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Spraying as an Essential Part of Profitable Apple Orcharding

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BY R. A. EMERSON, R. F. HOWARD, AND V. V. WESTGATE.

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SPRAYING AS AN ESSENTIAL PART OF PROFITABLE APPLE ORCHARDING.

BY R. A. EMERSON, R. F. HOWARD, AND V. V. WESTGATE.

In 1906 the Experiment Station, in co-operation with the United States Department of Agriculture, began a series of spraying demonstrations in eastern Nebraska apple orchards. The results of the first year's work were published in Bulletin 98, entitled "Spraying Demonstrations in Nebraska Apple Orchards." In 1907 the work was continued by the Experiment

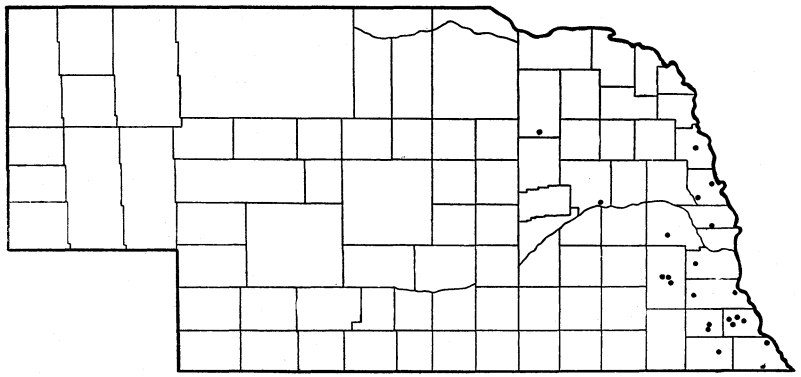

Fig. 1. Showing distribution of orchards in which spraying tests were carried on.

Station alone and the results reported in Bulletin 106 under the title "Does it Pay to Spray Nebraska Apple Orchards?" In 1908 the work was again conducted jointly by the Experiment Station and the United States Department of Agriculture and in 1909 and 1910 the Experiment Station was alone in the undertaking. The work of the last three years has not been reported

previously. During the five years, demonstrations have been made in twenty-two orchards, representing eighteen localities in thirteen counties. That the orchards selected were well distributed over the eastern part of the state can be seen by reference to the accompanying map.

Before the work was begun it was well known that it was possible by proper spraying to control scab and codling moth, the most generally troublesome pests of apple orchards in this state. There was available, however, very little definite information regarding the cost of spraying or the profits to be derived from it under our conditions. The majority of farmers made no attempt at spraying. Many of the more prominent commercial orchardists, even, were trying to produce apples without spraying, and those who were spraying more or less regularly were, with few exceptions, not sufficiently thoro in their work to get the best results. On account of the lack of knowledge of the proper means to employ in combating the common orchard pests, many orchardists had come to believe that apple growing was not a profitable business. And under the conditions prevailing in many orchards, this was a perfectly correct conclusion.

It was therefore planned from the start not merely to demonstrate the possibility of controlling apple insects and diseases but also to determine whether they could be controlled profitably. To accomplish this it was necessary to know exactly what it cost to spray, what sprayed fruit yielded, and what it was worth in comparison with unsprayed fruit from the same orchards. In every spraying demonstration the time spent in mixing and applying the materials and the quantity of material used were recorded. The cost of labor of men and teams per hour was taken at the orchard owners' estimates and the cost of materials was charged at the prices actually paid by the orchardists. In every orchard a block was set apart for the demonstration spraying, and another block, in every way comparable with the first, was left without spraying as a check on the results of spraying. The exact yields of both marketable and

unmarketable fruit from the sprayed and from the unsprayed blocks, or from considerable parts of them, were noted. The net value of the fruit was determined by deducting from the actual prices received by the owners the estimated cost of picking, grading, packing, hauling, etc. The net value, therefore, was what the fruit was worth on the trees.

The work was done under all sorts of conditions. The trees varied in age from ten years to twenty-eight years and averaged about eighteen years. In some orchards they had been well pruned, but in more cases they had been pruned little or not at all for some years. In some cases the spraying was hindered by the closeness of the trees and in others by a secondary crop of bush fruits. In some orchards, on the other hand, the trees were conveniently spaced and the ground was free from troublesome bushes. A few orchards had almost every convenience for mixing and applying the spray materials while others were almost completely without such conveniences. Take for instance a case where it was necessary to go a half mile or more from the orchard to get the water for spraying and where it was then necessary to pump it by hand and lift it up to the spray barrels in buckets. Contrast this with the cases where the mixing stations were near the center of the orchards, where a sufficient supply of water to spray a considerable part of the orchard was held in a large tank filled by a windmill or gasoline engine, and where the supply tank, dilution tanks, etc., were on platforms higher than the spray wagon so that the mixtures simply ran down into the spray tank. Under the first set of conditions it often cost more to mix the spray and get it to the orchard than to apply it, while under the second set of conditions little time was spent in mixing and hauling the spray. Some orchards were provided with efficient gasoline power spray pumps mounted on trucks carrying large spray tanks, overhead platforms, and the like to facilitate the work. The other extreme was a poor hand pump with which it was barely possible to maintain pressure for one spray nozzle. The cost of spraying naturally bore a very

direct relation to the facilities for work in the various orchards. The labor cost of mixing and applying the spray varied from one and one-half cents per gallon under the most unfavorable conditions to only slightly over three-tenths cent per gallon where the conditions were in every way favorable. The average cost of mixing and applying the spray in these demonstrations, namely, one cent per gallon, is therefore higher than it need be, at least in commercial orchards.

Not only did the somewhat unfavorable conditions noted make spraying more costly than necessary, but the rather poor average condition of the trees, mostly from crowding and lack of pruning, reduced the average yield of choice fruit materially and indirectly increased the relative cost of spraying. That is, the cost of spraying per bushel of good fruit produced was considerably greater than it would have been had the trees been in better condition. In one orchard, for instance, over half the Winesap apples from the sprayed block were graded as No. 2. Tho almost entirely free from scab and codling moth, many of the fruits were small and poorly colored because of a lack of proper pruning. That same season the same variety in another orchard of the same age on similar soil and not far from the first produced fruit, nearly all of which, from the sprayed block, graded No. 1, not because it was more free from scab or codling moth but because it was of much better size and color. The trees in this second orchard had been more thoroly pruned than the trees in any other orchard in which spraying demonstrations were made.

Of the five seasons covered by these spraying tests, three have been unfavorable owing to the prevalence of killing frosts at blossoming time. The yields of fruit secured have not, therefore, been so favorable as they would have been under more nearly average conditions. The prices received for the fruit have, however, been good on the whole, in part at least offsetting the rather poor yields. Moreover the difference in value between the sprayed and the unsprayed fruit has probably been as great as

it would have been in more favorable seasons because of the fact that spraying seems to increase the yield of fruit more in an off year than in a good fruit year.

On the whole, then, it may be said that these spraying demonstrations were conducted, not under ideal conditions, but under conditions fairly representative of eastern Nebraska orchards and that therefore conclusions rightly drawn from the work should be of value to orchard owners in that part of the state. The results were not exceptionally good. In fact, the up-to-date orchardist should be able to get, and does get, better results than those reported here.

The following statements give a summary of the results obtained from the first four years' work:

COST OF SPRAYING.

Number of orchards sprayed, 16.
Total number of trees sprayed, 3,300.
Average age of trees, 18 years.
Average number of sprayings per year, 4.
Average quantity of spray per tree each year, 13 gallons.
Average quantity of spray per acre (50 trees), 650 gallons.
Average cost of spray material per 100 gallons, $0.87.
Average cost of applying spray per 100 gallons, $0.98.
Average total cost of spraying per 100 gallons, $1.85.
Average annual cost of spray material per tree, 11.3 cents.
Average annual cost of applying spray per tree, 12.7 cents.
Average total annual cost of spraying per tree, 24.0 cents.
Average total annual cost of spraying per acre (50 trees), $12.00.

RESULTS OF SPRAYING.

Average annual yield and net value *per tree*—

Sprayed trees.

Marketable fruit.....	4.4 bushels	at 52	cents...	$2.28
Culls and windfalls..	1.1 bushels	at 6	cents...	.07
Total.....	5.5 bushels	at 43	cents..	$2.35

Brought forward				$2.35
Unsprayed trees.				
Marketable fruit....	1.8 bushels at 41 cents.		$0.73	
Culls and windfalls..	1.7 bushels at 5 cents.		.08	
Total.....	3.5 bushels at 23 cents.....			.81
Difference between sprayed and unsprayed trees..				$1 54
Average cost of spraying.....				.24
Average net gain from spraying.....				$1.30

Average annual yield and net value *per acre* (estimated on basis of 50 trees)—

Sprayed trees.				
Marketable fruit.....	220	bushels.....	$114.40	
Culls and windfalls...	55	bushels.....	3.30	
Total.....	275	bushels.....		$117.70
Unsprayed trees.				
Marketable fruit.....	90	bushels.....	$36.90	
Culls and windfalls....	85	bushels.....	4.25	
Total.....	175	bushels.....		41.15
Difference between sprayed and unsprayed trees.				$76.55
Average cost of spraying.....				12.00
Average net gain from spraying.....				$64.55

Whether it pays to spray apple orchards in eastern Nebraska is no longer a question. The records reported here—records secured under actual farm conditions—show that spraying pays twice its cost by increasing the yield of fruit and three times its cost by improving the quality of the fruit, or six times its cost by both increased yields and improved quality. The gain due to spraying one-half acre of apples one year will, on the average, buy a good barrel-pump, 50 feet of hose, two extension rods, two nozzles, and five barrels for use in mixing spray materials. The sprayer will last several years and can be used to fair advantage in orchards up to five acres. The gain from the proper spraying of five acres one year will, under average conditions, pay for a

power outfit, including a small gasoline engine, pumps, rods, nozzles, hose, 250-gallon spray tank, elevated spray platform, and the truck on which to mount the whole outfit. One such power sprayer is ordinarily sufficient for an orchard of 20 acres and is often used in orchards of more than twice that size. The question of whether one can afford to spray has been answered. It would not be so easy to determine how any one who owns an orchard can afford not to spray.

COOPERATION IN SPRAYING SMALL ORCHARDS.

For the most part, the commercial orchards of the state are now being sprayed. On the other hand, the small home orchards that receive this attention are exceptions rather than the rule.

Nearly every farmer in eastern Nebraska has fruit trees growing about his place, tho he may consider this a very minor phase of his farming business. The mere fact that fruit growing is incidental to his general farming, coupled with the seeming trouble of mixing and applying the materials, is why these small orchards are neglected. Early in the spring is the time when there are many things demanding the farmer's attention. This is the time also when the important sprayings have to be made if the apples are to be protected from codling moth and scab. The average man with an acre or two of orchard does not feel he is justified in spraying it if his other work is interrupted. This same man would probably appreciate sufficiently the difference between sprayed and unsprayed fruit so that he would be willing to pay a reasonable price to have some one else spray his fruit.

If some method were introduced whereby these small orchards could be sprayed, a great need would be met. Spraying outfits could be run on the same plan that threshing machines are operated in this state. The figures given above might be used as a basis for determining the charge. A five- or ten-acre orchard is enough to justify a man in getting a power sprayer. The capacity of such a machine is easily twenty acres. Under these conditions the owner of the outfit might cooperate with fifteen or twenty of

the small orchard owners in his immediate locality to the extent of spraying their trees. He could in this way make his machine pay for itself, besides reducing to a minimum the possibility of infection to his own orchard from outside sources.

MIXING AND APPLYING SPRAY MATERIALS.

The two pests of chief concern to Nebraska apple orchardists at the present time are the apple scab and the codling moth. All careful experimental tests have shown that it is possible to keep both of these pests under control by spraying, providing the sprays are properly mixed and applied in sufficient quantity at the right times. As one of these pests is a chewing insect and the other a fungous disease, the same spray will not do for both.

For apple scab, some fungicide is necessary—the common one being Bordeaux, altho lime-sulfur is beginning to be used considerably as a fungicide. Bordeaux mixture is composed of copper sulfate (bluestone), lime and water—the copper sulfate being the active agent. Various formulas, containing these materials in different quantities, have been tried. At present, the 3-3-50 formula is believed to be sufficiently strong to kill the germinating spores of apple scab. This formula is made up as follows:

3 lbs. of copper sulfate (bluestone).
3 lbs. of lime (unslacked).
50 gallons of water.

The lime that is used in the spray neutralizes the injurious effect of the bluestone and it also causes the spray material to adhere better to the foliage. In making Bordeaux, it is necessary that the lime and copper sulfate solutions be kept separate until they are ready to be united in the sprayer. They should also be mixed together in dilute and never in concentrated form if best results are to be expected.

In some rather recent experimental tests, we have found commercial lime-sulfur to be a good fungicide. This material can be purchased on the market in concentrated form. As a summer

spray for apples, about a gallon of the concentrated solution is mixed with 30 gallons of water.

Sometimes self-boiled lime-sulfur is used as a fungicide, especially for the second spraying, since it does not "russet" the fruits as does Bordeaux. As this spray is gradually becoming of more importance, it is advisable to consider a few points in its preparation. This self-boiled lime-sulfur is mainly a mechanical mixture of lime and sulfur—the only heat used in its preparation being that generated from the slacking lime. In making it, flowers of sulfur and good unslacked lime are used. As a common spray for apples, this mixture should be used in the proportion of 10 pounds of lime and 10 pounds of sulfur to 50 gallons of water. Mr. W. M. Scott of the United States Department of Agriculture* showed that an 8-8-50 strength would largely control peach brown rot and scab.

In mixing self-boiled lime-sulfur, place the proper amount of lime in a barrel and pour on water until the lime is almost half covered. The sulfur should be run thru a sieve to break up the lumps, and, as soon as the lime begins to slack, the sulfur should be added to it. Enough water should then be added to the mixture to facilitate the stirring but not enough to check its boiling. Allow the mixture to cook until the lime is well slacked, about 10 to 15 minutes; then add enough water to prevent further boiling. The mixture is then ready to be strained into the spray tank and diluted for use. If made in rather large quantities, say 30-30-150, better cooking will result.

Several insecticides are found on the market, of which the two best for controlling biting insects are Paris green and lead arsenate. Each of these arsenic sprays has been used to good advantage in controlling the codling moth. Where Paris green is used, it should be mixed at the rate of $\frac{1}{3}$ pound to 50 gallons of water. In case lead arsenate is used, $1\frac{1}{2}$ pounds should be mixed with the same quantity of water. Paris green has large, heavy particles which will not stay in suspension long in water

* Bul. 174, Bureau of Plant Industry, U. S. Dept. of Agriculture (1910).

and it does not adhere well to the foliage. Altho lead arsenate is more bulky than Paris green it has three advantages over it and all other insecticides: First, it is absolutely harmless to the foliage; second, it remains in suspension a long time without stirring; and third, it is far more adhesive. As this is the poison that we have used in our experiments and prefer, it will be the one usually referred to later. In several of the sprayings, it is feasible to add the poison to the Bordeaux. When this is done, the cost of applying the sprays is lessened. In case lead arsenate is to be applied in connection with the fungicide, it is mixed at the rate of $1\frac{1}{2}$ pounds with 50 gallons of the Bordeaux.

SPRAYING CALENDAR.

In ordinary years, it will be necessary to spray four or five times during late spring and summer with one or another of these spray materials. The kinds of spray used and the times of applying them may be summarized as follows:

1st. After the cluster buds of the apples open but before the individual flower buds expand—using Bordeaux mixture or lime-sulfur. No poison.

2d. Just after the petals have fallen but before the calyx cups have closed—using either Bordeaux or lime-sulfur, plus the insect poison.

3d. Three weeks after the petals have fallen—using the same materials employed for the second spraying.

4th. Seven weeks after the third spraying—using the insecticide alone.

The first spraying is chiefly for apple scab and of course for this Bordeaux or lime-sulfur alone is sufficient. If the canker-worm should be working on the foilage of the trees at the time of the first spraying, which does occasionally happen, the poison should be added to the fungicide. The first spraying is given just as the leaves are beginning to develop. Because of the open condition of the trees at this time, the sprayer can thoroly coat the twigs and expanding leaves with spray, which should be done.

The second spraying, given when the petals have fallen, is the most important of all applications. It is always the most important spraying for the codling moth, and in a good many years it is the chief one for apple scab. This second application should also be the heaviest one given. As the trees have a mass of foliage that must be thoroly covered, we shall find the spray dripping from the trees after the job is completed. Under normal conditions the first flowers will be the ones to set fruit. For that reason the second spraying may have to be given before the petals have fallen from the late blossoms in order to fill the closing calyx cups with the poison. However, a too early spraying is undesirable, as it would kill many bees which are pollinating the blossoms. The reason for thoroly filling the calyx cups is that a large number of the codling moth larvae will enter the apple thru the calyx. In careful tests, it has been found that fully 75 to 80 per cent of the larvae enter in that manner. Altho the eggs of the moths are not hatched until two or three weeks after the second spraying, if a sufficient amount of spray has been placed in the calyces at this second spraying, enough will be held there to destroy the larvae as they enter. Strong Bordeaux at this spraying will be apt to "russet" the fruits. For that reason, a weak solution, 2 lbs. of copper sulfate to 50 gallons of water, is preferable, or, even better, one or the other of the lime-sulfur sprays described elsewhere in this bulletin.

The third spraying is applied just about the time the eggs of the first brood of codling moths are hatching. By coating the foliage and fruits with spray at this time, a large number of the worms will be killed. This spraying is especially valuable for destroying those larvae which may attempt to enter the apple at some point other than the calyx.

Apple scab largely spreads about the time of the first, second, and third sprayings. If the weather is hot and dry during this period, the germination of the spores is retarded, and in such a season apple scab does little damage; but if we have moist conditions the disease thrives. As we do not know in advance what

weather conditions will be, the only safe plan to follow is always to make the first three sprayings with the fungicide. As scab is not developing when the fourth spraying is made, it means a waste of material to apply Bordeaux. Lead arsenate, mixed at the rate of $1\frac{1}{2}$ pounds to 50 gallons of water, should be used at this time,—which is for controlling the second brood of the codling moths. Carefully mixing and applying the second and third sprayings means that comparatively few larvae of the first brood will escape, hence the second brood would be few and would cause but little trouble. For that reason, it behooves the orchardist to be unusually careful with the earlier sprayings. At times in the past, a fifth spraying has been recommended, but certainly it is not very essential providing the earlier sprayings have been properly given. Where a fifth spraying is made, it should be with the insecticide alone and should be applied three to four weeks after the fourth.

Many believe that spraying is the most disagreeable phase of orcharding. This opinion is due in no small degree to the fact that such individuals have worked with crude mixing devices and sprayed with poor machines. Where the orchardist has ideal equipment, spraying is certainly not the worst part of orchard management. In equipping one's self with spraying devices, the type of the same will depend upon the size of the orchard to be sprayed. For rather large orchards of 15 acres and over, power sprayers should be used and the mixing devices should be so constructed that the material can be prepared in large quantity and readily transferred to the spray machine. But the individual who has only a few trees cannot afford to buy a power sprayer and construct elaborate mixing devices. It is therefore necessary to devise something which will supply his needs as well.

In general the person who has a small orchard will use somewhere from 100 to 500 gallons of the mixture in each average spraying. For such small amounts it will be preferable to mix the spray material in 50-gallon lots. Take 4 pounds of copper sulfate (otherwise known as bluestone or blue vitriol) and dis-

solve it in a half-barrel (25 gallons) of water. To do this, place the copper sulfate in a common gunny sack and hang the sack in the barrel so that the sulfate will be partially submerged in the water. By using this scheme, one gets the bluestone to dissolve

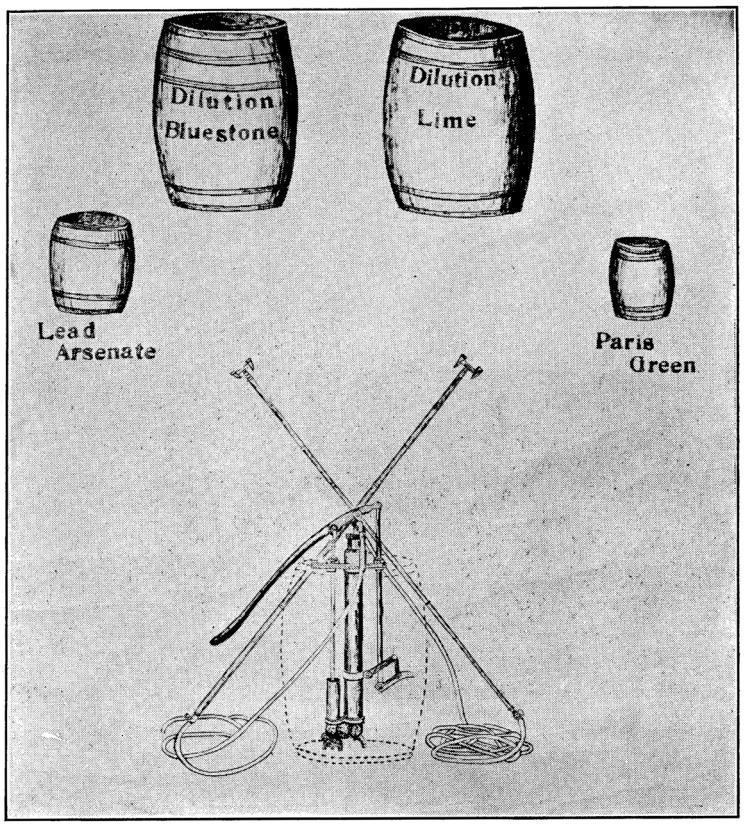

Fig. 2. Type of barrel sprayer, suitable for a home orchard.

more quickly, as the more concentrated solution is always at the bottom of the barrel.

Also slack 4 pounds of lime in a second barrel. At first use only enough water to slack the lime. When it has slacked, add enough water to make 25 gallons of the mixture. The copper sul-

fate and lime solution should be poured together into a third barrel or they can be put directly into the sprayer. In either case, the materials should be evenly mixed. That is, a bucket of lime water and a bucket of the bluestone solution should be run thru the strainer at the same time. In order that the spray nozzles shall not become clogged with sediment later, it is necessary that the solutions be thoroly strained. Excellent copper strainers, having 18 to 20 meshes to the inch, can be found on the market.

Fig. 3. A barrel sprayer outfit in operation. Columbus orchard, 1910.

A fairly good artificial strainer can be made by taking a small box, about a foot square, knocking out the bottom of the same and nailing several strips of ordinary window screen over the bottom.

For actual spraying work, we have several types of bucket and knapsack machines, but these are too small and do not give sufficient pressure to be of service in spraying trees. A good vertical barrel pump sprayer is serviceable for general use in a small or-

chard. It is not our purpose to recommend any particular make of pump, but there are several things to be considered when buying one. First of all, it should have a large air chamber so that 75 pounds pressure can be generated. The cylinder, plunger, valves, and in fact all working parts should be of brass. The pump should also be so fixed in the barrel that it can easily be removed in case of needed repairs. For convenience in getting the pump about in the orchard it will be best to mount it on a wagon.

Two leads of hose should be attached to the pump, as one man can drive and pump while two men spray. The men can "trade off" occasionally, as pumping is very fatiguing. The one who is pumping should always endeavor to keep at least 70 pounds pressure. For spraying orchard trees, extension rods must be attached to the end of the hose. Bamboo poles with inner brass rods are used for this purpose. These rods should have brass stopcocks at the base so that the spray can easily be turned on or off as desired by the operator.

No one part of a spray machine is of greater importance than the nozzle. It is absolutely impossible to spray trees properly with the best pumps unless good nozzles are used. Good nozzles are those which give a fine spray and yet do not easily clog with sediment. However, if clogging does occur, the nozzle should be so constructed that the sediment can be easily and quickly removed. There are several good types of nozzles on the market, such as the Vermorel, Bordeaux, and Cushman.

In concluding this topic, it would be well to state that the one who is planning to spray should not be "stingy" with his equipment. He should always have extra barrels, hose, extension rods, nozzles, etc., for one can never tell just when these things may be badly needed. Often a great deal of time is wasted because certain parts of the equipment break and nothing is on hand that can be used in making the needed repairs.

In spraying large orchards where one uses power sprayers carrying 200 to 250 gallons, it means that the material must be

made on a large scale. In doing this, stock solutions of both copper sulfate and lime are made. In making the ordinary copper sulfate stock solution, the material is dissolved in water at the rate of one pound to each gallon of water. To do this weigh out 50 pounds of bluestone, place it in a sack, and hang the

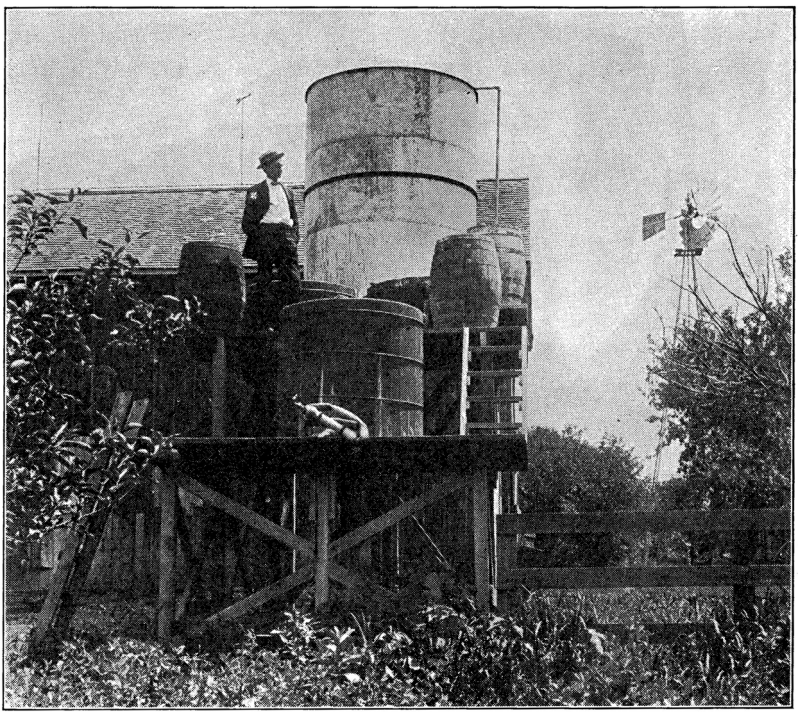

Fig. 4. A convenient type of mixing apparatus, showing stock solution barrels, dilution tanks, and elevated water tower.

sack in the top of a 50-gallon barrel which is nearly filled with water. Allow the material to remain there 12 to 20 hours to dissolve. After it has entirely dissolved, remove the sack and add enough water to fill the barrel. One should always make his stock solutions a day or so before they will be needed, because of the time required for the copper sulfate to dissolve.

The stock solution of lime is prepared in a similar manner.

Weigh out 50 pounds of lime and slack it in a barrel, using at first just enough water to slack the same. In slacking such a large amount of lime, one has to be careful and keep it vigorously stirred to prevent burning. As soon as the entire quantity of lime is well slacked, fill the barrel with water.

After the stock solutions have been prepared, the barrels should be covered so that evaporation will be lessened, unless

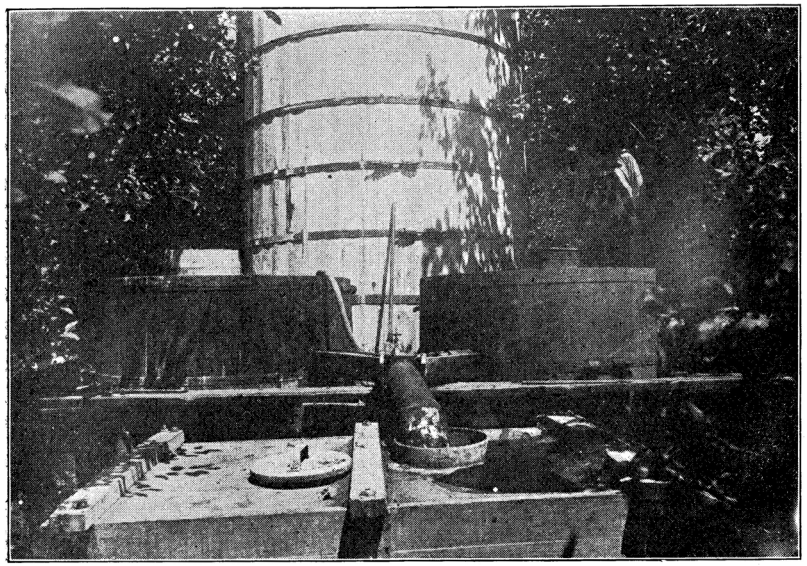

Fig. 5. Mixing apparatus, showing method of combining the streams from dilution tanks before they enter the sprayer.

one is intending to use the material immediately. In case the stock solutions are kept for a long time and considerable evaporation has resulted, the amount of water evaporated from the barrels should be replaced.

Between the two stock solution barrels on an elevated platform one should have two dilution tanks. These should be rather large in diameter but not very deep (about $2\frac{1}{2}$x6 or 7 feet) so that it will be possible to readily stir the mixtures which are placed in them. Each tank should hold at least 150 gallons.

The elevated platform just mentioned should be large enough to accommodate the two dilution tanks, the stock solution barrels, and the men who mix the materials. This platform should be about six feet from the ground, so that the bottom part of the tanks will be a trifle above the solution tank of the spray machine when the machine is brought alongside. A trough should extend out from each dilution tank and unite to form a larger one just beyond the platform. In joining these troughs to the dilution tanks, the plan of the valves should be such as to make it possible to either partially or entirely open them at the will of the operator. Also, when the flow is shut off, the construction should be such that no leakage will result. At times considerable spray material is wasted, due to leaky valves. Back of the dilution tanks at the same or a trifle higher elevation should be a large water supply tank. A piece of 4-inch fire hose with a stopcock should be attached to the base of this tank, so that it will be possible, when desired, to quickly fill the dilution tanks with water.

In making the Bordeaux from these stock solutions, one should first thoroly stir each stock solution so that the dissolved materials will be uniformly distributed thruout the mixtures. For making 200 gallons of spray, the usual amount carried in a power sprayer, take 12 gallons from each stock solution barrel, which would be the amount of stock material required for the above quantity of spray for the 3-3-50 strength. The copper sulfate solution should be placed in one dilution tank and the lime water in the other. Water should then be added until there is 100 gallons in each tank. The materials are then ready to be run thru the troughs into the spray machine. As they are run out, the lime stock solution should be kept well stirred to prevent settling. It should also pass thru a copper strainer that has a fine mesh, before it enters the spray tank. Where an insecticide is used in the spraying, the amount of the poison needed for 200 gallons of spray (6 pounds of lead arsenate) is weighed out and thoroly mixed with water in a bucket. It is then poured thru the strainer as the Bordeaux is being run into the machine.

If one uses home-boiled or self-boiled lime-sulfur instead of Bordeaux, the general plan of the apparatus will be quite similar to the Bordeaux apparatus explained above.

For applying these spray materials to the trees, a gasoline power sprayer is the best machine to use. With a power sprayer giving 140 to 180 pounds pressure a fine mist spray can be at-

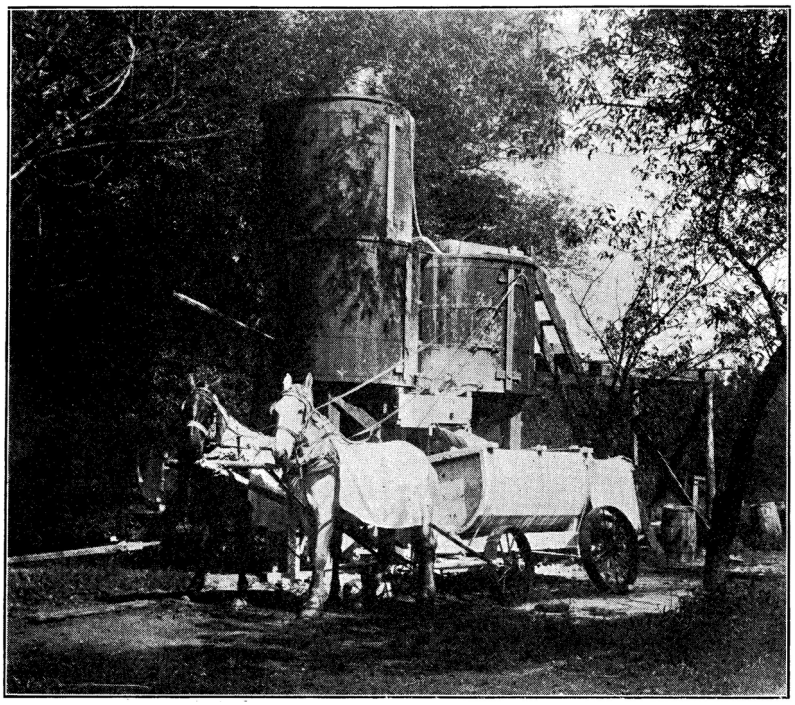

Fig. 6. Mixing apparatus in Lincoln orchard.

tained—a thing that is necessary for best results. Three leads of hose can also be attached to a power sprayer, thus making the process of spraying comparatively rapid. Where three leads of hose are used, the driver of the machine can handle the third lead. In order that he may best reach the tops of the trees and cover with spray those portions of the same that are generally

missed by the persons spraying from the ground, a small elevated platform should be constructed above the spray tank.

The same types of extension rods and nozzles that were recommended for the small orchard sprayer are equally well adapted for the power machine. Good strong hose is especially necessary with the power sprayer outfit, because of the high pressure to which it is subjected. With such a high pressure machine it is also necessary to always keep on hand plenty of hose, nozzles, and fasteners, in case of needed repairs.

LIME-SULFUR AS A SUBSTITUTE FOR BORDEAUX.

While Bordeaux is probably the best all-round fungicide we have at present, it has certain characteristics that sometimes make it undesirable. Some varieties of apples, for instance, are russeted so badly by it that their market value is materially decreased. Improperly mixed Bordeaux or unfavorable weather conditions often cause a burning of the foliage. With the evidence we now have regarding spray materials, it is highly probable that it is necessary to abandon Bordeaux, at least for certain varieties.

It has been known for some time that certain mixtures of lime and sulfur possess fungicidal as well as insecticidal properties. Recent demonstrations have proved that the lime-sulfur sprays have properties that warrant their use when winter treatments for San José scale are needed.[1] As a summer spray to combat fungous troubles they have to be used in a more cautious manner. Lime-sulfur sprays may be divided into three groups: Commercial, homemade, and self-boiled lime-sulfur.

Commercial lime-sulfur as it is put on the market by several firms is in the form of an orange-red solution. It is the product of these two substances after they have been boiled together until they go into solution. The products of different firms vary in degree of concentration and, as Parrott showed,[2] there may be a

[1] Symons, Md. Agr. Exp. Sta. Bul. No. 131.

[2] Bul. 320, New York (Geneva) Agr. Exp. Sta. (1909).

wide range of variation in this respect in the product of a given firm. The only safe plan to follow in using these commercial brands as summer sprays for the apple is to have a hydrometer and know just what dilution is being made.

The hydrometer is a glass instrument consisting of a weighted bulb with a graduated stem which determines the weight or density of liquids. To test a solution, suspend the hydrometer in the liquid and take the reading at the surface. Hydrometers are

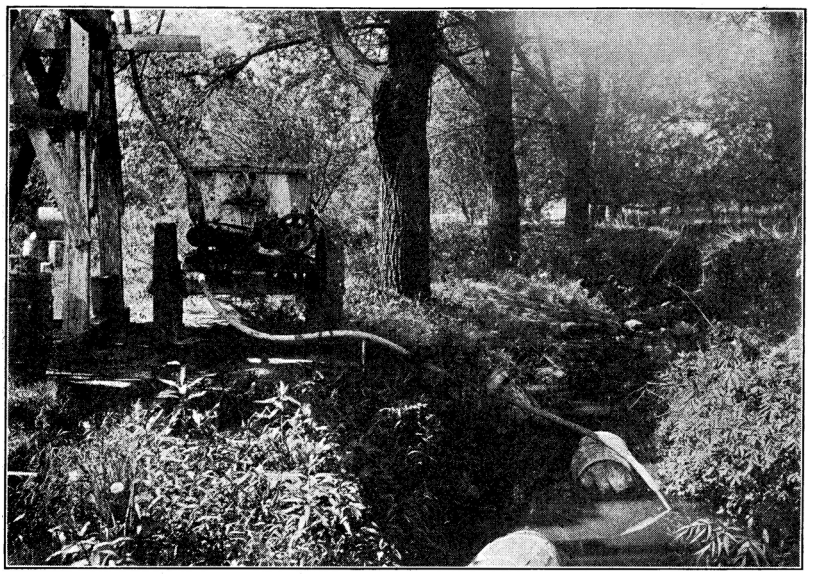

Fig. 7. Filling spray tank from a stream by means of a rotary pump.

of two kinds, Beaumé and Specific Gravity, which differ in the standards of measurement on which they are based. These two types may be combined in the same instrument by having separate graduations on opposite sides of the tube. Those instruments with a range of 0 to 36 degrees Beaumé or 1,000 to 1,330 Specific Gravity are recommended for this work. They can be purchased from Bausch & Lomb Optical Company, Rochester, N. Y., and Eimer & Amend, New York City. A commercial lime-sulfur

solution testing 32 degrees Beaumé will require about 30 gallons of water for each gallon of concentrate as a summer spray for apples.

Homemade lime-sulfur is similar to the commercial, tho not so concentrated. If properly made, it may be used as a summer spray for apples, tho its chief use has been as a winter wash for San José scale. Methods for making home-boiled lime-sulfur are discussed in Bulletin No. 320 of the New York (Geneva) Experi-

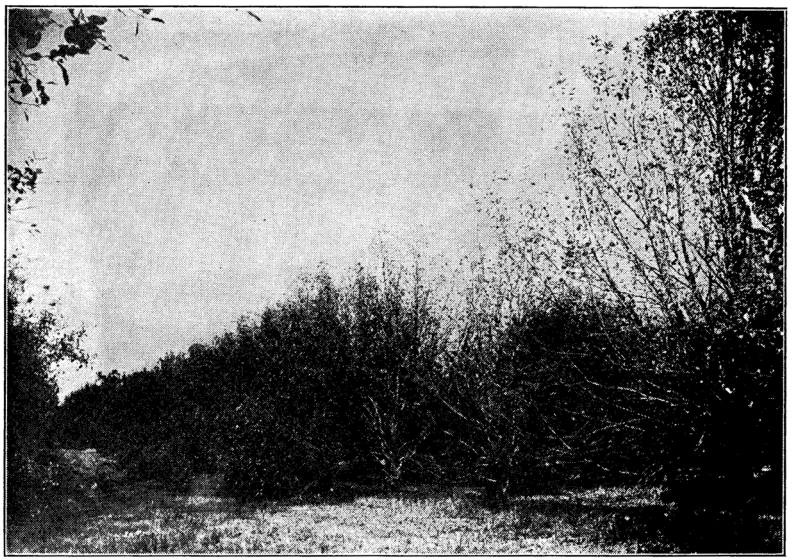

Fig. 8. Check plat in foreground. Showing defoliated condition of trees as compared with Bordeaux plats in background. (Arlington orchard.)

ment Station and in Circular No. 7 of the Virginia Experiment Station.

In connection with the spraying demonstrations of 1909 and 1910 tests were carried on to see how apple scab could be best controlled without russeting the fruit or burning the foliage. To determine this, Bordeaux, Commercial (Rex), and self-boiled lime-sulfur were employed. Different strengths were used. Certain plats had Bordeaux thru the season; others had the fungi-

cide omitted the second spraying, and still others had lime-sulfur either for the second spraying or thru the season. The scab results for 1909 were somewhat contradictory. These tests were repeated in 1910, but no scab developed even on the unsprayed plats. A representative tree was picked from each plat and the fruits sorted for russet. Two grades were made. Those showing no injury and those showing it slightly but not enough to injure their sale were put into one grade, and those with russet enough to injure the market value into the other.

Results of the use of Bordeaux alone and in combination with lime-sulfur in russeting Ben Davis apples.

Spray mixture used		Badly russeted		Free or only slightly russeted	
First spraying	Second spraying	No. of apples	Per cent	No. of apples	Per cent
4-4-50 Bordeaux	3-9-50 Bordeaux	105	31.8	228	68.2
Omitted	3-3-50 Bordeaux	55	9.0	550	91.0
4-4-50 Bordeaux	3-3-50 Bordeaux	116	15.3	635	84.7
4-4-50 Bordeaux	4-4-50 Bordeaux	66	17.5	310	82.5
4-4-50 Bordeaux	Omitted	56	2.9	1874	97.1
4-4 50 Bordeaux	1½-50 Rex	100	6.8	1361	93.2
1½-50 Rex	1½-50 Rex	13	1.4	866	98.6
4-4-50 Bordeaux	10-10-50 Self-boiled	40	4.3	882	95.7

The results from this table indicate plainly that it is the second spraying that causes russeting. The lime-sulfur sprays do not russet the fruit—the small per cent noted in the table is probably due to the Bordeaux from adjacent plats. No serious leaf injury resulted from any of the mixtures. In the Columbus orchard, 1910, the self-boiled lime-sulfur plat seemed to have brighter foliage than either the Bordeaux or the Rex plats. No injurious effect has ever resulted from using arsenate of lead in combination with the lime-sulfur sprays.

RECOMMENDATIONS.

1. Do not wait until spraying time to begin making preparations. Plan mixing devices and be provided with all the necessary materials and the spray machine well in advance of the spraying season.

2. Properly constructed mixing devices are very essential for rapid and efficient work. (Page 19.)

3. The first spraying for apples should be made with 3-3-50 Bordeaux, 1½-50 commercial lime-sulfur, or 10-10-50 self-boiled lime-sulfur just before the individual flower buds open. No poison.

4. The second spraying is the most important one and it should be applied after the flowers have begun to drop and before the calyx lobes close. For such varieties as Ben Davis and Gano that are easily russeted, use one of the lime-sulfur sprays. Use either Paris green at the rate of ⅓ pound to 50 gallons or lead arsenate at the rate of 1½ pounds to 50 gallons in combination with the fungicide. Thoroness and high pressure are very essential.

5. The third spraying should be made with the combination fungicide and poison about three weeks after the second.

6. The fourth application should be made with the poison alone about seven weeks after the third. (A fifth application, consisting of poison alone, some time in August, is to be recommended in orchards where the skeletonizing caterpillars are troublesome.)

7. Self-boiled lime-sulfur 10-10-50 will control mild cases of apple scab, and it will not burn the foliage or russet the fruit. (Page 11.)

8. Commercial lime-sulfur can be used as a summer spray for apples with as little danger to the foliage as Bordeaux. It does not russet the fruit enough to injure its market value. A hydrometer should be used in diluting concentrated lime-sulfur. (Page 23.)