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Three Years of Dust Spraying Under Missouri Conditions



A modern power duster in operation.

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Three Years of Dust Spraying Under Missouri Conditions

K. C. SULLIVAN

ABSTRACT.—This bulletin reports only three years of experiments with dust sprays on apples. In 1925 two strengths of sulphur dust were used. Both strengths were applied at the rate of two and five pounds per tree. Two pounds per tree give as good results as five pounds per tree and the mixture of 90 pounds of sulphur with 10 pounds of arsenate of lead gave as good results as the 85-15 mixture. Home-mixed copper dusts were also used, but the results were not as good as from the sulphur dusts. Dust sprays were more costly than the liquid sprays, and a greater number of applications had to be made in order to obtain comparable results. In 1926 the same sprays were used but only at the rate of two pounds per tree. The home-mixed copper dusts failed to give sufficient control. The sulphur dusts, when used often enough, compared favorably with the liquid spray. As a supplement to the liquid sprays the sulphur dust showed promising results. In 1927 a commercial copper dust gave favorable results. The sulphur dusts also compared favorably with the liquids though the results were not quite so good. The dust sprays are still in the experimental stage and it would be exceedingly unwise to substitute them entirely for the liquid sprays for the control of apple insects and diseases. When carefully and properly applied they may be expected to control the codling moth. Dust sprays, because they do not remain on fruit and foliage as long as the liquid sprays, may be used for the late summer sprays to largely eliminate the spray residue problem.

INTRODUCTION

Some fifteen years ago several commercial apple growers in Missouri attempted to utilize dust sprays for the control of apple insects and diseases. These attempts were not successful and the dusts were abandoned. At that time the dusts were new and not well adapted for the purpose, and dusting machines were not as well suited for the purpose as they are now. Also much new information regarding the insects and diseases which attack the fruits, especially those of the apple, has been developed in the last decade.

Because the dusts did not give satisfactory results when first utilized on a large scale, the commercial apple growers of Missouri are taking a very conservative stand regarding their use at the present time. This is as it should be, for the dusts, at least in this section of the country, are still in the experimental stage. The commercial apple grower knows what to expect of the liquid sprays when they are properly applied. He cannot at the present be so certain regarding the dust sprays and it is, therefore, wise to assume a conservative attitude until we know more about the dusts.

Three factors have been largely responsible for the interest which the Missouri grower now has in the dust sprays. They are as follows: (1) The great amount of damage caused by the codling moth during the past three years, brought about by the abnormal life cycle of the insect with a resultant increase in numbers. This abnormal life cycle has made

the codling moth difficult to control without the application of a greater number of sprays than ordinarily required. The possibility of using the dusts for these additional sprays has appealed to the commercial grower. (2) In order to prevent loss from the late summer codling worms it has been necessary to make one or more spray applications during the late summer. This may result in a large amount of spray residue remaining on the fruit at picking time. This residue may be largely or entirely eliminated by using the dust for the late codling moth sprays. (3) The dusts can be applied much more quickly than the liquid sprays. This factor may be of great importance in controlling the codling moth. At times it becomes necessary to get a cover spray on in the shortest possible time in order to prevent the young larvae from entering the fruit.

Some minor factors which may be considered are the elimination of the need of water when dusts are used, the saving of much labor, and the possibility of spraying the orchard with the duster when the ground is too soft to attempt the work with a liquid spray machine.

Although the dusts may have certain advantages over the liquids, the one big factor which must be considered is the net returns from the orchard at the end of the season. Will the quantity of marketable apples from dusted trees be as great or greater than from trees sprayed with the liquids?

RESULTS IN 1925

In the spring of 1925 a commercial dusting machine was obtained and arrangements were made to use it in the commercial orchard of Paul Jaeger at Boonville, Missouri. Mr. Jaeger's orchard has been kept in excellent condition for many years and was considered as an ideal place to compare the dust sprays with the liquid. A block of Gano trees, about twenty-five years of age, was selected and divided into plots containing on the average ten trees each. A ten-tree plot has the disadvantage of being too small for a good commercial test, due to the fact that a good dusting machine will drive the material out with such force that trees in the adjoining plots will receive some of the mixture. This difficulty, however, was largely avoided by using great care in making the applications and by applying the dust on days when there was little or no breeze.

Table 1 gives the formulae used and the amount applied per tree together with the cost of chemicals per acre.

Table 2 shows the number of applications and the dates on which they were applied. All applications were dusts except those marked liquid.

Table 3 shows the results which were obtained at picking time.

That part of the orchard which was not dusted received three applications of lime-sulphur and arsenate of lead at the usual summer

THREE YEARS OF DUST SPRAYING UNDER MISSOURI CONDITIONS 5

TABLE 1.—FORMULA USED, AMOUNT PER TREE AND COST PER ACRE—1925

Plot No.	Sulphur lbs.	Arsenate of Lead—lbs.	Lime lbs.	Copper lbs.	Calcium Arsenate lbs.	Lbs. applied per tree	Cost per Acre	
1	90	10	-----	-----	-----	5	\$ 47.00	
2	90	10	-----	-----	-----	2	42.30	
3	90	10	-----	-----	-----	2	18.80	
4	90	10	-----	-----	-----	5	105.75	
5	85	15	-----	-----	-----	5	124.90	
6	85	15	-----	-----	-----	5	70.50	
7	85	15	-----	-----	-----	2	22.50	
8	85	15	-----	-----	-----	2	49.95	
9	-----	-----	80	12	8	2	12.15	
10	-----	-----	80	12	8	5	30.40	
11	-----	-----	80	12	8	5	68.40	
12	-----	-----	80	12	8	2	27.35	
13	All sprays liquid							13.00

TABLE 2.—NUMBER OF SPRAYS AND DATES OF APPLICATION—1925

Plot No.	No. of applications	Cluster bud spray	Calyx spray	3rd* spray	4th spray	5th† spray	6th‡ spray	7th§ spray	8th spray	9th spray
1	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
2	9	4/12/25	4/22/25	4/30/25	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
3	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
4	9	4/12/25	4/22/25	4/30/25	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
5	9	4/12/25	4/22/25	4/30/25	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
6	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
7	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
8	9	4/12/25	4/22/25	4/30/25	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
9	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
10	4	4/12/25	4/22/25	-----	5/11/25	-----	-----	-----	7/14/25	-----
11	9	4/12/25	4/22/25	4/30/25	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
12	9	4/12/25	4/22/25	-----	5/11/25	5/15/25	6/1/25	6/15/25	7/14/25	7/27/25
13	3	Liquid	Liquid	-----	-----	-----	-----	-----	Liquid	-----

*Rain in evening following application

‡Showers following night

†Hard rain and hail same evening.

§Rain following evening and next day.

TABLE 3.—RESULTS AT PICKING TIME—1925

Plot No.	Codling Moth		Curculio %	Brown rot %	Blotch %	Scab %	Efficiency for insects and diseases
	Calyx injury %	Side injury %					
1	.5	15.3	36.0	6.1	.3	.4	10th
2	.3	8.8	16.9	2.5	.2	.0	1st
3	1.1	19.7	20.1	4.9	1.9	.0	9th
4	.2	11.4	17.7	4.9	1.0	.1	3rd
5	.1	9.4	22.5	2.6	1.5	.3	2nd
6	.9	17.5	21.8	3.5	.4	.9	6th
7	.7	15.1	23.0	3.2	.7	1.8	7th
8	.2	8.8	24.9	3.3	.4	1.5	4th
9	1.5	11.9	24.4	5.1	1.9	3.0	13th
10	.6	12.0	24.3	3.8	7.3	1.2	11th
11	.2	10.1	24.2	4.4	1.1	.4	5th
12	1.0	12.7	24.6	5.2	1.1	1.7	12th
13	1.0	14.0	20.0	2.8	8.7	1.5	8th

strength, 3 gallons of commercial liquid lime-sulphur, and 4 pounds of arsenate of lead powder to 100 gallons of water. Plot 13 received this treatment and was used as a check with which to compare the dusted plots.

It will be noted that Plot 2 gave the best returns. This plot received nine applications of the 90-10 sulphur-lead dust. Not only was the codling moth better controlled on this plot but also the apple curculio, which at that time was the most serious pest in the orchard, caused less injury than on any other plot. The diseases were also better controlled on Plot 2. The cost for chemicals, nine applications per acre, using two pounds of the 90-10 mixture per tree, was \$42.30. The cost of nine applications of the liquid would be \$39.00. The saving in labor in favor of the dusts is considerable.

The copper dust used was a home-mixed dust and it will be noted that as a whole the results obtained from its use were not as good as from the sulphur-lead dust.

Two pounds of dust per tree seemingly gave as good results as five. At any rate the difference is not enough to justify the use of five pounds per tree.

General observations indicated that the dust covered the foliage and fruit more thoroughly than did the liquid spray, but the dust did not remain on as long and was easily washed off by the rains. It is evident that in order to obtain as good results with the dusts as with the liquid sprays a greater number of applications must be made. The results obtained substantiate this conclusion.

Plot 13 received only three liquid sprays and yet the results obtained were better than with some of the dusts.

These tests did demonstrate that apple insects and diseases can be controlled with dust sprays under conditions which prevailed during the season of 1925 in Central Missouri.

RESULTS IN 1926

Using the results which were obtained in 1925 as a basis on which to work, the dusting schedule for 1926 was formulated.

The plots were increased in size in order to eliminate the possible drifting of dusting chemicals at the time of application and due to this increase in size some additional varieties besides Gano were taken in, including Jonathan, Winesap and a few Grimes Golden.

The schedule in Table 4 was maintained during the season. The sulphur dust used was a 90-10 mixture; the copper dust, 80 pounds of hydrated lime, 8 pounds copper and 12 pounds of calcium arsenate.

At the last of June a very severe hail storm seriously damaged the entire crop. The damage was so severe that the owner did not think it

economical to apply any additional sprays. However, applications of dust sprays were continued on Plots 3 and 8 and all received a late summer application.

TABLE 4.—DATE OF APPLICATIONS, NUMBER OF APPLICATIONS, AND COST PER ACRE

Plot No.	Cluster 4/28-29	Calyx 5/8-9	3rd. 5/25	4th 6/4	5th 6/11	6th 6/19	7th 6/26	8th 7/3	9th 7/12-14	Total no. of appli- cations	Cost of chemical per A.
1	Liq.	Liq.	Liq.	--	--	--	--	--	Sul.	4	\$16.70
2	Sul.	Sul.	Sul.	--	--	--	--	--	Sul.	4	18.80
3	Sul.	Sul.	Sul.	Sul.	Sul.	Sul.	Sul.	Sul.	Sul.	9	42.30
4	Liq.	Sul.	Liq.	--	--	--	--	--	Sul.	4	17.40
5	Liq.	Liq.	Sul.	--	--	--	--	--	Sul.	4	17.40
6	Liq.	Liq.	Liq.	--	--	--	--	--	Sul.	4	16.70
7	Cop.	Cop.	Cop.	--	--	--	--	--	Liq.	4	20.89
8	Cop.	Cop.	Cop.	Cop.	Cop.	Cop.	Cop.	Cop.	Liq.	9	49.04
9	Liq.	Cop.	Liq.	--	--	--	--	--	Liq.	4	17.63
10	Liq.	Liq.	Cop.	--	--	--	--	--	Liq.	4	17.63
11	Liq.	Liq.	Liq.	--	--	--	--	--	Liq.	4	16.00

First Brood of Codling Moth.—Practically all larvae of the first brood of the codling moth had left the apples by July 10. On July 12 counts were made of apples injured by the first brood larvae in order to determine the efficiency of the various treatments for the control of the first brood. Table V shows the results obtained.

TABLE 5.—FIRST BROOD OF CODLING MOTH—1926

Plot No.	WINDFALLS		APPLES ON TREES	
	No. apples counted	Codling moth %	No apples counted	% Codling moth
1	31	14.3	875	2.5
2	5	0	800	3.3
3	9	11.1	750	.66
4	18	0	701	.71
5	5	100.	828	2.4
6	10	90.	906	1.1
7	207	100.	677	31.2
8	84	100.	962	8.2
9	4	100.	706	8.3
10	11	27.2	905	3.8
11	50	30.	1132	4.2

The greatest number of windfalls were from the trees which were most severely infested with the larvae of the first brood of codling moth, and it will be noted that the plots treated with the copper dust were more heavily infested than any others. All of the plots except plots 3 and 8 had received, up to the time the counts were made, only three applications. Plot 3 had received eight applications of sulphur dust and Plot 8 the same number of copper dust. Evidently the additional sulphur dusts applied during the month of June helped to some extent but not

enough as compared to the straight liquids to justify the additional applications. The copper dust did not give enough control to be considered satisfactory. The sulphur dust used as a supplement to the liquids and applied for the calyx spray showed promising results. In this respect the plot which had received the supplemental sulphur dust for the calyx spray had fewer worms than the plot which received the first dust for the third spray. This seems to indicate that a good dust may be effectively used for the calyx application.

In no case did the copper dusts give desirable results. The infestation was so serious on Plots 7, 8, 9 and 10 that the dusts were abandoned and a liquid spray was applied for the second brood of codling moth on July 14.

Summer Brood of Codling Moth.—Between May 25 and July 12-14 none of the plots except Plots 3 and 8 had received a spray. As indicated by Table 5 the first brood gained considerable headway. A July spray was applied to all of the plots on July 12-14 at the height of emergence of the second brood. However, the emergence of the second brood of adults was long drawn out with the result that the one July application failed to give sufficient protection. Also due to the very severe hail injury to the fruit the young larvae had little trouble in entering the fruit. Practically all of the larvae of the second brood entered the fruit at a wound caused by hail. The results obtained also demonstrate the great importance of controlling the first brood.

Results at Picking Time.—At the time the fruit was harvested counts were again made and the following table shows the final results.

TABLE 6.—FINAL RESULTS—1926

Plot No.	Codling Moth		Curculio %	Brown rot %	Scab %	Perfect Apples %	Efficiency for insects & diseases
	Calyx injury %	Side injury %					
1	.1	18.2	54.5	2.9	0	38.3	4th
2	.3	26.3	73.0	3.8	1.4	21.6	8th
3	0	14.8	46.8	3.0	.3	33.7	1st.
4	0	12.8	53.9	15.0	0	41.7	6th
5	.4	19.2	45.8	2.4	.2	44.7	2nd
6	1.3	26.0	53.0	3.0	0	33.7	7th
7	.7	25.4	88.8	10.6	0	9.4	9th
8	4.0	48.3	92.8	14.9	1.1	5.3	11th
9	12.8	49.0	77.4	3.9	0	13.5	10th
10	.6	24.5	52.9	.9	.1	38.6	5th
11	.4	19.2	46.9	2.7	.4	42.2	3rd

Plot 3 showed the best results. This plot received nine applications of sulphur dust. Plots 5, 11 and 1 followed consecutively. Plot 5 received a liquid at the cluster bud and calyx sprays and sulphur dust at the third spray and again on July 12. Plot 11 received four liquid sprays, Plot 1

three liquids and a sulphur dust on July 12. The copper dust gave exceedingly poor results. As a whole the results indicate that the sulphur dust may give very satisfactory results when used as a supplement to the liquids for the cover sprays. When the dusts are used alone practically twice as many applications are necessary as with the liquid in order to obtain comparable results. Plot 3 received nine sulphur dusts and the results were practically the same as Plot 11 which received four liquid applications. In fact, Plot 11 produced more marketable apples than Plot 3.

The dust sprays did not show any superiority over the liquids in controlling the curculio or the apple diseases.

RESULTS IN 1927

In 1927 the work was carried on in the Riverview Orchards at McBaine, Missouri, and the work at Boonville discontinued. The Riverview Orchards are near Columbia and gave a better opportunity to follow the work more closely.

The plots consisted primarily of Jonathan trees about twenty-five years of age and in good bearing condition.

The following spray schedule was followed:

TABLE 7.—NUMBER OF SPRAYS APPLIED, DATES AND COST PER ACRE—1927.

Plot No.	No. of applications	Cluster bud	Calyx 4/29	3rd 5/11	4th 5/26	5th 6/11	6th 7/9	7th 7/26	Cost per Acre
1	6	----	Sul.	Sul.	Sul.	Sul.	Sul.	Sul.	\$28.20
2	6	----	Cop.	Cop.	Cop.	Cop.	Cop.	Cop.	38.86
3	6	Liq.	Liq.	Liq.	Liq.	Liq.	none	Liq.	25.98
4	7	Liq.	Liq.	Liq.	Sul.	Sul.	Sul.	Sul.	36.44

The sulphur dust used was composed of 90 pounds of dusting sulphur and 10 pounds of arsenate of lead.

The copper dust was a commercial preparation manufactured by one of the spray chemical companies.

Due to the very wet spring, with almost continuous rain, it was impossible to get from Columbia to the orchard to apply the cluster bud spray. The apple diseases in the orchard have never been and are not now serious, and so far as insect damage is concerned it is doubtful if omission of this application affected the final results.

First Brood of Codling Moth.—The entire orchard was carefully watched throughout the summer and the cover sprays were applied according to the emergence dates of the adult moths. The first brood of moths amounted to practically nothing and so few apples were infested

that it was not thought necessary to make counts. The entire orchard was surprisingly free from infestation.

Summer Broods of the Codling Moth.—There was little codling moth injury until very late summer, or more specifically during the latter part of August. This injury was caused by the late individuals of the second brood and by a partial third brood. The injury consisted primarily of side stings. At the time of harvest the worms were still small and oftentimes one apple would contain as many as five larvae, each one being about one-third grown.

The Apple Curculio.—The apple curculio has become a very serious pest in orchards located on the steep Missouri River hills. It is not practical to do much cultivating; consequently the orchards are kept in sod. This type of cover affords ideal harboring quarters for the curculios and they cause an unusual amount of injury.

Apples picked and counts made August 28.

TABLE 8—FINAL RESULTS—1927

Plot No.	Codling Moth		Curculio %	Brown rot %	Blotch %	Scab %	Cedar Rust %	Perfect apples %	Efficiency for insects & diseases
	Calyx injury %	Side injury %							
1	5.42	33.99	35.69	2.7	.55	2.8	1.67	24.4	3rd
2	5.51	27.06	25.53	2.6	.66	.79	.39	45.21	1st
3	4.89	30.53	33.2	2.0	.48	.14	1.14	23.12	2nd
4	8.81	39.46	38.47	1.8	1.2	.12	1.97	37.43	4th

The last spray applied was on July 26. Practically all of the codling moth injury at picking time was of the pin-worm type. A spray applied about the middle of August would probably have prevented much of this injury.

The final results show that there was very little difference in the four plots as far as the codling moth was concerned. Plot 2 treated with the copper dust gave the greatest percentage of perfect apples, being much better in this respect than any of the others. The copper dusts used in 1926 were home mixed and gave practically no results. The copper dust used in 1927 was a proprietary preparation. It will be given further tests. The straight liquid sprays gave slightly better results than the straight sulphur dust. The sulphur dust used as a supplement to the liquid and applied as cover sprays during June and July did not show up so well.

SUMMARY

Taken as a whole the dust sprays used over a period of three years were not entirely satisfactory. They do, however, possess some valuable possibilities. The dusting chemicals are somewhat more expensive than

the liquids but less labor is required to apply them and a much greater acreage can be covered in the same length of time.

Indications are that the home-mixed sulphur-lead dusts may be depended upon to control apple insects if enough applications are used and applied at the proper time. When so used they have given results comparable to the normal liquid sprays. The dust sprays seem to cover more evenly the foliage and fruit than the liquid sprays but they will not remain on as long; consequently a greater number of applications must be used. The home-mixed copper dusts were practically failures while one season's work with a proprietary copper dust showed promising results.

As a whole, the dust sprays do not seem to control apple diseases as well as the liquid sprays. No apple disease was serious in the orchards where the dusts were used, and for this reason it is impossible to draw definite conclusions.

At present it seems that the most promising use of the dust spray is as a supplement to the liquids for the control of the codling moth, and that the time of application must be governed largely by local conditions. When it becomes necessary to get a cover spray on in the shortest possible time the dusts may be used to an advantage. Also, by using them for the late summer cover sprays arsenical residue is largely eliminated.

The dust sprays are still in the experimental stage. There is room for much improvement in both dusting chemicals and dusting machines. This improvement is bound to come and the time is probably not far distant when the dust sprays can be used with as great or even greater success than the liquids.

Under present conditions the large commercial orchardist may afford to invest in dusting equipment but he should not depend upon the dust sprays for the complete control of insects and diseases.

CONCLUSIONS

As a result of three years work with the dust sprays the following conclusions may be drawn. These conclusions are by no means final, as a three-year period is entirely too short a time to enable anyone to draw definite conclusions regarding any spray materials.

- (1) The use of two pounds of dust on trees, twenty to thirty years old, seems to be as effective as the use of five pounds.
- (2) A sulphur dust containing 90 pounds of sulphur and 10 pounds of arsenate of lead seems to be as efficient as one containing 85 pounds of sulphur and fifteen pounds of arsenate of lead. The finest possible dusting sulphur should be used.

- (3) The home-mixed sulphur dust gave very satisfactory results. The home-mixed copper dust was a failure. A proprietary copper dust gave promising results.
- (4) The dust sprays will not remain on the foliage and fruit for great lengths of time. Practically twice as many applications must be made as with the liquids in order to obtain comparable results.
- (5) Dusting chemicals are a little more expensive than liquid chemicals.
- (6) The labor necessary for the application of a dust spray is much less than the labor necessary for the application of a liquid spray.
- (7) The dust sprays may be used under conditions where it is impossible to use a liquid spray machine. A dusting machine is light and may be used on wet soggy ground and on steep hills.
- (8) Dust may be successfully used as cover sprays to supplement the liquids.
- (9) The dusts will largely eliminate the spray residue when used for the late summer sprays.
- (10) A 90-10 sulphur dust properly used will ordinarily control apple insects.
- (11) At present no dust can be relied upon to thoroughly control apple diseases.
- (12) Under present conditions in Missouri it would be exceedingly unwise to entirely replace the liquid sprays with the dust sprays.
- (13) The time of application of the primary codling moth sprays should always be based on the emergence records of the adults. The running of breeding cages in the orchard is of vital importance.