or silver-tip stage. Pending the development of conclusive evidence that would warrant the extension of the spraying period during the spring, it cannot be too strongly emphasized that treatment of apples with tar distillate emulsions should be completed before the buds show any signs of the gray or silver-tip stage.

In the case of cherries, applications should be made early in the spring while the buds are brown. Spray solutions containing more than 5 gallons of the stock tar distillate emulsion are not recommended for this fruit.

The need of exercising caution with respect to proper timing of applications arises from the fact that the chances of injury to buds should never be overlooked. With no type of spray mixtures is this consideration of greater importance than with tar distillate emulsions. The possibility of damage as a result of spraying late in the fall or of making treatments to apples in the silver-tip and green-tip stages is considered in the following paragraphs. Mention is also made of the possible influence of a hard winter, particularly in the case of fall treatments and the susceptibility of buds and wood to damage from strong mixtures. Even in the case of experimental operations to determine the safeness of treatments to buds in various stages of development under his own local conditions, the grower should do so with full appreciation of the possible risk that is involved in undertakings where treatments as to strength of the spray mixture and time of application are different from those specified.

INJURY TO TREES

For the most part in the different experimental orchards tar distillate emulsions have caused no injury of material importance when applied to apple trees at concentrations not greater than 7½ per cent, if treatment was made during early spring when buds were dormant. Spray mixtures composed of 10 or 12 per cent proved destructive to buds of a number of varieties without injuring other sorts. Bud injury was not generally accompanied by damage either to twigs or limbs.

One block of apple trees, which includes such varieties as Rome Beauty, Westchester, Adersleber Calville, and Peerless, has been
sprayed 4 years as follows: 1930, 10 per cent concentration applied during late winter; 1931, 5 per cent during early spring; 1931 and 1932, 5 per cent during late fall. To date, there has been no indication of harmful effects. In addition, a number of Greening trees were sprayed during the late fall of 1932 with concentrations of 3 and 5 per cent. Also, similar treatment was given during the fall of 1932 to Greening trees at Hilton, the concentrations being 5 and 7 per cent. In no instance has there been any indication of injury. With respect to applications of tar distillate emulsion during autumn, it should be noted that the last two winters have been exceptionally milder than normal.

With the growing interest in tar distillate emulsions as manifested during the past 2 years, the question is not infrequently raised as to the possibility of spraying trees during the spring when buds are in the gray or silver-tip stage or at a somewhat later period when the buds are about ready to break, commonly known as the green-tip stage. Applications of the new sprays have been made at precisely these different stages of bud development and so far there has been little evidence of appreciable injury to buds when the concentrations did not exceed 7½ per cent except on Twenty Ounce and Wealthy and a few somewhat uncommon varieties. In this connection it should be recorded that in one instance Greenings were sprayed with 7½ per cent tar distillate emulsion when the buds had almost reached the green-tip stage and subsequent bud and blossom development seemed normal.

The most noticeable effect observed on common commercial sorts with late winter and early spring treatments is a retardation in the unfolding of blossom and leaf buds. In some instances there were evidences of injury to the outer leaves of the blossom clusters. Affected foliage displayed burned edges, but apparently the blossoms were unharmed. Similarly, fall treatments during 2 years have shown a tendency to delay the breaking of the buds which, however, has not been so marked as has been the case with spring treatments. It would appear from these results that a grower who for one reason or another should happen to spray trees in the early silver-tip stage with a 5 per cent concentration need not be unduly apprehensive as to possible injury. Nevertheless, it should be made clear that this is one of a number of problems that has been raised by the introduction of tar distillate emulsions and which will be
stressed in future experiments. As has been the experience with other insecticides, doubtless it will be revealed that immunity and susceptibility to injury are correlated with vigor of tree, variety, seasonal conditions, degree of concentration of spray mixture, and tree dosage.

Our tests have been principally with such varieties as Alexander, Baldwin, Delicious, R. I. Greening, McIntosh, Hubbardston, Twenty Ounce, Rome Beauty, Ben Davis, King, Roxbury Russet, Wealthy, Wagener, Summer Banana, and Winter Banana. Data are lacking as to the effect of tar distillate emulsions on other varieties grown more or less extensively in this State, such as Duchess of Oldenburg, Early McIntosh, Fall Pippin, Northwestern Greening, Red Astrachan, and Cortland.

The experiments with cherries have been conducted on a less extensive scale than those with apples. Montmorency and Windsor trees have received applications of tar distillate emulsions at 4 per cent concentration during two consecutive seasons, while such varieties as Idar, Lyons, and Napoleon have been sprayed during one season with a 4 per cent concentration. Similarly, Schmidt has been treated with concentrations of 4 and 5 per cent and Black Tartarian with 5 per cent; also, one grower sprayed Black Tartarian, Schmidt, and Windsor with 6 per cent. In no instance did the trees show any ill effect except the usual manifestation of slow development in the unfolding of buds.

Each spring during the past 4 years a few pear trees of such varieties as Bartlett, Bosc, and Seckel have been sprayed without injury with concentrations of 4 and 5 per cent as the tips of buds were ready to break.

Data are lacking with cherries and pears as to the effect of fall applications.

MODIFICATION OF TAR DISTILLATE EMULSION BY ADDITION OF PETROLEUM OIL

Tar distillate composed exclusively of tar oil or of tar oil with small amounts of vegetable or petroleum oils have a limited range of usefulness. First of all, weak dilutions containing 1 per cent applied during the delayed dormant stage and preparations containing only 0.75 per cent applied during the summer caused serious harm to the green structures of apple trees which very definitely
limits treatment to the period when buds are dormant. Secondly, if foliage injury is to be avoided then obviously, if any benefit is to be derived by an application of the tar distillate emulsion, this will be strictly limited to that group of destructive insects which overwinter on the fruit trees.

In this State the principal fruit pests which pass the winter on the trees are as follows: Various species of aphids, such as the rosy and green aphids on apple and the black cherry aphid, all in the egg stage; a number of species of scale insects, among which should be mentioned the oystershell scale and the scurfy scale in the egg stage and the San Jose scale in the nymphal stage; several species of capsids, particularly the apple red bug in the egg stage; the fruit tree leaf roller, the white apple leafhopper and the European red mite, all in the egg stage; and the overwintering caterpillar of the bud moth in its hibernating shelter or hibernaculum.

The outstanding merit of tar distillate emulsions is that they possess a degree of insecticidal efficiency against a number of the foregoing pests, at the stages designated, which in general is not equalled by any other known spray material. With present information, the exceptions are the apple red bug, the fruit tree leaf roller, the white apple leafhopper, and the San Jose scale. Also the utility of tar washes to combat the red mite has not been established.

To extend the range of utility of these sprays so as to embrace particularly the red bug, the fruit tree leaf roller, and infestations of the San Jose scale, attempts are being made to enhance their insecticidal efficiency by the incorporation of relatively large amounts of petroleum oil. Workers in the British Isles, notably, have compounded and used such mixtures for a number of years at concentrations which seem rather high, according to our experience, and which apparently do not produce the deleterious effects on the trees sometimes noticeable in this country from spray mixtures with so high an oil content. Moreover, by the incorporation of a larger volume of petroleum oil in the tar distillate emulsions noticeable benefits in combating fruit capsids have been observed, altho the results in commercial orchard operations have been somewhat variable and appear to be affected by weather conditions.

Our interest in these new developments has been largely directed to determining if these modifications of tar distillate sprays were safe under New York conditions. The efforts in this direction have
special interest just now in view of the fact that some manufacturers seem inclined to use considerable petroleum oil in tar distillate emulsions. Then, again, other compounders are giving instructions to growers relative to the combining of additional petroleum oil with their brands for the express purpose of controlling the San Jose scale and various aphids with the same application.

Tests of these new formulas were made during 1931. At one extreme when the spray mixture contained 2.5 per cent of actual tar distillate and 3 per cent of lubricating oil, injuries to buds were quite severe on Wealthy and only moderately so on most other varieties. At the other extreme, a mixture containing 6.5 per cent of tar oil and 8 per cent of lubricating oil proved very toxic to leaf and fruit buds of all varieties used in the test. In some instances all the primary buds were destroyed. Secondary buds developed later. Larger branches generally were uninjured except on several trees, but many of the twigs died during the following winter on a large number of varieties. Mixtures of intermediate concentration produced a medium amount of damage. On the other hand, during 1933, tests were made with two preparations that contained equal amounts of tar distillates and petroleum oil, vis., one a brand that analyzed 37.5 per cent tar oil and 37.5 per cent petroleum oil, while the other mixture consisted of a tar wash to which was added enough petroleum oil to make the tar oil and petroleum oil content equal to that of the foregoing brand. The petroleum oil and emulsifier were claimed to be the same as was originally used in the tar wash to which the oil emulsion was added. Baldwin trees about 30 years of age were sprayed with the first mentioned brand and with the mixture using 5 and 7½ per cent concentrations. In addition, a number of Greening and Rome Beauty trees, all about 15 years of age, were treated, using the dilutions just mentioned, with the brand that contained 37.5 per cent of each kind of oil when manufactured. No injury occurred to either buds or twigs. The reasons for the discordant results with respect to injury between the tests of 1931 and 1933 are not known.

During past years, as a result of applying lubricating emulsion with a larger oil content than 6 per cent, severe injury has been noted in a number of apple orchards, especially those in light soils. According to our experience it does not appear that tar oils are safer than petroleum oils and, seemingly, their effect on buds and wood is somewhat different. Until more is known of the tolerance
limits of the different fruits to combinations of tar and petroleum oils, especially where the total oil content is high, the variable results with these mixtures suggest the need of great caution with respect to their use in orchard operations.

EXPERIMENTS WITH TAR DISTILLATE EMULSIONS AGAINST VARIOUS FRUIT INSECTS

The first tests with tar distillate emulsions at this Station were made by F. L. Gambrell in a series of experiments with various insecticides to determine their value in controlling the spruce gall aphid (*Adelges abietis*). The material was furnished by the Imperial Chemical Industries Limited of England.

Laboratory and field tests with tar distillate emulsions have been conducted against the following fruit insects: The rosy apple aphid (*Anuraphis roseus*), the green apple aphid (*Aphis pomi*), apple red bug (*Heterocordylus malinus and Lygidea mendax*), buffalo tree hopper (*Ceresa bubulus*), San Jose scale (*Aspidiotus perniciosus*), oystershell scale (*Lepidosaphes ulmi*), the scurfy scale (*Chionaspis furfura*), eye-spotted bud moth (*Spilonota ocellana*), fruit tree leaf roller (*Cacoecia (Archips) argyropila*), black cherry aphid (*Myzus cerasi*), cherry casebearer (*Coleophora pruniella*), and pear psylla (*Psyllia (Psylla) pyricola*).

In a number of orchards opportunity was afforded to observe the effect of tar distillate washes on the leafhopper (*Typhlocyba pomaria*), plum curculio (*Conotrachelus nematicus*), and the apple seed chalcid (*Syntomaspis druparum*). Then, too, an experiment was conducted to determine the effect of 0.75 per cent of actual tar oil applied in three successive cover sprays on the codling moth (*Carposcopsa pomonella*). The findings with respect to the last four species were negative and for that reason they are dismissed from

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———. Tests with tar distillate sprays for foliage applications. *Jour. Econ. Ent.*, 26, 480-486. 1933.
further consideration. It should be recorded, also, that the tests against the buffalo tree hopper gave inconclusive results, due, it is believed, to heavy parasitism. With respect to the fruit tree leaf roller, the tar distillate emulsions proved much less effective than lubricating oil emulsions. In the experiments against the cherry casebearer there was a noticeable reduction in the number of the insects as a result of one season's application. During the succeeding year satisfactory experiments could not be undertaken owing to the general decline in infestation. With respect to the remaining species, the principal experimental results are briefly summarized.

**ROSY APPLE APHID**

From the standpoint of the apple industry of this State with no insect pest is the consideration of tar distillate emulsions of greater importance than with the rosy apple aphid, since most orchards display commercial losses of varying severity during seasons when this species is abundant. Since periods of heavy infestation are not predictable and recur at surprisingly frequent intervals, annual spraying for the control of this insect on susceptible varieties is practiced by many growers. Whether plantings are large or small, it is the universal opinion that the rosy aphid is a very hard pest to combat. Fruit growers who possess large acreages find it difficult as a rule to spray the trees thoroly at the specified period because of unfavorable weather and soil conditions. The tendency to make the delayed dormant application serve the dual purpose of controlling both the rosy aphid and apple scab is also a complicating factor and such efforts sometimes fail to attain their real object with the result that the control of either pest may be imperfect. In view of the obstacles encountered by the apple industry, much attention each season is devoted to tests with numerous insecticides, among which tar distillate emulsions have seemed to offer considerable promise.

All brands previously listed have been tested against the rosy aphid. The efficiency of tar distillate emulsions at concentrations of 5 per cent or more has varied generally from 85 to 100 per cent as the average per plat.

During the past two seasons considerable attention has been given to concentrations of 4, 3, and 2 per cent. In 1933, a number of commercial orchardists applied these emulsions at 4 per cent concentration on a considerable acreage with excellent results. One grower
sprayed three plats, using 3½, 4, and 5 per cent concentrations, respectively, and obtained a high degree of control with no appreciable difference in efficiency between the various treatments. A number of experimental plats sprayed during 1933 with different brands at 3 per cent concentration displayed marked freedom from rosy aphid as compared with untreated trees. During this same year tests with a 2 per cent concentration gave evidence of good commercial control, altho similar experiments during 1932 showed inferior results.

For two seasons fall applications with 5 per cent concentration and applications in two other orchards during the autumn of 1932 with 3, 5, and 7 per cent concentrations showed efficiencies only slightly less than that of spring treatments. In all instances very good commercial control was obtained.

The foregoing results indicate that the grower now has at his disposal two methods of treatment in fighting the rosy aphid instead of one as has prevailed in the past; namely, the employment either of nicotine sulfate with lime-sulfur as a delayed dormant application or of tar distillate emulsion as a dormant treatment. Either one is effective if applied thoroly and under proper conditions. With respect to tar distillates it would appear that these preparations may enable orchardists to overcome some of the difficulties experienced in the past with the delayed-dormant application of nicotine sulfate in lime-sulfur. In making this treatment in large plantings particularly, experience has shown that the period when optimum conditions exist for spray operations may be very short during some seasons. With this new adjunct, the grower now has the option either of spraying a portion of his trees during the dormant season with tar distillate emulsions and of reserving the remainder of the orchard for treatment during the delayed dormant period with nicotine sulfate in lime-sulfur or of spraying the entire planting with either of these mixtures at the appropriate period.

The application of tar distillates during the dormant season should be regarded as a special or extra treatment. It is not a substitute for the delayed dormant application of lime-sulfur for the prevention of apple scab. The usual precautions for controlling this disease should not be disregarded. As in the use of nicotine sulfate in combating aphids, the importance of exercising great care in wetting all areas of the trees cannot be too strongly emphasized. Tar distillate sprays are contact insecticides and destroy only such aphid eggs as are wetted
by the spray. Experience has shown that the degree of control varies largely in proportion to the skill of the operator.

**THE GREEN APPLE APHID**

The eggs of this species proved susceptible to tar distillate emulsions and, considering the data as a whole, the degree of control was higher than that with the rosy aphid. Apparently the eggs of the green aphid occupy, in the main, more exposed positions on the bark, and for that reason fewer escape treatment during the spray operations. As has been the experience with nicotine sulfate in the delayed dormant treatment, trees treated with tar distillate emulsion were free from the insect until the re-invasion of the orchard from early summer migrants.

**THE OYSTERSHELL SCALE**

The tar distillate emulsions proved toxic to eggs of this species and concentrations of these sprays at 5 and 7½ per cent were very effective in demonstration tests in commercial apple orchards. In 1931, a single apple tree displaying severe infestation was given an application of 7½ per cent concentration and subsequent inspections showed that the insecticidal efficiency of the treatment was high. During 1932 an apple orchard displaying abundant infestation on most of the trees was sprayed, four brands (Barko, Carbokrimp, Mortegg, and Tarolene) being used at concentrations of 5 and 7½ per cent, respectively. Excellent control was obtained. At the same time tests were made in this planting with lime-sulfur 1 to 8, and a comparison of the two sections indicated that tar distillate emulsion was the more effective material. During 1933, applications of two brands of tar distillate emulsion (Niagara and Tarolene), each at 5 per cent concentration, resulted in good commercial control. Trees which have received two successive annual applications of tar distillate emulsions now display marked freedom from the pest as compared with conditions prior to treatment.

**THE SCURFY SCALE**

Tests\(^8\) conducted during 1932 in the Hudson Valley with lubricating oil emulsion against the scurfy scale indicated that the percentage

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of egg masses killed with 6 per cent oil was 93.31; with 5 per cent oil, 85.64; with 4 per cent oil, 89.84; and with the check, 1.50. During 1933, lubricating oil emulsion was compared with a tar distillate emulsion (Arbo) with the following results: 6, 4, and 2 per cent tar distillate emulsion, 96.55; 72.60, and 69.43 per cent killed respectively; 4 and 3 per cent lubricating oil emulsion, 71.40 and 47.33 per cent killed respectively; and the check, 1.11 per cent. All treatments were made in the spring when buds were dormant. "No noticeable injury to the trees resulted from the use of the tar distillate emulsion. Bud development was delayed and a few buds were killed where the 5 and 6 per cent oil emulsion was used. This condition proved of little consequence, however, since the trees soon assumed a normal appearance."

THE SAN JOSE SCALE

In instances of heavy infestation lubricating oil emulsion, 3 per cent oil, has proved more effective against this pest than one brand of tar distillate emulsion (Barko, petroleum oil content 15 per cent) at 5 per cent concentration. In one experiment where infestation was light, the same brand of tar distillate emulsion at 5 per cent concentration prevented red spotting of the fruit by the pest. In other instances noticeable discoloration of apples by San Jose scale has been observed in commercial orchards sprayed with these materials. In view of such variable experiences, the value of these preparations for the control of this insect is not definitely indicated.

THE APPLE RED BUG

It has proved difficult to secure satisfactory data relative to the insecticidal efficiency of tar distillate emulsions against red bugs. These insects fluctuate in numbers from season to season and the rate of infestation of different trees in the same orchard is usually extremely variable. It appears, however, from tests in 4 orchards that tar distillate sprays of the composition used in different tests at concentrations ranging from 5 to 10 per cent do not afford commercial control.

THE EYE-SPOTTED BUD MOTH

The control of this species is closely associated with spray practices for combating the rosy aphid. In the standard spray program for apple orchards, provision is made for nicotine sulfate (40 per
cent nicotine) in the delayed dormant application, its chief function being to combat the newly-hatched nymphs of the rosy aphid and the caterpillars of the bud moth. The efficiency of tar distillate emulsion against the eggs of the rosy aphid has been previously pointed out. If these new sprays should be used as a dormant treatment for this species, the effectiveness of this application against the bud moth is a matter of considerable practical importance. This explains the interest in this particular problem.

In field tests during the past 4 years, tar distillate emulsions at 5 per cent concentration have displayed insecticidal efficiencies of between 60 and 70 per cent against the bud moth. In some instances the degree of control has been greater and in others less. In the tests where the results were below the general average of efficiency as indicated by the foregoing figures, it should be stated that the inferior control is attributed largely to poor spray outfits incapable of maintaining high pressure and to the dense crowns of the trees which were badly in need of pruning. In some cases the constitution of a particular brand of tar distillate emulsion appeared to be at fault. All the available domestic and a number of the foreign brands were used in these experiments. Tar distillate emulsions at the rate of 7½ gallons of the stock material in 100 gallons of spray mixture showed efficiencies usually ranging from 70 and 80 per cent in different orchards. Comparison of plats designed to show the relative merits of the two kinds of treatment indicated that these results are about the same as those that can usually be obtained from 1 quart of nicotine sulfate and 3 gallons of lubricating oil emulsion in 100 gallons of spray mixture applied at the green-tip stage.

In general, therefore, tar distillate emulsions of 5 per cent concentration appear to be effective where moderate infestation of the bud moth exists. In such instances, apparently, a spray of this strength should serve the needs of many growers, since with the same treatment, a high degree of protection should be afforded the trees from both the bud moth and rosy aphid. Where the control of bud moth presents an acute problem due to heavy infestation, the desirability of applying a concentration of 7½ per cent as a special or emergency measure is indicated.

**THE BLACK CHERRY APHID**

Tar distillate emulsions have been tested for 2 years on the varieties Windsor and Montmorency and for 1 year on Ida, Lyons,
Napoleon, Schmidt, and Black Tartarian. During 1932 the brand Barko at 4 per cent concentration was used exclusively. In 1933, Arbo, Barko, Tarolene, and Tarzol were tested at 4 per cent concentration in one orchard and Niagara and Tarolene at 4 and 5 per cent concentrations in another planting; also one grower used Tarolene at 6 per cent. The tar distillate emulsions at the three strengths proved safe to the trees and were apparently about equally effective, showing ovicidal efficiencies of from 95 to 100 per cent except in one instance where the treatment showed 88 per cent control. So far, no tests have been conducted to determine the effect of fall applications on either the insect or the buds.

**THE PEAR PSYLLA**

During the past 4 years tar distillate emulsions at a concentration of 5 per cent have been applied to pear trees, principally of such standard varieties as Bartlett, Seckel, Beurre Bosc, Kieffer, and Clapp Favorite. As with other fruits, the work has been conducted along two lines, *viz.*, to ascertain the effect of the treatment on buds and wood, and to determine the efficiency of the distillate emulsions against various insects of the fruit, particularly the psylla.

The former efforts have been confined for the most part to a large apple orchard in which is interplanted a considerable number of pear trees, and both fruits have received two successive annual applications. Since infestation with psylla is of little significance in this orchard, the chief value of the undertaking consists in the information that has been secured relative to the influence of the treatment on the health of the trees. As has been previously recorded for other kinds of fruits, so far there has been no indication of any harmful effect as a result of repeated applications.

In the tests relative to insecticidal efficiency during 1931 a brand of tar distillate emulsion known as Dormoil, applied to trees of the variety Beurre Bosc, showed an efficiency of 92 per cent against the eggs of the pear psylla, while adjoining plats sprayed with lubricating oil emulsion (3 per cent oil) showed 98 per cent control. During 1932 a brand designated Barko, applied to six Bartlett trees infested with pear psylla, displayed an ovicidal efficiency of 96 per cent.

Concentrations of 5 per cent can apparently be used with safety on pear trees and the treatment is highly toxic to adults and eggs of
the pear psylla. Considering the needs of most pear orchards with respect to the control of insect pests, there has been no evidence that tar distillates possess qualities superior to those of lubricating oil emulsion, and since the latter is more economical, for the present it stands as the preferred treatment for psylla control.

SUMMARY

A number of foreign and domestic brands of tar distillate emulsions have been analyzed and were tested in commercial orchards to determine their safeness to fruit trees and their effectiveness against a number of important injurious insects.

Considerable variation exists between different brands with respect to their constituents, namely, the boiling fractions of tar oils and quantities of each, amount of tar acid, the proportion of petroleum oil, and the kinds of emulsifying agents. The differences in these respects suggest the need of further qualitative and quantitative studies, supplemented by field experiments to determine the influence of the variation of the several principal constituents on insecticidal efficiency against various insect pests as well as on the vigor and productive capacity of fruit trees. Considering the insects under discussion, with few exceptions, all brands so far tested gave about the same degree of control under comparable experimental conditions.

The original tar distillate emulsions had as their chief constituent refined coal tar creosote, with variable amounts of tar acids and bases. Present brands show two trends, viz., the use of all the fractions in a straight-run creosote oil, thus following rather closely the original European types; and a restriction of the mixture to the higher boiling fractions with the elimination or reduction in the amount of tar acids and perhaps also of the tar bases. These two types may be subdivided into other groups the first of which consists entirely of tar distillates as the active ingredients, while the second contains varying amounts of petroleum oil in addition to tar oils to make the mixtures effective against a larger number of insect pests. The tar distillates and petroleum oils, if present, are rendered miscible with water by means of various emulsifiers.

As compared with existing contact insecticides, the distinctive merit of tar distillate emulsions is that they display a high degree of effectiveness against eggs of various species of aphids and scale insects
and the overwintering stages of such species as bud moth and case-
bearers.

Efficient control is recorded of the rosy and green apple aphid, the black cherry aphid, the oystershell scale, and the scurfy scale. Marked reduction in numbers of the hibernating caterpillars of the bud moth is also noted. The tar distillate emulsion afforded only partial control of apple red bugs and proved ineffective against the fruit tree leaf roller.

In tests with tar distillate emulsions at concentrations of 2, 3, 4, 5, 6, and 7½ per cent, differences in degree of susceptibility were noted among the foregoing species of insects. The eggs of various aphids displayed greater vulnerability to the weaker preparations than the hibernating caterpillars of the bud moth. Marked susceptibility of the latter species was indicated only with mixtures at maximum strength. Intermediate concentrations were toxic to common scale insects. Effective concentrations for the different apple insects are as follows: Rosy apple aphid and green apple aphid, 4 per cent; oystershell scale and light infestations of bud moth, 5 per cent; scurfy scale, 6 per cent; severe infestations of bud moth, 7½ per cent.

Considering cost of treatment and average efficiency of spray material in commercial plantings, 5 gallons of tar distillate emulsion to 95 gallons of water are suggested as a strength which should serve a useful purpose in many apple orchards in view of the need of a preventive treatment to combat several insect pests. A spray of this concentration is effective against the eggs of the rosy and green aphids and applications for successive years should prove of considerable value in combating light infestations of bud moth and of various common scale insects. In cherry orchards 4 gallons of the tar distillate emulsion in 96 gallons of water are suggested for the control of the black cherry aphid.

Treatment of fruit trees with tar distillate emulsion is restricted to the period when buds are dormant. The treatment in most instances retarded the opening of the buds for a few days, but apparently it did not cause any harmful effect. In various orchard tests applications have been made late in the fall after leaves have dropped and in the spring before opening of the buds. So far as the health of the trees is concerned, there was no discernible difference as regards the effect of the treatments applied at the two periods.
With respect to fall applications, there is a lack of information as to the relative susceptibility or immunity of buds and wood to spray injury under varying weather conditions, and particularly as to the effect of a hard winter following fall treatment upon the well being of fruit trees. Future experience will reveal the actual hazards as well as the benefits that attend fall applications, but until there is more knowledge to guide sound spray practices, the safest rule to follow is to limit applications of tar distillate emulsions to that period in the spring when buds are strictly dormant or when they display no appreciable amount of swelling.

DIRECTIONS FOR USING TAR DISTILLATE EMULSIONS

The tar distillate emulsions now available to fruit growers are commercial preparations manufactured in accordance with the formulas of individual compounders and are designated by trade names. The promising results attending tests with these materials have been given widespread notice which will doubtless encourage a more extensive use of these new spray mixtures.

In 1929, there were no domestic brands of tar distillates available to the fruit growers of this State, but by 1933 at least five brands were on the market. Judging from the sentiments expressed by manufacturers of insecticides or their agents, it would appear that the number of brands will be considerably increased. If experience shows that these preparations have a definite field of usefulness, the demand for commercial brands will undoubtedly prompt other manufacturing concerns to compete for the trade.

As has been stated, tests with 10 brands have shown variations in composition. While with few exceptions satisfactory control of certain species of insects has been obtained at the concentrations used in spite of variability of composition, the lack of uniformity between the different brands would appear to be an important matter for consideration, particularly in regard to the relative market value of the products and with respect to the amount of dilution with water to form spray mixtures of required strength.

It is probably safe to assume that the more reliable compounders realize the necessity of producing a uniformly high grade product and will endeavor to maintain a standard strength for their particular brands guaranteed to the purchaser. Better standardization of the leading competing brands will presumably be generally adopted,
since there would apparently be but a small demand for mixtures that show considerable variation in their composition so that they lack uniformity in insecticidal efficiency.

From the standpoint of both manufacturer and fruit grower, tar distillate emulsions are to a large extent experimental spray mixtures. In view of the variations that exist between different brands fruit growers can do no better for the present than to follow the instructions furnished by the manufacturer. If these are vague or are not sufficiently specific insofar as the control of certain insect pests are concerned, the following directions, which for the present should be regarded as tentative, will serve as a guide in the selection of strengths of spray mixtures needed to combat the different species of injurious insects as listed:

**STRENGTHS OF SPRAY MIXTURES FOR DIFFERENT INSECTS.**

<table>
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| Rosy apple aphid, green apple aphid and black cherry aphid | 4 gallons tar distillate emulsion  
  96 gallons water |
| Oystershell scale and light infestations of bud moth and scurvy scale | 5 gallons tar distillate emulsion  
  95 gallons water*  
  *A spray of this strength will control the foregoing apple insects and may prove of some value in reducing a light infestation of San Jose scale. Because of its effectiveness against a larger number of important species, a mixture of this strength will perhaps best serve the needs of most apple growers. |
| Scurfy scale, heavy infestation...          | 6 gallons tar distillate emulsion  
  94 gallons water |
| Bud moth, heavy infestation......           | 7 1/2 gallons tar distillate emulsion  
  92 1/2 gallons water*  
  *A spray of this concentration will control all the foregoing apple species, except possibly infestations of San Jose scale. |

**TIME OF APPLICATION**

Tar distillate emulsions should be applied in the spring while buds are dormant. If possible, select quiet, balmy days for the application of the mixture, when temperatures are 45°F or higher. Avoid spray operations when there is a likelihood of temperatures falling considerably below freezing within 10 hours after treatment.
CHOICE OF BRANDS AND HANDLING OF MATERIAL IN SPRAY TANK

The experiments so far have not made it possible to discriminate between different brands. Since some appear to mix better in certain waters than others, it seems advisable to suggest that growers test samples of a number of brands in the water used for spray purposes and select the one that diffuses the best at the desired dilution. Some distributors of spray materials are willing to render this service. Generally speaking, a good rule to follow is to select one of the various brands approved by the leading growers in the immediate vicinity.

Occasionally, a can of material from an otherwise satisfactory run of tar distillate goes wrong. Rather than waste the product because of breaking in the spray tank, it is oftentimes possible to re-emulsify the material by adding a small amount of a saturated solution of caustic soda in water and thoroly agitating the spray material. In preparing the spray material for application to the trees the stock tar distillate emulsion should be added to the spray tank which contains not more than one-tenth of the required volume of water. With the agitator running add the remainder of the water needed to make the desired dilution.

The stock emulsions should always be protected from low temperatures, since freezing may cause materials of this character to break in the spray tank. Long standing in storage may allow the oils and the emulsifier to form layers. In diluting with water it is important that the different constituents in the stock material be well mixed. For that reason the tar distillate emulsions should be well shaken or thoroly stirred before removal from the containers. This can be done by rolling the container back and forth on a smooth surface. With the thick, pasty kinds one should resort to stirring.

METHODS OF SPRAYING TREES

Tar distillate emulsions are contact insecticides. The eggs of aphids and scale insects are tiny objects, for which reason these sprays should be carefully applied in order to secure satisfactory control. All surfaces of the trees, including the larger limbs and trunks, should be completely wetted with the spray material. Since the distillate emulsions are caustic to the skin, direct the spray mixture so that there will be as little drift as possible on operators and horses. It is better to spray with the wind, treating as much of each
tree as is possible. With the veering of the wind to an opposite direction, finish the task, exercising great care to leave no area on any of the trees untreated.

AIDS TO SPRAYING TREES IN A DORMANT CONDITION

As has been previously pointed out, there is usually a rather short period when optimum conditions exist for spraying dormant trees in the spring, considering the difficulties that may be encountered with respect to weather and soil. The grower should plan to utilize all days propitious for the treatment of his trees. It greatly facilitates spray operations if the necessary supply of tar distillate emulsion is on hand, if the spray machine is in excellent working order, and if the orchard is trimmed and the brush removed. Failure to take these precautions may prevent the grower from taking advantage of conditions that are most favorable for the treatment of his plantings.

PROTECTION OF SPRAY OPERATORS AND TEAM

Avoid wind drift by spraying with the wind. Protect team with waterproof covers. In measuring and mixing distillate emulsions use heavy leather gloves. For the protection of eyes and face ventilated safety goggles and masks are being used by some operators to advantage. Burning of the skin may be lessened in many instances by washing with vinegar diluted at the rate of 1 part to 3 parts of water. Some workers reduce the effects of the caustic action of the spray by covering the hands and face with heavy grease, but this has proved ineffective with others. Preparations are now on the market which are said to prevent the unpleasant effects from tar distillate emulsions. Experience shows that individuals vary greatly in their susceptibility to these materials.