PRUNING AS A MEANS OF ADAPTING APPLE TREES FOR CONCENTRATE SPRAY APPLICATIONS

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PRUNING AS A MEANS OF ADAPTING APPLE TREES FOR CONCENTRATE SPRAY APPLICATIONS

By

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INTRODUCTION

For many years hydraulic spraying has been the principal means of applying spray chemicals for the control of pests common in fruit growing. This method of spray application involves the use of a large volume of water and heavy spray equipment in order to obtain uniform coverage of the aerial portions of the tree. In 1939, airblast sprayers were introduced to replace hydraulic sprayers and as a result of airblast sprayers concentrate spraying of fruit trees has been made possible. The introduction of concentrate spraying is economically important particularly at this time as the margin of profit in fruit growing is continuing to decrease due to high production costs; and spraying is one of the largest single items in the total cost of growing apples (41). It may well be that concentrate spraying will offer an ultimate solution to high production costs or indications are that this method of spray application will decrease percent spray costs by reducing the quality of spray chemicals needed for pest control and by increasing the speed of spray application.

Concentrate spraying is merely the use of regular spray chemicals concentrated from two to ten or more times the conventional dilution by decreasing the amount

of water used as a carrier. The principle of concentrate spraying as described by Mitchell (31) is merely dispersing a small quantity of concentrated liquid spray in droplet form into a moving air stream which carries the spray droplets from the sprayer and deposits them evenly throughout the tree. By contrast dilute sprays employ a large quantity of water as a carrier of the spray materials and dilute sprays are applied by means of high pressure or an airblast. Concentrate sprays are sometimes divided into two groups, namely semi-concentrate and concentrate mixtures. Semi-concentrate sprays are mixtures less than ten times the conventional concentration, while the concentrate forms include mixtures beginning with ten times the conventional dilution. However in this study the term "concentrate sprays" will include both the so-called "semi-concentrate" and "concentrate" forms.

With the recent advances in pest control using concentrate sprays, new problems have been brought to the fore. In dilute spraying good results were dependent upon timeliness and thorough coverage. However, in developing concentrate spraying for fruit growing the question of dilution, pruning of trees for good coverage, quantitative deposit of spray chemicals, the effect of application on fruit finish, and the role of wetting agents are but a few of the problems encountered. It is felt that

these problems will be answered only through controlled experimentation and thus the reason for this study.

REVIEW OF LITERATURE

The practice of pruning is one of long controversy, and as stated by Ricks and Gaston (42) this is due probably to the fact that investigators have considered the various aspects of the problem from different points of view. The literature includes numerous methods of pruning which these authors have excellently reviewed. Ricks and Gaston (42) feel that the pruning of large, bearing apple trees should be merely the removal of weak, non-bearing wood. They do not include a method of pruning that will help to keep a tree within a specific height and spread or open it to light and sprays.

Many writers have reported that pruning of fruit trees may result in a reduction of total yield (8, 12, 13, 14, 15, 20, 21, 29, 45). However, Sears and Shaw (46) in their pruning experiments using forty year old bearing apple trees found no marked effects from pruning on the yield and quality of fruit. A report from Michigan by Marshall (29) shows that very light pruning of large bearing apple trees resulted in increased yields, and although the size of the fruit was reduced, the net returns were greater than from the heavy or even moderately pruned trees. Ruth (43) found that by pruning the Grimes Golden variety the size of

the fruit could be maintained without reducing total yields. Oskamp (35) working with the Baldwin variety found that for a period of four years that pruning one year only, pruning in two consecutive years, or pruning three times in four years had no measurable effect on production during that period. However, there was some indication that reduced yield might have resulted if three-fourths of the total estimated growing points had been removed during the period of four years. His work also showed that the Rhode Island Greening variety followed a trend similar to that of the Baldwin. A report from Illinois by Ruth (44) states that the Grimes Golden variety can be pruned without reducing yield, but that this did not hold true for the Jonathan variety. Chandler (12) states that irrespective of species heavy pruning reduces the total amount of fruit produced and especially by the late bearing varieties. Studies by Gardner as reported by Beaumont (2) showed that light pruning of Rome Beauty, Winesap, Stayman Winesap, and Red Delicious is advantageous in maintaining yield. Marshall (29) found that pruning old, vigorous, bearing apple trees, despite the increase in high quality fruits total yield and total returns were actually reduced and that the decrease in yield held over to subsequent years.

Most investigations indicated that the increase in size of fruit was related to the severity of pruning.

Marshall (29) found that pruning increased fruit size, and increased the yield of those fruits larger than 2.5 inches. However, the increase in high grade fruit was due largely to increase in size rather than to increase in total number of fruits. Oskamp (35) states that pruning may increase fruit size and that the maximum effect on fruit size is during the year that the pruning is done. His work showed that pruning did not significantly increase the size of the fruit of Rhode Island Greening but that pruning of the Grimes Golden variety did result in a more desirable size of fruit without a decrease in yield. Contrary to this he reports that pruning did increase the size of the fruit of the Jonathan variety but at the expense of yield. Gardner, Bradford, and Hooker (21) state that pruning produces a marked effect on size of fruit but that the difference is not great enough to compensate for the reduction in yield.

It has been reported by Chandler (12), Marshall (29), Ruth (44) and others, that color of fruit is a factor that may be influenced by pruning. Marsh (26) found that old trees required detailed pruning in order to produce large, high colored fruit. Murneek (34) states that pruning helps to increase size and color of fruit by conserving moisture and nitrogen, when they are limiting. He gives as a reason for this the increase in the carbohydrate supply brought about by the development of

larger leaves, and by increased light penetration into the tree. Clark (13) substantiates these findings. Ruth (44) also reports that pruning resulted in better color of fruit of the Jonathan variety. However, Oskamp (35) working with the Baldwin variety found that pruning had no consistent effect on color of fruit. Stewart (47) indicates that color of fruit is directly dependent on exposure to sunlight and the state of maturity of the fruit at the time of harvest. Hence he concluded that environmental factors which hasten maturity increase the color of the fruit while environmental factors that retard maturity reduced the color of the fruit.

It has been made evident by Murneek (34) that four or five times as many bushels of cull apples have to be sold to obtain the same gross income as received from one bushel of U. S. No. 1 fruit. He states that cull apples are the growers' number one enemy against successful apple production and that the lack of size and color account for over one-third of the culls. Hawkins (24) states that there is no better way to reduce the cull fruit supply than by pruning. Investigations by Parsons (36) in Maine indicates that the more important causes of cull apples are lack of size and the presence of scab and limb-rub. He found that a large portion of the cull apples was due to controllable defects, fifty

per cent of which could have been controlled by spraying and thirty-five per cent by other orchard management practices.

It has been reported by Ballou (1), Burkholder et al. (7), Gardner (20), and others that pruning may result in more thorough coverage by spraying and dusting, as pruning opens up the tree and allows better penetration of spray chemicals. Burkholder (7) also reported an increase in arsenical deposit on the leaves and fruit by opening up the top center of the tree. He states that by decreasing the amount of leaf area, better coverage and penetration was obtained.

It has been found by experimentation that the physiological response of the tree may be controlled by pruning. Kraybill (25) states that there was reduced flower bud formation by shading. Murneek (34) has shown that the life of the tree is shortened by heavy pruning. Gardner (20) states that spurs are the machinery of fruit production and that severe pruning forces spurs into vegetative growth reducing the number for fruit production. He further states that too much pruning reduces the number of fruit spurs while too little pruning weakens spurs, reduces their vitality, shortens their life, and causes them to function irregularly.

In summary it may be said that the practice of pruning generally reduces fruit yields, increases fruit

size, increases fruit color, and aids to reduce the amounts of cull fruits. However, varieties do respond differently and this may account for some of the reported variations. A very important factor is that pruning makes possible better spray coverage than for unpruned trees and results in a reduction of cull fruit as a result of better pest control. This in itself is an important aspect in the economy of apple production.

Much can be said of the progress made in the development of spray materials and their application. Campbell (11) gives a comprehensive review of the historical background of spray materials and application methods to include the first use of the power sprayer and present day equipment.

Potts (38) states that coverage sufficient to give control of insects on shade trees may be accomplished with concentrate spray applications. Marshall and Miles (28) report that the development of concentrate spraying in British Columbia for pest control in fruit growing is nearing a state of perfection. They state that coverage adequate to control mites, codling moth, pear psylla, tarnished plant bug, and other orchard insects is satisfactory.

Several investigators indicate that spray chemicals applied in concentrate form weather better than when applied as dilute sprays. Mitchell et al. (32) found

that deposits of residual parathion on the leaves of apple trees applied in concentrate form was far greater after 21 days of weathering than parathion applied as a dilute spray. Young (49) working in Ohio states that deposits of spray chemicals from concentrate spray applications were greater than those resulting from dilute spraying. Pratt (39) has found by analysis of sulfur deposit on apple leaves taken after the third codling moth cover spray that the sulfur present on the leaves after weathering applied as a concentrate spray was 92.0 per cent retained while that applied as a dilute spray was only 35 per cent retained. Borden (3) states that a Speed Sprayer adapted for concentrate spraying will give coverage and deposit equal to that of dilute applications. Marshall (27) applying parathion in concentrate form using a turbo-type mist sprayer concluded that more material was deposited in both lower and upper branches than from the use of the hand gun in dilute spraying although less parathion was used per acre in the concentrate applications.

Experimental evidence presented by Pratt (39) indicate that codling moth and red-banded leaf roller are controlled satisfactorily with mist sprayers using concentrate mixtures. Burrell (10) states that control of apple scab and certain insects was satisfactory with 2 X, 4 X, and 8 X concentrates of the usual fungicide-insecticide

combinations. Cutright (16, 17) was able to control European red mites on apple leaves with several acaricides used at 5 X and 10 X concentrations equally as well as by dilute spray methods. Mitchell et al. (32) obtained control of European red mite with parathion in concentrate form. Garman (22) concluded after two years experience with a mist sprayer using concentration sprays of approximately two pounds of solids per gallon of water that suitable pest control was possible. Brann (4) has reported satisfactory control of apple scab and codling moth with concentrate applications. Burrell (9) concluded after trials with double strength concentrations of spray chemicals that perfect control of apple scab even in a bad year was possible. Mitchell (30) in 1948 obtained control of scab and codling moth on Northern Spy and Red Delicious varieties using 2 X spray concentrations. Garman (22) states that insect and disease control in 1947 was nearly as good with only five concentrate spray applications as was obtained with eleven or twelve applications made in dilute form.

Mitchell (30), using 2 X and dilute spray applications on the Red Delicious variety, found only 8.2 per cent heavy fruit russet in the concentrate spray treatment and 15.4 per cent in the dilute spray treatment. Burrell (10) reports that as the concentration of spray mixture increased, interference with fruit color

development decreased. He states that higher and more uniform color was obtained because the spray liquid did not accumulate into large droplets and cause blotchy finish of the fruit.

Pratt (40) has indicated that spreaders or spreader-stickers added to concentrate spray mixtures result in the deposit of smaller droplets, a more uniform spray coverage, and a spray deposit more resistant to weathering than when no spreader is used. He states that the addition of a spreader is particularly advantageous when the trees are in full foliage. Potts (37) states that the addition of a wetting agent to concentrate water base sprays reduced the size of droplets dispersed in the air blast 30 to 35 per cent. He states that droplet size is an important factor in foliage injury and that the danger of injury is lessened with decreased droplet size. He also states that droplets less than 30 microns in size are usually not deposited on plant surfaces and that a desirable range for droplets in concentrate spraying would be 35 to 60 microns. Brooks (6) gives 20 microns as the smallest dust particle usually deposited on plant surfaces.

French (19) found that airblast sprayers used for applying water base sprays produced droplets of about the same size as did hydraulic sprayers operated at 500 to 600 pounds pressure per square inch.

Investigators indicate that increased speed of operation, more timely application, and decrease in spraying costs can be attained by the use of concentrate spray applications. Borden (3) states that approximately 50 per cent decrease in cost of spray materials resulted from the use of low concentrate mixtures. Marshall (28) reports that labor costs were 80 per cent less when concentrate sprays were used.

Mitchell (31) and Marshall and McArthur (27) feel that proper pruning is necessary to obtain adequate spray coverage for insect and disease control in all parts of the tree.

Most investigators are in agreement that spray injury to foliage and fruit is no greater than is incurred from the use of dilute sprays.

EXPERIMENTAL PLOTS AND EQUIPMENT

A variety block of large, bearing apple trees was selected at the Michigan State College Horticultural Farm, East Lansing, Michigan to determine the value of pruning as a means of adopting large apple trees for concentrate sprays applications and to determine the effect of pruning on the yield and quality of fruit. The block included two rows of ten McIntosh trees, one row of eleven Jonathan trees, and one row of eleven Red Delicious trees which were selected for this study. The odd numbered trees in each row were pruned heavily and the even numbered trees were pruned lightly. The block was divided so that five trees of each row were sprayed with dilute mixtures using a John Bean Company hydraulic sprayer equipped with a Bean Low-Boy Oscillating Mast and six trees in each row were sprayed with a John Bean Company Model 7 Mist Duster[1] using 10 X spray concentrations. The mast of the hydraulic sprayer was designed to deliver 22.5 gallons of spray a minute at 600 pounds pressure and the rate of travel of the sprayer was 1.25 miles per hour. The concentrate sprayer delivered 4.2 gallons a

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[1]Manufactured by the John Bean Company, Division of the Food Machinery Corporation, San Jose, California. Model 7 Mist Duster has an airblast capacity of 8,000 cubic feet per minute at a velocity of 120 miles per hour.

minute and the rate of travel of the machine during the spraying operation was 2.25 miles per hour. The spray delivery of each machine was such that two-thirds of the spray was directed into the upper one-third of the tree. A constant speed was maintained for all spray applications with the aid of a tractor mounted low-speed odometer. Ten potato nozzles equipped with two-outlet whirl plates and number 2.5 discs were used on the concentrate sprayer to disperse the liquid in the form of fine droplets, throughout the airblast. In the dilute spraying each tree received approximately 12.5 gallons of spray per application while each tree sprayed with the concentrate mixture received approximately 1.26 gallons. As the concentrate mixture was ten times the dilute mixture, each tree in both treatments was covered with approximately the same amount of active spray chemicals.

The apple spraying schedule as suggested for Michigan conditions (33) was followed throughout the experiment. The timing of applications and the spray chemicals used are given on the following page.

A second block consisting of 30 large, bearing Red Delicious apple trees was selected at the Michigan State College Graham Experiment Station, Grand Rapids, Michigan, to determine the value of 4 X and 2 X concentrate sprays for pest control and their effect on fruit finish. This block was heavily pruned and appeared to be well suited

Date	Spray Chemical Used	Amount Used per 100 Gallons of Spray*
May 11, 1950 (pre pink)	Liquid lime sulfur	2 gallons
May 22, 1950 (full bloom May 18, 1950)	Magnetic 70 Paste	8 pounds
May 25, 1950 (early calyx)	Magnetic 70 Paste	8 pounds
June 1, 1950 (first cover)	Ferbam 15 per cent wettable parathion	1.5 pounds .5 pound
June 4, 1950	Ferbam	1.5 pounds
June 9, 1950	Ferbam 50 per cent wettable DDT 15 per cent wettable parathion	1.5 pounds 1 pound .5 pound
June 14, 1950	Ferbam 50 per cent wettable DDT 15 per cent wettable parathion	1.5 pounds 1 pound .5 pound
June 23, 1950	Lead arsenate 50 per cent wettable DDT wettable sulfur	3 pounds 1 pound 5 pounds
July 5, 1950	Lead arsenate Wettable sulfur Zinc sulfate (20 per cent grade)	3 pounds 4 pounds 1 pound
July 21, 1950	Lead arsenate Zinc sulfate (20 per cent grade) Ferbam (on McIntosh only)	3 pounds 1 pound 0.75 pound

* The same spray chemicals were used for both dilute and 10 X concentrate applications.

for concentrate spray applications. This block was divided into two groups of trees, one of which was sprayed throughout the season with a 4 X spray concentration and the other with a 2 X spray concentration. All sprays in both treatments were applied with a John Bean Company Model 36 Speed Sprayer[1] equipped with Speed-Mist nozzles.[1] The discharge of the sprayer was so designed that the nozzles on one manifold were used for making the 2 X applications delivered 24 gallons a minute while the nozzles on the second manifold used for making the 4 X applications delivered 12 gallons a minute. As an average speed of two miles per hour was used during the process of spraying, approximately six gallons of 2 X spray and three gallons of 4 X spray was applied to the average tree per application. The regular spraying schedule suggested for apples (33) was followed throughout the season. The timing and materials used are given in the table on the following page.

A third block of large bearing Northern Spy apple trees was selected at the Taylor Orchards, Albion, Michigan to determine the distribution pattern of spray chemicals of 4 X concentration on light and heavily pruned trees using a Hardie Orchard Mist Concentrate Sprayer.[2] The sprayer was equipped with six Tee Jet

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[2]Manufactured by the Hardie Manufacturing Company, Hudson, Michigan. This applicator produced 20,000 cubic feet of air at a velocity of 110 miles per hour.

Date	Spray Chemical Used	Amount Used per 100 Gallons of Spray
May 19, 1950 (Pink)	Wettable sulfur 15 per cent parathion	8 pounds 0.5 pound
May 25, 1950 (Early Calyx)	Wettable sulfur	8 pounds
June 3, 1950	Wettable sulfur 15 per cent wettable parathion	8 pounds 0.5 pound
June 8, 1950	Ferbam 50 per cent wettable DDT 15 per cent wettable parathion	1.5 pounds 1 pound 0.5 pound
June 15, 1950	Ferbam 50 per cent wettable DDT	1.5 pounds 1 pound
June 29, 1950	Ferbam 50 per cent wettable DDT	1.5 pounds 1 pound
July 18, 1950	Lead arsenate Zinc sulfate 20 per cent Lime	3 pounds 1 pound 3 pounds
August 7, 1950	Lead arsenate Zinc sulfate 20 per cent Lime	3 pounds 1 pound 3 pounds

nozzles designed to discharge 8 to 9 gallons per minute. The ground speed of the sprayer was 1.75 miles per hour and approximately 3.5 gallons of spray mixture was applied per tree.

A fourth block consisting of large bearing Northern Spy apple trees was selected at the Pierson Orchards, Ionia, Michigan to determine the distribution patterns of

spray chemicals of 5 X and 3 X concentrations on heavy and lightly pruned trees using a Meyers Concentrate Sprayer.[3] The machine was equipped with five potato type nozzles which dispersed the spray mixtures in droplet form into the airblast. The sprayer applied approximately 2.83 gallons of spray per tree as the machine passed the tree at a rate of 2.0 miles per hour.

A fifth block of large McIntosh apple trees was selected at the Michigan State College Horticultural Farm to determine the value of a spreader in dilute and 10 X concentrate spray mixtures for distributing spray chemicals over the surface of apple leaves. A dilute lead arsenate spray was applied with a John Bean Company hydraulic sprayer[1] and a 10 X concentrate lead arsenate spray mixture was applied with a John Bean Company No. 7 Mist Duster.[1] One half-pint of Titron B-1956[4] per 100 gallons was added to both the dilute and 10 X concentrate spray mixtures. The dilute spray was applied at the rate of 12.5 gallons per tree and the 10 X concentrate at the rate of 1.26 gallons per tree. Applications of dilute and 10 X concentrate sprays were made also without the spreader to serve as check treatments.

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[3] Manufactured by the F. E. Myers Company, Ashland, Ohio. This machine delivered 26,000 cubic feet of air per minute at a velocity of 90 miles per hour from two oscillating heads.

[4] A product of the Rohm and Haas Chemical Corporation, Philadelphia, Pennsylvania.

Trees from which leaf samples were taken were selected in all cases to represent the average of the large apple trees within each block. These trees in every case averaged approximately 25 to 30 feet in diameter and 18 to 24 feet in height. Five entire spur samples to include all the spur leaves were selected at random from the low and in some instances from the low interior, middle, and middle interior, top, and top interior of the tree. Low samples were gathered from the outer periphery at a height of five to six feet. Low interior samples were taken at the same height but from an area four to six feet within the outer periphery. Middle and middle interior samples and top and top interior spur samples were gathered in the same manner except at heights of 12 to 14 feet and 18 to 22 feet. All samples were taken from a quarter of the tree which was not directly in front of the discharge units of the sprayer.

From the five spur samples taken at random from each location, one spur of each group was selected randomly for the leaf print. The leaf printing technique used was basically the same as that reported by Hamilton (24) for printing lead arsenate except for modifications as suggested by Brann (5) and those made by the author to better fit available equipment, and specimen material.

The method used is as follows:

(a) Trees were sprayed with lead arsenate solution, allowed to dry, and leaf samples were taken for printing within 12 hours after spray application.

(b) Two sheets of white bond paper were soaked approximately three minutes in a five per cent sodium hydroxide solution. The paper found most desirable was of good quality 20-pound bond without water marks. Excess sodium hydroxide was allowed to drain from the paper.

(c) The leaf sample was then placed between the two sheets of treated paper. They in turn were placed between two sheets of heavy white blotting paper cut slightly larger than the bond paper.

(d) Pressing was done in a hydraulic press using a one quarter-inch foam rubber pad above and below the blotting paper. The foam rubber pads were each backed by stiff metal plates.

(e) Pressure of 1,000 pounds per square inch was applied for two minutes then increased to 2,000 pounds per square inch for one minute and then released immediately.

(f) The bond papers were then placed immediately into a five per cent solution of liquid lime sulfur and allowed to stand for five minutes.

(g) At the end of five minutes the papers were washed in cold water until the papers turned white.

(h) The papers were then removed from the water and spread out on a flat surface to dry.

In the study at the Horticultural Farm and the Graham Experiment Station a second single spur sample was selected from each group of spurs for quantitative determinations of lead deposited per square centimeter of leaf area. Leaf areas were determined by matching each leaf with a leaf outline of similar shape and size of a

known area which had been determined previously by means of a Coradi Compensating Planimeter.

The quantitative analysis to determine the amount of lead deposited were made by the Department of Biochemistry of Michigan State Experiment Station. The procedure used was an adaptation of the dithizone (diphenylthiocarbazone) method described by Winter, et al. (48).

At the time of harvest a random sample of 100 apples was taken from each tree in the studies made at the Michigan State College Horticultural Farm and the Graham Experiment Station. The apples from the Michigan State College Horticultural Farm plots were graded into three sizes as follows: McIntosh over 3 inches, 2.5 to 3 inches, and those under 2.5 inches; Red Delicious over 2.75 inches, 2.5 to 2.75 inches and those under 2.5 inches; Jonathan over 2.75 inches, 2.5 to 2.75 inches, and those under 2.5 inches. All the apples of the three varieties were further graded within each size range for color as follows: Those with over 75 per cent red color; those with 50 to 75 per cent red color; and those with less than 50 per cent red color. Also all three varieties were checked for the presence of apple scab and codling moth injury. The yield records of each tree were obtained at harvest time. The samples of apples from the Graham Experiment Station plots were examined for the presence of apple scab and codling moth injury, and the presence

of fruit russeting. Two severities of russeting were established and all apples were classified as follows: Heavily russeted, lightly russeted, and those free from russet.

RESULTS

The results included herein are based on only one year's study under field conditions but they appear to be sufficiently interesting for presentation.

The findings of the study carried on at the Michigan State College Horticultural Farm, East Lansing, Michigan are summarized in Tables I, II, III, and IV, and illustrated in Figure 1. Figure 1 includes a composite of prints of leaves from heavy and lightly pruned, large, Red Delicious apple trees sprayed with dilute and 10 X concentrations of lead arsenate. As shown by the leaf prints the amount of lead arsenate deposit by both methods of application was less in the top than in the lower areas of the tree. However, both sides of the leaves of the 10 X concentrate treatment were uniformly covered whereas the lower side of the leaves from dilute sprayed trees were incompletely covered. Also, the coverage resulting from the dilute spray treatment was blotchy and unevenly distributed while that of the 10 X spray concentration was more uniform. Of interest is the difference in the method of deposit as is shown by the leaf prints. The deposit brought about by the evaporation of small droplets sprayed on the leaf surface in concentrate form is clearly evident in contrast to the complete liquid coverage of the dilute application.

The amount of lead deposited per square centimeter of leaf area at various locations on the tree by the different methods of application is given in Table I. As is evident from the leaf prints, Figure 1, and by the quantitative analysis, Table I, the quantity of lead arsenate deposited by both methods of spray application was progressively greater from the top to the lower portion of the tree. The trees in both spray treatments received the same quantity of lead arsenate per application even though the leaves of the trees sprayed with 10 X concentration had the largest amount of lead arsenate deposit. A comparison of sub-figures 1 to 4 and 4 to 8, Figure 1, indicates that there was no measurable difference in the amount of lead arsenate deposited on the leaves of the outer periphery of heavily or lightly pruned trees within each spray treatment.

The results of the two methods of spray application on the control of apple scab and codling moth and the yield, size, and color of fruit, of the light and heavily pruned apple trees are given in Table II.

There was little or no difference in the size or color of the fruit on the heavy and lightly pruned McIntosh, Jonathan, and Red Delicious apple trees. However, the yield per tree was larger for the lightly pruned McIntosh and Jonathan trees than for the heavy pruned trees.

TABLE I

MICROGRAMS OF LEAD PER SQUARE CENTIMETER OF LEAF AREA ON HEAVY AND LIGHTLY PRUNED RED DELICIOUS APPLE TREES SPRAYED WITH DILUTE AND 10 X SPRAY MIXTURES. HORTICULTURAL FARM, EAST LANSING, MICHIGAN

Treatment	Location on Periphery of Tree		
	Top	Middle	Lower
Dilute spray, lightly pruned	2.7	12.1	12.8
Dilute spray, heavily pruned	1.5	7.6	12.6
10 X spray, lightly pruned	2.5	9.6	20.3
10 X spray, heavily pruned	3.4	6.4	19.3

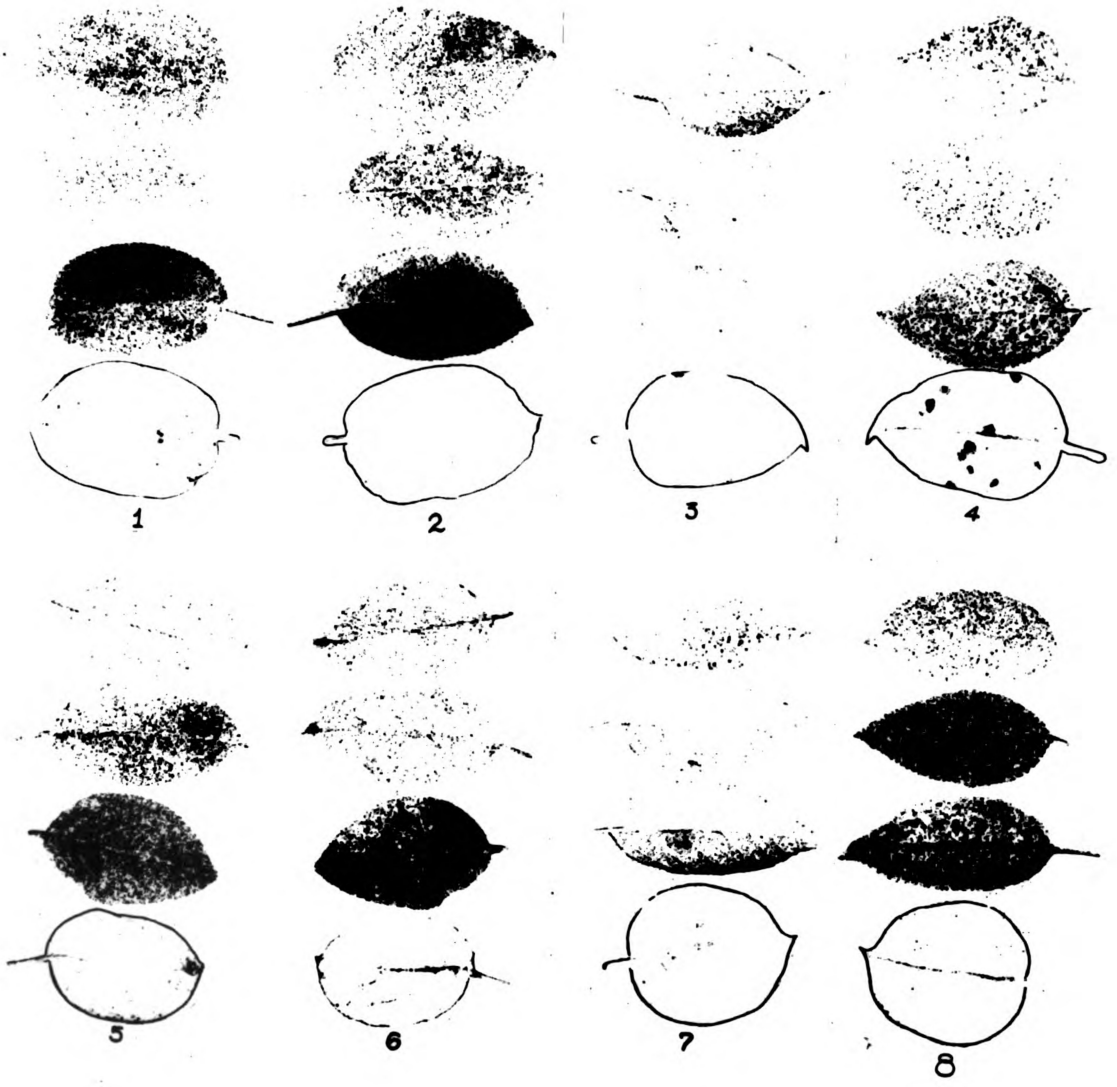

FIGURE 1

A composite of leaf prints taken from the outer periphery of a heavy and lightly pruned large Red Delicious apple trees sprayed with dilute and 10 X spray concentrations of lead arsenate (1-8). Reading from top to bottom; top, middle lower, and control leaf. (1) lower side and (2) upper side of leaves from a heavily pruned 10 X sprayed tree; (3) lower side and (4) upper side of leaves from a heavily pruned dilute sprayed tree; (5) lower side and (6) upper side of leaves from a lightly pruned 10 X sprayed tree; (7) lower side and (8) upper side of leaves from a lightly pruned 10 X sprayed tree.

TABLE II

THE EFFECT OF HEAVY AND LIGHT PRUNING OF LARGE, BEARING APPLE TREES ON QUALITY AND YIELD OF FRUIT. HORTICULTURAL FARMS, EAST LANSING, MICHIGAN (1950)

Variety and Treatment (pruning)	Size 2.25-2.50"				Size 2.50-2.75"				Size 2.75" +				Yield in Bushels
	Color			Total	Color			Total	Color			Total	
	-50%	50 - 75%	+75%		-50%	50 - 75%	+75%		-50%	50 - 75%	+75%		
Jonathan Heavy (6 trees)	0.5	0.5	0.8	1.8%	7.4	10.0	4.9	22.3%	18.9	32.0	25.9	76.8%	135
Light (5 trees)	0.0	1.4	0.6	2.0%	10.7	8.5	1.6	20.8%	26.3	30.3	20.5	77.1%	113
McIntosh Heavy (11 trees)	0.8	1.0	0.2	2.0%	6.9	5.3	3.6	15.8%	26.3	37.9	18.6	82.8%	72.5
Light (9 trees)	0.6	0.4	0.2	1.2%	8.2	4.5	2.7	15.4%	26.1	34.9	21.7	82.7%	74
Red Delicious Heavy (6 trees)	2.0	2.8	1.4	6.2%	9.8	12.1	10.4	32.3%	8.6	25.1	27.8	61.4%	73
Light (5 trees)	0.0	0.6	0.6	1.2%	5.0	12.3	10.4	27.7%	8.2	28.4	34.3	70.9%	73

By contrast heavy pruning of Red Delicious trees did not result in any reduction in yield below that of the lightly pruned trees. The control of apple scab and codling moth expressed in Table IV was relatively the same for both pruning treatments with the exception of the Jonathan variety which had a higher incidence of both apple scab and codling moth on the lightly pruned trees. Comparing methods of spraying, apple scab and codling moth were more readily controlled with the 10 X concentration applications than with the dilute sprays as is expressed in Table III.

The results of the study carried on at the Michigan State College Graham Experiment Station, Grand Rapids, Michigan are presented by Figures 2 and 3 and in Tables V and VI.

Figure 2 is a composite of prints of leaves from a large, Red Delicious apple tree sprayed with a 2 X concentration of lead arsenate on July 18 and August 7, 1950 for the control of apple maggot. Spray material distribution was relatively uniform throughout the entire tree. The top areas of the tree have less dense prints than the lower areas.

The treatment for which the results are expressed by Figure 3 is similar to those of the 2 X treatment expressed by Figure 2 except that 4 X concentrate sprays were used. As is shown by the leaf prints the spray

TABLE III

RESULTS FROM THE USE OF DILUTE AND 10 X CONCENTRATE SPRAY MIXTURES THROUGHOUT THE SEASON ON LARGE BEARING APPLE TREES FOR THE CONTROL OF APPLE SCAB AND CODLING MOTH IN 1950

Horticultural Farm, East Lansing, Michigan

Variety	Spray Treatment*	Number of Trees	Per Cent Scab	Per Cent Codling Moth
Jonathan	10 X	6	0.2	4.5
	Dilute	5	0.7	3.2
McIntosh	10 X	11	2.0	0.6
	Dilute	9	14.7	1.2
Red Delicious	10 X	6	8.0	0.7
	Dilute	5	14.4	1.2

* 10 X concentrate spray mixtures were applied by John Bean Mist Duster and dilute spray mixtures were applied by a John Bean Hydraulic 25 gallon per minute applicator. Both machines are products of the John Bean Company.

TABLE IV

THE EFFECT OF HEAVY AND LIGHT PRUNING OF LARGE APPLE TREES ON THE CONTROL OF CODLING MOTH AND APPLE SCAB USING SPRAY CHEMICALS AT DILUTE AND 10 X CONCENTRATIONS THROUGHOUT THE GROWING SEASON OF 1950

Horticultural Farm, East Lansing, Michigan

Variety	Pruning Treatment	Number Of Trees	Per Cent Codling Moth	Per Cent Scab
McIntosh	Heavy	11	1.65	6.50
	Light	9	1.97	8.92
Jonathan	Heavy	6	3.54	0.5
	Light	5	4.45	0.21
Red Delicious	Heavy	6	1.5	6.25
	Light	5	0.4	16.4

FIGURE 2

A composite of leaf spur prints from a heavily pruned large Red Delicious apple tree sprayed with a 2 X concentrate spray concentration of lead arsenate; (9) upper side and (10) lower side of leaves top periphery; (11) upper side and (12) lower side of leaves middle periphery; (13) upper side and (14) lower side of leaves lower periphery; (15) upper side and (16) lower side of leaves top interior; (17 upper side and (18 lower side of leaves middle periphery; (19) upper side and (20) lower side of leaves lower interior. Application made with a John Bean Company Speed Sprayer.

FIGURE 3

A composite of leaf spur prints from a heavily pruned large Red Delicious apple tree sprayed with a 4 X concentrate spray concentration of lead arsenate; (21) upper side and (22) lower side of leaves top periphery; (23) upper side and (24) lower side of leaves middle periphery; (25) upper side and (26) lower side of leaves lower periphery; (27) upper side and (28) lower side of leaves top interior; (29) upper side and (30) lower side of leaves middle periphery; (31) upper side and (32) lower side of leaves lower interior. Applications made with a John Bean Company Speed Sprayer.

material distribution is reasonably uniform throughout the entire tree. Upper and lower leaf surfaces are uniformly covered with spray material. The use of a 4 X spray concentration resulted in a more thorough coverage in the top portions of the tree than did the 2 X spray mixtures.

The amount of lead deposited per square centimeter of leaf area at various locations on the trees following two applications of lead arsenate made with a Speed Sprayer[1] using 2 X and 4 X concentrations for apple maggot control is given in Table VI. The distribution of lead arsenate when applied at both 4 X and 2 X concentrations was relatively uniform over the outer periphery of the tree. The deposit on the interior leaves was also fairly uniform and approximately one-half the amount deposited on the outer periphery. However, in all locations of the tree the amount of lead arsenical deposited by 4 X concentrations was greater than when 2 X concentrations were used.

The percentage of apple scab and codling moth present and the degree of fruit russeting on the harvested fruit using 4 X and 2 X spray mixtures is given in Table V. The results presented indicate that good commercial controls of apple scab and codling moth was obtained and that the amount of fruit russeting was insignificant in both treatments. However, the figures

TABLE V

THE RESULTS FROM THE USE OF 2 X AND 4 X SPRAY CONCENTRATIONS THROUGHOUT THE GROWING SEASON OF 1950 ON RED DELICIOUS APPLE TREES TO CONTROL APPLE SCAB AND CODLING MOTH AND TO REDUCE FRUIT RUSSETING

Spray Treatment*	Number of Trees	Per Cent Russet		Per Cent Scab	Per Cent Codling Moth	Total Fruits
		Heavy	Light			
4 X	8	0.7	1.3	1.3	2.5	791
2 X	15	1.2	2.4	2.5	4.5	1472

* A Model 36 Speed Sprayer equipped with Speed Mist nozzles, manufactured by the John Bean Company, was used to make all spray applications.

TABLE VI

MICROGRAMS OF LEAD PER SQUARE CENTIMETER OF LEAF AREA DEPOSITED ON SPUR LEAVES OF LARGE RED DELICIOUS APPLE TREES FOLLOWING TWO LEAD ARSENATE APPLICATIONS USING 2 X AND 4 X SPRAY CONCENTRATIONS

Graham Experiment Station, Grand Rapids, Michigan

Treatment	Location of Leaf Spurs on the Tree					
	Outer Periphery			Interior of Tree		
	Top	Middle	Lower	Top	Middle	Lower
2 X	11.0	6.3	8.5	2.6	3.4	4.0
4 X	15.2	14.2	23.0	7.7	7.1	6.0

do indicate a trend in favor of the 4 X concentrate spray mixtures inasmuch as the incidence of fruit russet and pest injury on the harvested fruit was less from the trees that received the 4 X spray treatments.

The results of the study at the Taylor Orchard, Albion, Michigan are summarized by Figure 4. There was a more uniform distribution of 4 X concentrate spray mixtures throughout the heavily pruned tree than the lightly pruned tree.

The results of the study at the Pierson Orchard, Ionia, Michigan using 5 X and 3 X spray applications of lead arsenate on heavy and lightly pruned Northern Spy apple trees are shown in Figures 5, 6, and 7. It is of interest that a more uniform distribution of lead arsenate was obtained throughout the heavily pruned tree sprayed with the 5 X spray concentration than throughout the lightly pruned tree, Figures 5 and 6. As is shown by the prints of the leaves from the trees sprayed with 3 X concentration, Figure 7, the amount of lead arsenate deposited was considerably less than when 5 X concentration was used, Figure 6, even though the speed of the sprayer was the same, two miles per hour, for both applications and both trees were similar in density of foliage.

The results of the study on the value of a spreader in dilute and 10 X concentrate sprays to improve the distribution and deposit of spray chemicals on apple leaves

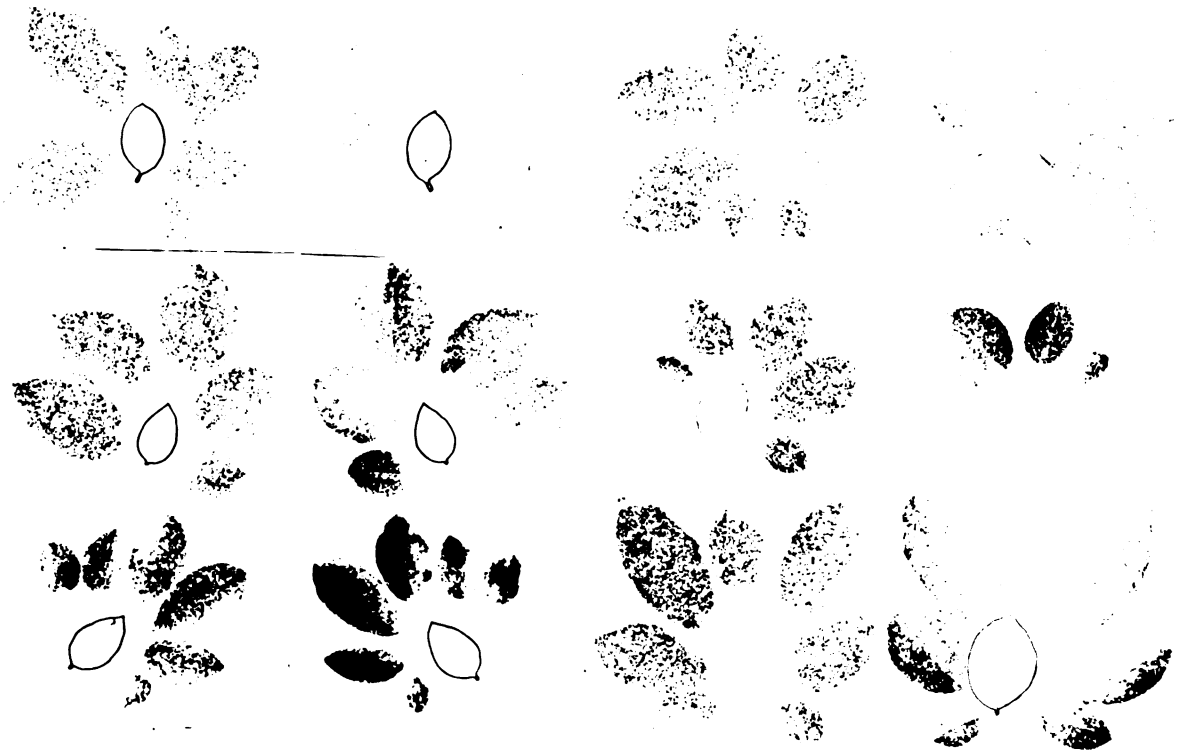

FIGURE 4

A composite of leaf spur prints from the periphery of heavy and lightly pruned large Northern Spy apple trees sprayed with 4 X concentrate spray concentrations of lead arsenate. Reading from top to bottom; top, middle, and lower periphery and from left to right; upper, lower, upper, and lower side of the leaves. The six prints on the left are from heavily pruned trees and the six on the right are from lightly pruned trees. Applications made with a Hardie Concentrate Sprayer.

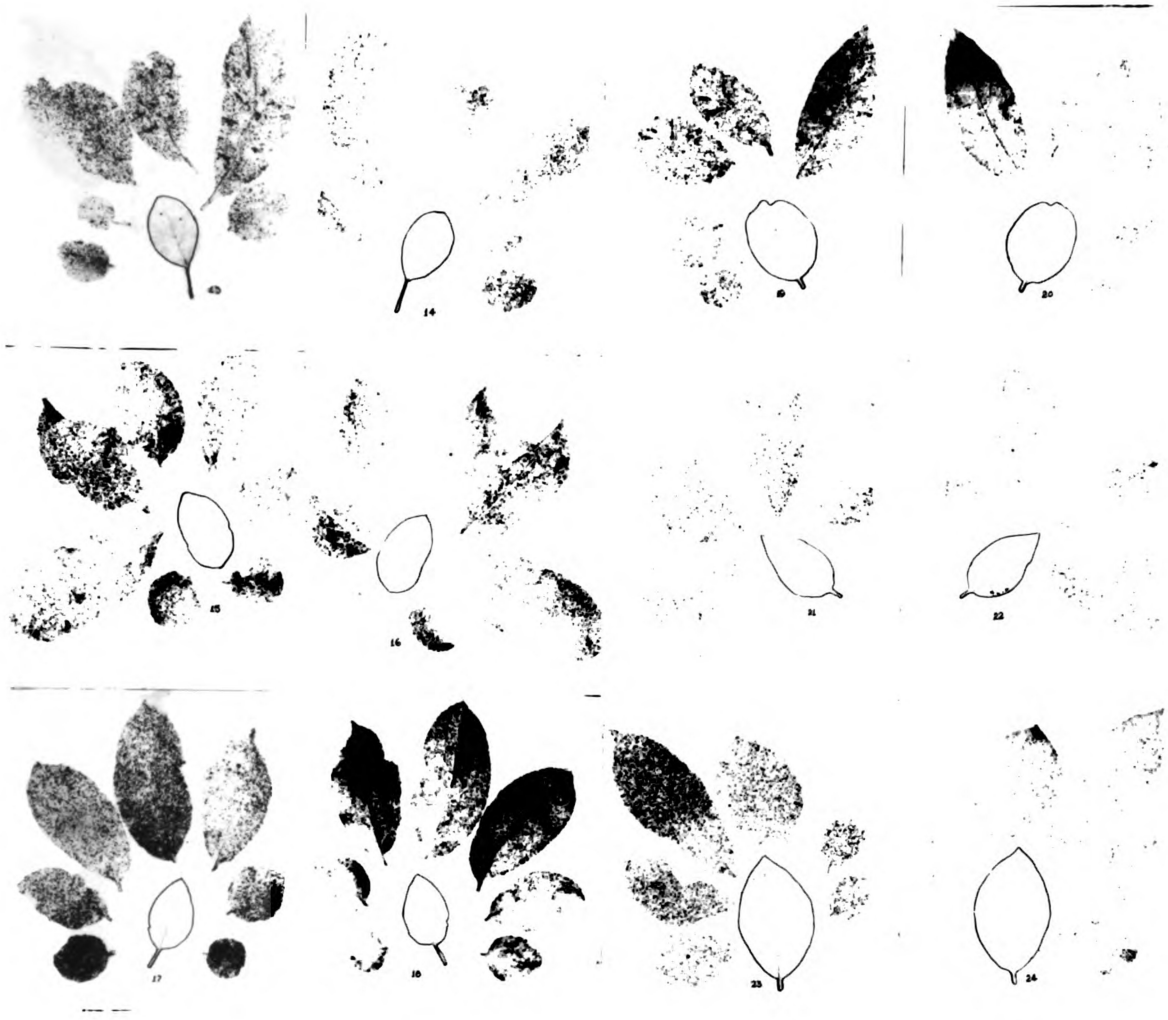

FIGURE 5

A composite of leaf spur prints from a lightly pruned large Northern Spy Apple tree sprayed with a 5 X concentrate application of lead arsenate. (13) upper side and (14) lower side of the leaves from the top periphery; (15) upper side and (16) lower side of the leaves from the middle periphery; (17) upper side and (18) lower side of the leaves from the lower periphery; (19) upper side and (20) lower side of the leaves from the top interior; (21) upper side and (22) lower side of the leaves from the middle interior; (23) upper side and (24) lower side of the leaves from the lower interior. Applications made with a Meyers Concentrate Sprayer.

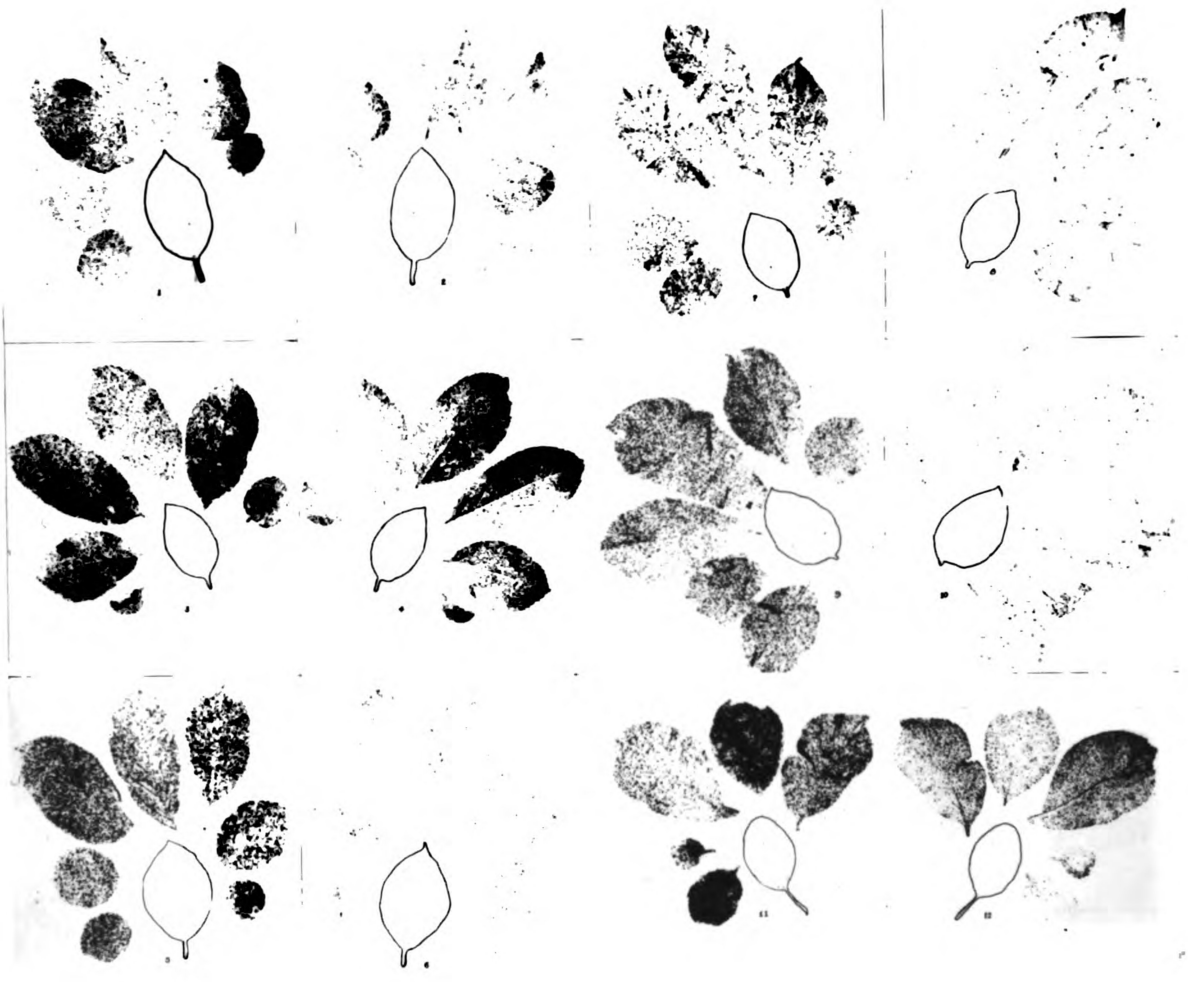

FIGURE 6

A composite of leaf spur prints from a heavily pruned large Northern Spy apple tree sprayed with a 5 X spray concentration of lead arsenate. (1) upper side and (2) lower side of the leaves from the top periphery; (3) upper side and (4) lower side of the leaves from the middle periphery; (5) upper side and (6) lower side of the leaves from the lower periphery; (7) upper side and (8) lower side of the leaves from the top interior; (9) upper side and (10) lower side of the leaves from the middle interior; (11) upper side and (12) lower side of the leaves from the lower interior. Applications made with a Meyers Concentrate Sprayer.

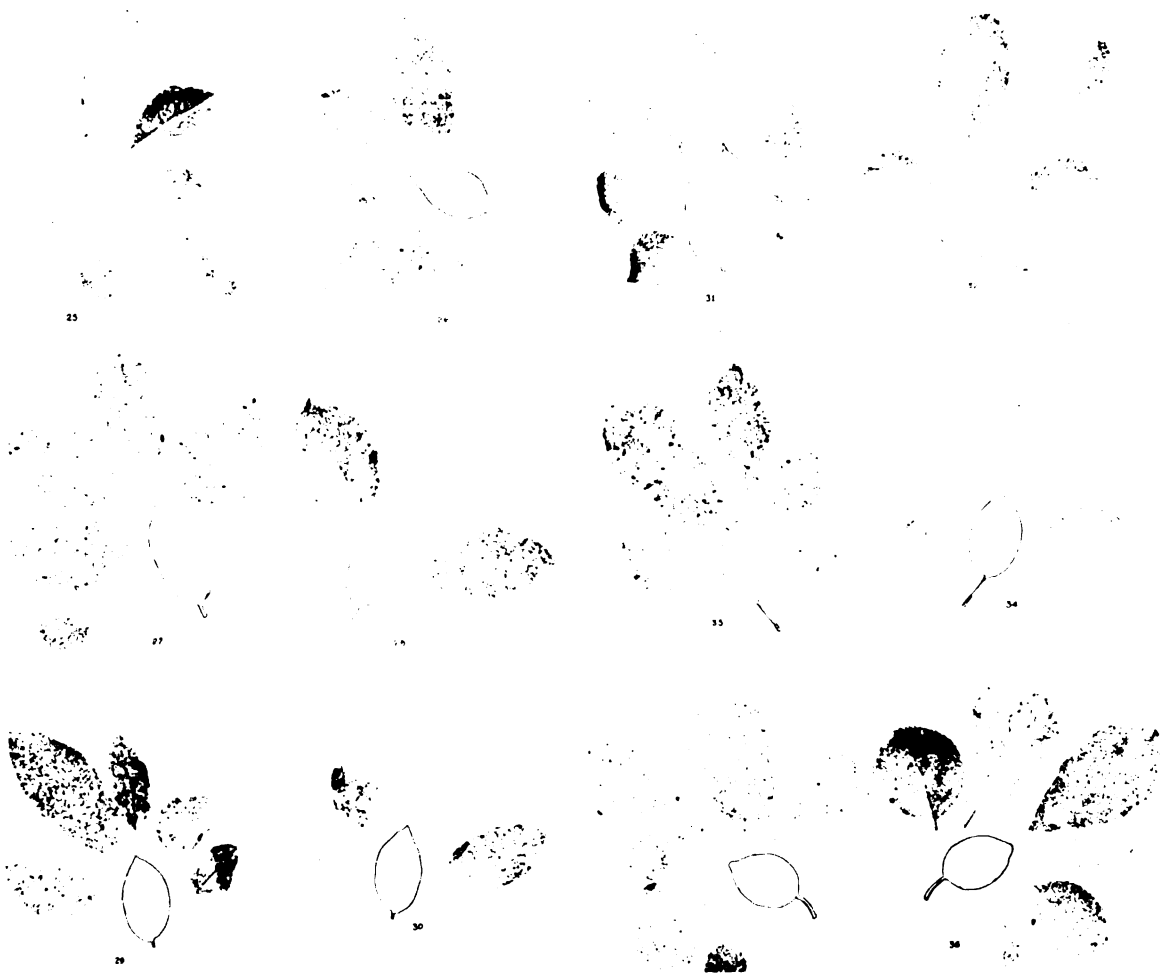

FIGURE 7

A composite of leaf spur prints from a heavily pruned large Northern Spy apple tree sprayed with a 3 X concentrate application of lead arsenate. (25) upper side and (26) lower side of the leaves from the top periphery; (27) upper side and (28) lower side of the leaves from the middle periphery; (29) upper side and (30) lower side of the leaves from the lower periphery; (31) upper side and (32) lower side of the leaves from the top interior; (33) upper side and (34) lower side of the leaves from the middle interior; (35) upper side and (36) lower side of the leaves from the lower interior.

are shown in Figures 8 and 9. The use of the spreader in the dilute spray mixture gave a more uniform distribution of the lead arsenate on the surface of the leaves than when no spreader was used. Also it appeared to increase the coverage on the lower side of the leaves, Figure 9. When the spreader was used in the spray mixture of 10 X concentration, it increased the uniformity of the size of the droplets and improved the distribution of the lead arsenate on the surface of the leaves over the treatment in which no spreader was used.

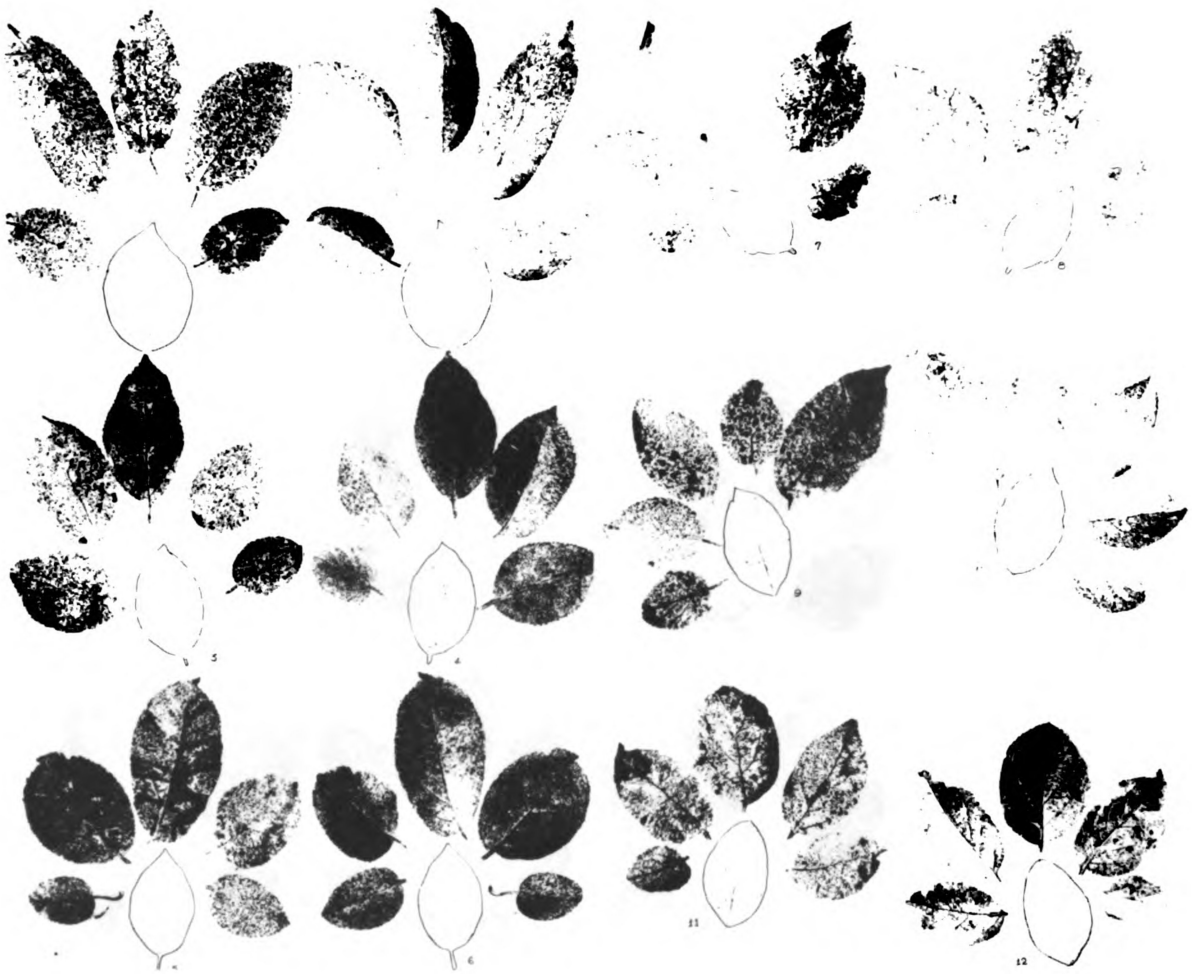

FIGURE 8

A composite of leaf spur prints from the periphery of large McIntosh apple trees sprayed with dilute lead arsenate chemical. (1-6) with spreader; (7-12) without spreader; (1) upper side and (2) lower side of the leaves from the top periphery; (3) upper side and (4) lower side of the leaves from the middle periphery; (5) upper side and (6) lower side of the leaves from the lower periphery; (7) upper side and (8) lower side of the leaves from the top periphery; (9) upper side and (10) lower side of the leaves from the middle periphery; (11) upper side and (12) lower side of the leaves from the lower periphery. Applications made with a John Bean Company hydraulic sprayer.

FIGURE 9

A composite of leaf spur prints from the periphery of large McIntosh apple trees sprayed with 10 X lead arsenate. (13-18) with spreader; (19-24) without spreader; (13) upper side and (14) lower side of the leaves from the top periphery; (15) upper side and (16) lower side of the leaves from the middle periphery; (17) upper side and (18) lower side of the leaves from the lower periphery; (19) upper side and (20) lower side of the leaves from the top periphery; (21) upper side and (22) lower side of the leaves from the middle periphery; (23) upper side and (24) lower side of the leaves from the lower periphery. Applications made by a John Bean Company No. 7 Mist Duster.

DISCUSSION

Commercial apple growers are interested in the factors which will give them the greatest economic return from their orchards. Spraying is one of the most expensive orchard operations, therefore any means of reducing spraying costs without reducing fruit yield and quality is desirable. Experimental results obtained from the use of machines designed to apply concentrate forms of spray chemicals indicate that this method of pest control may be economically feasible.

The study at the Michigan State College Horticultural Farm using concentrate and dilute spray mixtures in relation to pruning and the resulting quality of fruit presented some interesting results. Heavy pruning did reduce the yield of fruit per tree on McIntosh and Jonathan varieties as expressed by many other investigators (12, 29, 35, 44). No reduction in yield was evident from heavy pruning of the Red Delicious variety, this being contrary to the findings of Marshall (29) and Chandler (12). Contrary to Marsh (26) there was no increase in the size of the fruit of the three varieties as a result of heavy pruning in comparison to light pruning; similar results were obtained for color of the fruit. These findings may indicate that pruning

is not the sole factor controlling yield, size, and color of fruit. Also, the findings reported herein are based on only one year's work, which may account for this contradiction.

In the studies of the Michigan State College Horticultural Farm spray deposit was not increased in any part of Red Delicious apple trees by either dilute or 10 X spray applications and heavy pruning. However, this was not true in the other studies carried on in the Pierson and Taylor Orchards. There is reason to believe that fruit trees must be pruned to fit the particular spray applicator if thorough coverage by concentrate spray mixtures is to be expected. In view of the data presented in Figures 4, 5, 6, and 7 it can be established that a more satisfactory coverage is obtained by adequate pruning. Indications are that the heavy pruned Red Delicious apple trees in the Michigan State College Horticultural Farm orchard were over pruned.

Adequate coverage and deposit are necessary to obtain commercial pest control. Deposit on foliage refers to the amount of material deposited on the leaf surfaces. One apple tree 20 feet high has approximately 3,200 square feet of leaf surface or about 2.2 acres of foliage per acre of orchard which means that it is difficult to obtain complete coverage even by careful

methods. The leaves from the dilute sprayed trees lacked thorough coverage on the lower side of the leaf, Figure 1. Trees sprayed with concentrate mixtures using airblast applicators were uniformly covered on both sides, Figures 2 through 7. It is believed that the leaf movement caused by the airblast is enough to give equal coverage of spray mixtures to both sides of the leaf.

In view of the type of spray coverage presented in Figure 1 it is evident that spray chemicals applied in dilute form by hydraulic sprayers are deposited in larger droplets than spray chemicals in concentrated mixtures applied by the airblast method. This is contrary to the findings of French (19) large droplets of spray material deposited on the surface of the fruit may interfere with the normal development of color which is undesirable. From observation of the harvested fruit it can be stated that fruit finish and color was more desirable from the trees sprayed with concentrate spray mixtures.

The speed at which a grower is able to cover an orchard with spray chemicals may often determine the degree of pest control. It is indicated by the rate of speed of the sprayer during the spraying process, 1.25 to 1.5 miles per hour for dilute applications and 2.0 to 2.5 miles per hour for concentrate applications, that

the time required to cover an orchard by concentrate methods is a little less than one-half that required to cover a similar orchard by dilute spraying.

Data presented in Table II reveals that almost twice as much lead was deposited on the tree receiving the 4 X concentrations as compared to the tree receiving the 2 X concentrations, indicating that perhaps the amount of active spray chemicals may be accurately controlled due to lack of runoff.

From the foregoing discussion and the data presented it should not be inferred that concentrate spray application will immediately change pest control measures. However it is believed that "concentrate sprays" will definitely fit into orchard management practices in the near future.

SUMMARY

1. During the growing season of 1950 a study was made to determine the value of pruning as a means of adapting apple trees for concentrate spray application by airblast type applicators. Leaf prints and quantitative analytical methods were used to determine the distribution and deposit of spray chemicals on leaves taken from different areas of light and heavily pruned large, bearing apple trees.

2. The effects of pruning on size, color, and yield of fruit was determined. The per cent of injury caused by apple scab and codling moth present on fruit harvested from light and heavily pruned apple trees sprayed with dilute and concentrate spray mixtures was also determined.

3. Prints were made of leaves selected randomly from various locations on light and heavily pruned large bearing apple trees to determine distribution and deposit of lead arsenate applied in both concentrate and dilute forms.

4. Under the conditions of this experiment, pruning reduced the yield of the Jonathan and McIntosh varieties; however, no reduction in yield was noted in the Red Delicious variety. Heavy pruning did not

increase or decrease the amount of red color of the fruit or increase the size of the fruit of any of the three varieties, when compared with the results from light pruning. Heavy pruning did aid in some instances to obtain a more satisfactory distribution of spray chemicals throughout the tree when applied in concentrate form. However, it was found that excessively heavy pruning was not necessary to accomplish satisfactory spray coverage with the concentrate applications included in this study.

5. Concentrate applications of 2 X, 4 X, 5 X, and 10 X using lead arsenate spray mixtures resulted in a more uniform coverage of the leaf surfaces than did hydraulic application of dilute spray mixtures of lead arsenate applied with a spray mast.

6. Concentrate sprays of lead arsenate applied with airblast applicators resulted in a greatly reduced droplet size, however the amount of spray chemical deposited was increased per square centimeter of leaf area in comparison to equal quantities of dilute lead arsenate spray applied by a hydraulic sprayer.

7. Spray concentrations of 10 X were applied in approximately 40 per cent of the time required to make dilute applications. This difference was due to the variation in the rate of travel of the spray equipment during the period of spraying.

8. The use of a spreader was found to be desirable in both the concentrated and dilute spray mixtures in applications made when the surface of the leaves are highly cutinized. The use of spreaders resulted in better distribution of the spray chemical and a heavier deposit of the spray chemical on the surface of the leaves.

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