EXPERIMENTS ON THE CONTROL OF *TETRANYCHUS BIMACULATUS* HARV. IN OKLAHOMA

EXPERIMENTS ON THE CONTROL OF TETRANYCHUS BIMACULATUS HARV. IN OKLAHOMA

by

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PREFACE

The spider mite Tetranychus bimaculatus Harv. has become of great economic importance to apple growers in Oklahoma and other states since the advent of DDT for the control of codling moths. It is commonly accepted that DDT will control the codling moth much more efficiently than arsenicals. It has been found that apple trees treated with DDT for codling moth control in Oklahoma almost without exception, experience heavy mite damage. The apple grower is now faced with the problem of finding an efficient mite control before he can safely use DDT against the codling moth.

With this situation in mind, a series of experiments were carried out during the 1946 season in an attempt to determine a means of controlling the spider mite and make possible the use of DDT in the orchard spray program in Oklahoma.

Indebtedness is acknowledged to Dr. F.A. Fenton, who assigned the writer this problem, to Dr. F. E. Whitehead for his valuable guidance and assistance, to the Department of Horticulture for the assistance of their staff members and the use of their apple orchard, to Dr. H. A. Waters, Dr. E. D. Witman and Dr. D. E. Howell for their constructive suggestions and criticisms, to Dr. C. H. Brett for the loan of laboratory equipment, and to Mr. R. R. Walton and Mr. Pinkston for their assistance in carrying out the experimental work for this project.

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INTRODUCTION

The spider mite is a small mite 0.4 to 0.6 mm in length, 0.25 to 0.3 mm in breadth, and 0.175 to 0.2 mm in thickness, broadly oval and broadest at a point in the anterior third of the body where the sides are somewhat swollen. This mite is pale orange or greenish yellow when young or without food, becoming more orange in color with food and age. The ajority of the specimens have a dark spot on each side due to food contents. The color varies widely between specimens, and some full fed adults may become entirely dark colored reaching a dark green or black.

The mites appear in apple orchards in Oklahoma in the early summer, usually in late June or early July, and feed first on leaves of new growth near the trunk of the trees. As the infestation increases, the population spreads over the entire tree. The mite pierces the leaf and sucks the sap causing the leaf to turn a dull bronze color. It is not uncommon for as many as 300 mites to be present on a single leaf, resulting in complete defoliation of the tree. This is accompanied by heavy fruit drop and damage to the fruit buds, thereby seriously reducing the yield of the tree the following year.

Research reported herein was conducted in the Horticulture orchard of the Oklahoma Agricultural Experiment Station, which is located approximately nine miles southeast of Stillwater, and the Department of Entomology orchard, which is located at Lake Carl Blackwell approximately

nine miles northwest of Stillwater. The Horticulture orchard included apple trees approximately 15 years of age, and the Department of Entomology orchard consisted entirely of the three-year-old trees. Preliminary research was conducted in the Department of Entomology laboratories on the Oklahoma A. & M. College campus.

This work was planned to obtain information on the toxicity of various chemicals to the spider mite and to determine the dosage and frequency of application of the various materials necessary to control the mite in the field under Oklahoma conditions.

These control experiments are preliminary in nature and should be considered as basic to further investigation.

The term "effective control" as used in this paper refers to the degree of control as computed by the use of "Abbott's formula".

The term "original infestation" is used in referring to the infestations just before treatments were applied.

Although the mite under consideration is known by several common names such as "red spider", "red spider mite", "red mite", and others, it is herein referred to as "spider mite" or "mite".

REVIEW OF LITERATURE

The spider mite Tetranychus bimaculatus, Harv. develops in large numbers on a wide variety of plants and attracted the attention of early workers as a pest difficult to control. A wide selection of chemicals and mixtures have been recommended, but none of them have been accepted as entirely satisfactory. In consideration of the literature related to the control of T. bimaculatus, the confusion of synonyms must be remembered, and the controls of certain other described species must be considered as applicable to T. bimaculatus until this taxonomic problem has been settled.

Morrison and Mote (1940) published a brief history in which they stated that Tetranychus telarius was first reported on the Pacific Coast in 1876, and Cook (1881) recommended one gallon of lye per gallon of water for its control.

Harvey described T. bimaculatus in 1892 and recommended Fir Tree oil, Cole's Insect Destroyer, and an alcoholic tincture of pyrethrum. Parker (1944) recommended flour paste (8-100) and lime sulfer (36 degree Baume, 1-100) as control measures.

Lovett (1923) recommended a 1.5 to 2.0 percent spray mixture consisting of concentrated lye, calcium caseinate and sulfur or a mixture consisting of two gallons of liquid lime sulfur, five pounds of dusting or sublimed sulfur and one-half pound of calcium caseinate in one hundred gallons of water for the control of the "common red spider".

with oil and sulfur sprays. They found oil sprays effective but causative of foliage injury. The lime sulfur, dusting sulfur, calcium caseinate combination previously recommended by Lovett was found most satisfactory.

Boyce et al (1939) found Dinitro-o-cyclohexylphenol more effective against T. telarius than against Paratetranychus citri in California in laboratory and field tests on citrus fruits.

Grayson (1940) found that the effectiveness of petroleum oil as a dormant spray against Paratetranychus pilosus C. and F. on apple in Virginia was slightly increased by the addition of dinitro-o-cyclohexylphenol when applied in March or April.

Morrison and Mote (1940) found dinitro-o-cyclohexylphenol far superior to rotenone-sodium lauryl sulfate, rotenone-sodium lauryl sulfate-lauryl thiocyanide, pyrethrum-hydrocarbon oils-acid insoluble ash, pyrethrum-acid insoluble ash, dusting sulfur-ortanic sulfur compound, and nicotine sulfate-hydrated lime-dusting sulfur combinations.

It is stated in the Fiftieth Annual Report of the Washington Agricultural Experiment Station by an anonymous author (1940) that dinitro-o-cyclohexylphenol caused severe injury to trees.

Smith (1942), in a discussion of cotton insects of California, mentioned T. bimaculatus Harv. as feeding on cotton and recommended field sanitation, sulfur dust, or dinitro-o-cyclohexylphenol as a control.

Huckett (1943) reported that T. bimaculatus damaged lima beans in Long Island, particularly in well drained fields near woodland or waste land. In experiments in 1942, sprays containing 12 pounds of wettable sulfur to 100 gallons of water, alone or with four pounds of cubé powder, and dusts of 50 percent sulfur alone or with ten percent cubé powder applied four times at 10 to 12 day intervals, beginning on June 25 proved extremely effective.

Proprietary compounds of dinitro-o-cyclohexylphenol gave satisfactory but variable results. Sprays and dusts containing cubé powder without sulfur were ineffective.

Borden (1944) found that Xanthone at the rate of 2 pounds to 100 gallons, following two arsenical sprays, apparently controlled codling moth and T. bimaculatus under California conditions. He cautioned against using the material in hot weather. He also found Dicyclohexylamine salt of Dinitro-o-cyclohexylphenol at the rate of one-third to one-half pound to 100 gallons of water applied at 4 to 6 week intervals satisfactory for the control of T. telarius. He found no injurious effects when used on alfalfa, wheat, corn, barley, oats, sorghum, lima beans, or peaches when used at the half-pound rate.

Hough (1946) found that DN-111 and DN-dry mix applied with DDT in the cover sprays gave good control of spider mites. Haring (1946) tested azobenzene dusts against the mites and found a 20 percent azobenzene dust in whiting or bentonite effective in laboratory and green house tests.

Comments on the increase in mite population resulting from the use of DDT were made by several investigators with widely divergent views.

- Harman (1945) found definite evidence that the mite population was not increased by the use of DDT in New York apple orchards. He found some bronzing of foliage "but the mite population was not high enough to have caused the damage". He attributed the bronzing to foliage injury by the DDT.

Dean (1946) found no increase in T. telarius on apple trees sprayed with DDT in New York. However, he cites one instance in which a heavy mite infestation did develop in a DDT-sprayed orchard.

Driggers (1946) reported that a great variety of insects were killed by DDT when peach trees in New Jersey were treated, but it appeared to have the opposite effect on orchard mites. A heavy build-up of mites followed the use of DDT during the three-year period.

Parencia et al (1946) tested DDT on cotton in Texas insects and found "in one experiment six applications of DDT caused marked increases in populations of the red spider, Tetranychus sp.".

Richardson (1946) in Iowa found that DDT treatment of apple trees gave a much better control of the codling moth than when a heavy lead arsenate spray schedule was followed by a terminal cover spray of DDT. He also reported no increase in mites in the DDT-sprayed plots. He did report some bronzing of foliage but attributed it to DDT injury.

TAXONOMIC STATUS

Harvey (11) first described this species of spider mite tentatively as Tetranychus 2-maculatus in 1892. He stated that it closely resembled in structure the Tetranychus telarius as described by Linnaeus (1761) but that it differed in host plants and habits sufficiently to doubt that they were of the same species.

Ewing (6) made a taxonomic study of the genus Tetranychus and published a paper in 1914, disagreeing with Harvey and insisting that there was not sufficient variation to separate Tetranychus telarius Linn. and Tetranychus 2-maculatus. He included T. cucumeris, T. rosarum, T. cinnabarinus, T. haematodes, and T. vitis, all European species described by Boisduval in 1867 in France as synonyms of T. telarius as well as T. gloveri Banks. He claimed that T. sexmaculatus Riley was separated from T. telarius only due to size and should be considered as a variety of T. telarius Linn. Ewing also objected to the common name "red spider" because "they are neither red nor spiders" and suggested the common name of "spider mite".

In 1942, McGregor (16) disagreed with Ewing in part, claiming that T. bimaculatus was properly named by Harvey and that the true species Tetranychus telarius Linn. does not occur in the United States. It is assumed by the author that McGregor considers the synonyms of T. telarius as listed by Ewing to be synonyms of T. bimaculatus Harv.

MATERIALS

The following is a list of the materials used in the tests discussed in this paper:

Azobenzene - 60 percent commercial dust prepared by Sherwin-Williams Company.

DMC - A 25 percent emulsion of Di (p-chlorophenyl) methyl carbinol with 23 percent emulsifying agent and 52 percent commercial solvent, obtained from Sherwin-Williams Company.

DN-111 - A commercial dust containing 20 percent dicyclohexylamine salt of Dinitro-o-cyclohexylphenol prepared and distributed by the Dow Chemical Company.

Hexachlorocyclohexane - A 50 percent wettable powder containing 10 percent of the active gamma isomer obtained from E. I. du Pont de Nemours and Company.

(Hydroxypentamethyl Flavan - 30 percent technical grade commercial dust prepared and distributed as a miticide by the E. I. du Pont de Nemours and Company.

PC-11 - This material is a 50 percent emulsion received from the Planetary Chemical Company. The sender has not divulged the formulation at the time of the writing of this paper.

Selocide - Eight percent potassium-ammonium-selenosulphide with 15 percent soap and 77 percent water.

Loro - A lauryl thiocyanate commercial product.

Sulfur - A commercial wettable sulfur.

Oil - Superla Summer Spray Oil produced by the Standard Oil Company (Indiana).

Lime Sulfur - Commercial liquid lime sulfur.

Lethane 420 - 100 percent active aliphatic thiocyanate manufactured by Rohm and Haas Company Inc.

METHODS AND TECHNIQUE

Various methods were used in carrying out the experiments. These may be described briefly as follows:

Preliminary dipping method - It was decided early in the spring of 1946 to make some laboratory tests of the materials available to determine which might possibly show some promise as miticides.

Dilutions were made by weighing out the desired amounts of insecticides and mixing them with 889 ml. of water in one-quart jars. These preparations were used in the dipping tests and stored in jars in paper cartons away from sunlight between series of tests.

Heavily infested leaves were selected from fully grown cotton and tomato plants in the college greenhouse. The leaves were cut from the plant and placed in paper bags and carried to the Entomology Building where the actual dipping was performed.

The infested leaves were dipped singly by holding them by the petiole and lowering them into the mixtures in the quart jars until they were completely immersed. They were withdrawn immediately, giving the leaf tips a maximum immersion period of four seconds. They were placed on folded paper towels to drain for approximately 30 seconds and then placed with the petioles in vials of water. The vials were placed on numbered sheets of paper towelling on a table in the laboratory. A minimum of two leaves were dipped in each material in each series, and more were used when the infesta-

tion appeared to be light. At least two leaves were dipped in water in each series to serve as checks.

After 24 hours, the leaves were removed from the vials, and the counts were made under a low power dissecting microscope. All counts were made by starting at the base of the midrib on the under side of the leaf and counting all mites that appeared in successive fields until the tip of the leaf was reached. The leaf was then shifted and moved back on a path parallel to the midrib. This procedure was followed on alternate sides of the midrib and on successive leaves of the same treatment until a total of 100 mites were observed. The total alive and dead were recorded.

Spraying Technique - In preparation for spraying, the desired quantities of insecticides were weighed in the laboratory and then taken to the field, the dry powders being carried in paper bags and the liquids in glass bottles. All field spraying was done with a 50-gallon Bean sprayer mounted on the back of a pick-up truck. A single nozzle spraygun with a number five disc was used, with a pressure of 350 pounds per square inch. The trees were sprayed with as much uniformity and thoroughness as they would receive in normal orchard spraying. After each application, the sprayer was thoroughly rinsed twice with clean water. During this procedure, the disc was removed from the spraygun to make a rapid release of pressure possible. The pressure was allowed to build up to the maximum and released to flush the spray residue from the expansion chamber in the pump. This procedure was repeated

several times.

It was found that approximately ten gallons of spray mixture were required to cover each tree in the Horticulture orchard. The trees were sprayed in pairs or groups of four, making 25 gallons and 50 gallons of spray mixture necessary to insure complete coverage. Because the trees in the Entomology orchard were smaller, only about one and one-half gallons were required for complete coverage. In treating these trees, the spray mixture was prepared in three-gallon lots in five-gallon water cans. The intake hose on the spray pump was inserted into the five-gallon can as was the return line extension hose; this took care of the overflow and furnished the necessary agitation. Otherwise, the same procedure was followed in both orchards in spraying the trees and cleaning the equipment.

Sampling Technique - All samples taken in the field tests consisted of 25 leaves from each tree. In the early tests, ten leaves were taken from new growth near the base of the trunk and from new growth near the center of the tree while the remaining 15 leaves were taken from terminal growth around the outside of the tree at a height of from 3 to 6 feet from the ground. Later in the season all of the leaves were taken from the outer margin of the tree in the same manner. All leaves were taken at random within the limitations set forth above. This latter method of gathering leaves was due to the apparent fact that early in the infestation there appeared to be a concentration of mites near the center of the tree;

later the mites became distributed throughout the tree, making outer margin sampling adequate. As a sample was picked, the leaves were placed in a paper bag for removal to the brushing station.

Brushing Technique - An apparatus for brushing samples was designed by the author and used throughout the field tests. This consisted of a turntable mounted on a 16-inch square stand 12 inches in height. The turntable was 15 inches in diameter and driven by a 24-volt D.C. motor mounted on the side of the stand. A three-eighths-inch pulley was mounted on the motor shaft, and the drive belt was fitted into a groove in the outer edge of the turntable giving a power ratio of approximately forty-seven to one. The motor was driven by a six-volt automobile battery very satisfactorily, as the motor used required but one and one-half amperes per hour for operation. A plastic cone three inches in diameter at the lower end, four inches at the top, and approximately six inches in height was mounted over the center and one-fourth inch above the surface of the turntable. This cone was mounted in a frame to make it easily removed for cleaning. Sampling papers four and one-half inches by five and one-half inches were numbered, coated with fresh varnish, centered under the cone, and fastened with common pins at each corner. The motor was then started and the mites were brushed from the sample leaves into the top of the cone through which they fell to the coated paper below. The brush used wa a three-fourths inch camel's-hair artist's

brush. After each 25-leaf sample was brushed, the paper was removed and a fresh paper placed in position on the turntable. The sample papers were printed with four segments of 10 degrees each centered at equal intervals around a point. These segments totaled 40 degrees or one-ninth of the area of the entire circle. The center point of the segments was centered on the turntable resulting in an even distribution of mites on the sample papers within a circular area marked off by the four segments. At the center of the circle, the segments became too narrow for accurate counting, so a small area was left open. This area was considered separately in making counts. As a series of samples were brushed, the sample papers were placed in a wooden box twelve inches long, five and one-half inches wide, and four inches deep with slots one-fourth inch deep at three-eighths-inch intervals on the inner surface. Two sample papers were placed in each slot back to back. This provided a satisfactory method for transporting the papers to the laboratory for counting.

Counting Technique - All counts were made within four hours of the time that the samples were brushed. The sample papers were taken to the laboratory and observed under a low power dissecting microscope. Counts were made of all living mites on the four marked segments and noted. The small open center area was then counted and noted. The total number of living mites on the four segments was then multiplied by nine, and the number found in the center area was added to give the to-

tal number of living mites on the paper - or the total brushed from the 25-leaf sample. Some difficulty was encountered in preliminary counting in determining a criterion for deciding if a mite were alive or dead. Body movement was an indication in most cases, but many mites were stuck to the varnish so securely that movement was nearly impossible, yet it was found that many of these immobile mites were actually alive. It was finally decided that all mites plump and not obviously dessicated would be considered as living.

PRELIMINARY DIPPING TESTS

- The preliminary dipping tests were designed to compare the toxicities of various miticides and develop a technique for handling and counting mites. This work was intended primarily as a source of information to be used in later field tests.

The materials included in the dipping tests were DN-111, hexachlorocyclohexane (666), Flavan, Selocide, sulfur, summer spray oil, lime sulfur, and Lethane 420. All concentrations used were recorded in weights or quantities of the active ingredients of the material as previously described under "List of Materials".

Results of the tests are shown in Tables I to V inclusive. Since the leaves were removed from the plants and could not be kept fresh sufficiently long, it was impracticable to test the residual effect of the materials used. As a result, these tests are not a complete comparison of the killing powers of the miticides. Several were too slow-acting to demonstrate their total toxicity within the 24-hour period observations.

A series of tests were made with DN-111 on both infested cotton and infested tomato leaves. A single series was run on cotton using DN-111 at the rate of 0.25 pounds per 100 gallons as recommended by the manufacturer and a 32 percent mortality was obtained. The higher rates were replicated four times on cotton and three on tomato as shown in Table I, on page 17.

TABLE I - Percent Mortality on Cotton and Tomato with DN-111.

	Cotton Series					Tomato Series			
Rate	1	2	3	4	Mean	1	2	3	Mean
.3 lbs/100 gal.	12	45	35	37	32.2		77	84	80.5
.4 lbs/100 gal.	35	56	32	44	41.7	75	89	82	82.
.5 lbs/100 gal.	15	71	36	33	38.7	93	87	76	85.3

DN-111 gave very poor results in the dipping tests at all concentrations from the recommended rate of 0.25 pounds per 100 gallons up to 0.5 pounds. This is the outstanding example of a material giving a poor kill in the dipping tests and showing much better results in field tests. This is no doubt explained by the slow action of the material on the mite and the high residual qualities of DN-111. It may be noted in Table I that the kills on tomato leaves were consistently higher than on cotton.

Lethane 420 was used at concentrations of one-half, and two pints per 100 gallons of water. Four replications were made with each strength on infested cotton leaves and three on tomato. Results of these tests are shown in Table II below.

TABLE II - Percent Mortality on Cotton and Tomato with Lethane 420.

	Cotton Series					Tomato Series			
Rate	1	2	3	4	Mean	1	2	3	Mean
1/2 pint/100 gal.	73	69	44	58	61.0	46	48	76	56.6
1 pint/100 gal.	86	68	37	84	68.7	61	71	91	74.3
2 pints/100 gal.	90	87	71	92	85.	91	97	97	95.

It is apparent in the above table that Lethane 420 does

give an effective kill at two pints per 100 gallons. However, this material was not used in the field tests because it has a tendency to burn foliage.

Flavan was tested at strengths of .33, .67, and 1.00 pounds to 100 gallons of water. Four replications of each strength were tested on infested cotton leaves, and three replications of each were made on tomato leaves. A single-replicate test was made on infested cotton, using 1.33 pounds of flavan in 100 gallons of water. Results of these tests are shown in Table III below.

TABLE III - Percent Mortality on Cotton and Tomato with Flavan.

	Cotton Series					Tomato Series			
Rate	1	2	3	4	Mean	1	2	3	Mean
.33 lbs/100 gal.	77	83	69	77	76.5	72	74	68	71.3
.67 lbs/100 gal.	95	83	70	95	85.75	81	41	83	68.3
1.00 lbs/100 gal.	87	93	83	96	89.75	99	59	62	73.3

Results from flavan were very erratic and did not show much promise in these tests. The 1.33 pound rate showed a 74 percent mortality, however, occasional high kills were obtained with as low as two pounds per 100 gallons concentration. It was decided to make further studies of this material in field test to determine if the material would have enough residual qualities to control the mites in the field over a long period of time.

Loro was included in a series of dipping tests in which this material was used at rates of one-fourth, one-half and three fourths pint per 100 gallons of water. Four replica-

tions were made on infested tomato leaves. In addition a single test was made using Loro at the rate of one pint in 100 gallons of water on infested cotton leaves. Results are shown in Table IV below.

TABLE IV - Percent Mortality on Cotton and Tomato with Loro.

	Cotton Series					Tomato Series			
Rate	1	2	3	4	Mean	1	2	3	Mean
1/4 pint/100 gal.	97	85	44	99	81.2	90	91	97	92.6
1/2 pint/100 gal.	99	97	83	96	93.7	100	99	97	99.3
3/4 pint/100 gal.	100	100	99	99	99.5	98	99	100	99.0

Loro gave extremely high kills at rates of one-half pint per 100 gallons or over and was fairly consistent in giving good kills at lower concentrations. A single test at one pint per 100 gallons gave a mortality of 98 percent. This material is not recommended for use on Jonathan trees due to its tendency to cause foliage injury. For this reason it was not included in the preliminary dipping tests.

Rates of 4.175, 8.375, 12.57, and 16.75 pounds per 100 gallons of water were used in the tests with four replications on cotton and three on tomato leaves. Results are shown in Table V.

TABLE V - Percent Mortality on Cotton and Tomato with 666.

Rate	Cotton Series 1	2	3	4	Mean	Tomato Series 1	2	3	Mean
4.174 lbs/100 gal.	94	76	81	80	82.7	53	86	76	71.6
8.375 lbs/100 gal.	93	94	52	99	84.5	65	82	90	79.0
12.57 lbs/100 gal.	94	98	83	99	93.5	82	83	97	87.3
16.75 lbs/100 gal.	98	97	93	100	97.0	94	95	98	95.6

Hexachlorocyclohexane (666) was one of the most promising materials tested as far as effective control was concerned. However, it will be noted in the preceding table that high concentrations of the material were necessary to obtain a uniformly high kill. It was felt that this material showed enough promise to continue the study in field tests.

A single series dipping test was carried out to obtain information on the miticide qualities of Selocide, sulfur, Superla Summer Spray Oil and lime sulfur. Infested cotton leaves were used in the test, and counts were made after 24 hours as in previous tests.

Selocide at .24 pounds per 100 gallons gave a lowkill with a 61 percent mortality. This material has another disadvantage in that it is a selenium compound and may be absorbed by the plant.

Sulfur was used at the rate of seven pounds per 100 gallons of water, and a kill of 28.5 percent was obtained. This does not agree with the recommendations of some workers who recommend sulfur sprays to control mites, but further tests were not considered because of the tendency of sulfur to

burn foliage.

Superla Summer Spray Oil was tested in a one percent concentration with excellent results. A mortality of 96 percent was obtained. This material was included in field tests as part of the cover spray until a warning was received that a combination of DDT and oil might result in severe damage to foliage

Lime sulfur gave a kill of 70 percent but was not continued because of the deleterious effect on foliage.

Infestation Control Tests

The infestation control tests were designed primarily to compare the effectiveness of the seven materials, Azobenzene, Hexachlorocyclohexane, DN-111, DMC, PC-11, Flavan and Summer Oil, in controlling an infestation of spider mites on apple trees after an infestation had become established. However, enough trees were available for additional test work and the tests were expanded to obtain an indication of the ability of DN-111 and Summer Oil to prevent the build-up of an infestation.

One experimental block of 68 trees was selected in the Horticulture orchard Southeast of Stillwater. This block consisted of rows 16, 17, 18, and 19 in the orchard. Each row included 17 trees approximately 15 years of age.

Rows 16 and 17 received a treatment of DDT at the rate of one pound to 100 gallons of water each time that a cover spray was applied to the remainder of the orchard. Row 16 had received DDT during the previous season.

Row 18 received three early cover sprays of DDT at the rate of one pound to 100 gallons of water plus one percent Superla Summer Spray Oil. On June 21 the oil was discontinued due to a warning received from the Bureau of Entomology and Plant Quarantine that a combination of oil and DDT was causing severe foliage injury at other stations and would not be recommended. The DDT applications were continued in each cover spray throughout the season.

Row 19 received six cover sprays of DDT at one pound plus DN-111 at 1.25 pounds per 100 gallons of water during the season.

Mites were first found in considerable numbers in this orchard on July 13. Counts were made on the four rows on that date and again on July 17 to determine if there had been any delaying of the infestation build-up due to the miticides used. The first count was made on all of the trees in each of the four rows. The second count was made on the four trees in each of rows 16, 17, and 19. By the time the second count was made, row 18 was being used in other tests and could not be included.

It was found that row 16, which had received treatments of DDT only during this and the previous season, had the heaviest infestation, with an average of 28.2 mites per leaf on July 13 and 23.5 mites per leaf on July 17.

Row 17, which had received DDT only during the current season, had an average infestation of 16.4 mites per leaf on July 13 and 29.0 mites per leaf on July 17.

Row 18, which received DDT and oil in three cover sprays before June 21, had an average infestation of 14.1 mites per leaf on July 13.

Row 19, which received a treatment of DDT and DN-111 in each cover spray throughout the season had the lowest average infestation with 3.3 mites per leaf on July 13 and 2.4 mites per leaf on July 17.

The above results indicate that DN-111 applied at the

rate of 1.25 pounds (0.25 pounds active ingredient) to 100 gallons of water controlled the infestation to a considerable degree. Observations made during the balance of the season tend to support the above data, since no signs of mite damage were observed in the DN-111-treated row during the entire season and since all of the trees in rows 16, 17, and 18 developed heavy infestations at some time during the season. Contrary to expectations, there was no chemical injury to the foliage observed in row 17 although some applications were made during extremely hot weather.

No data were taken to support the observation, but it was noticed that no heavily infested trees were found in row number 18 until considerably later than in rows 16 and 17. Row number 18 received three early treatments of summer oil, and it appears quite probable that this treatment did retard the development of a heavy infestation for some time.

Rows 16 and 17 were treated with DDT only througout the season, and both developed heavy infestations at about the same time. It must be noted, however, that row number 16 had received DDT during the season prior to the test and row number 17 had not. This may account for the fact that on July 13 the infestation in row number 16 was nearly twice that of row 17.

A second test block of 54 apple trees was selected in the Entomology orchard near Lake Blackwell, northwest of Stillwater. This orchard was treated with DDT at the rate of one pound to 100 gallons of water on May 6 and at inter-

vals of two weeks until August 3.

Infested trees were selected from the four-row test block in the Horticulture orchard and from the Entomology orchard for treatment with miticides to determine the effectiveness of the materials in controlling an infestation after it was established. This work was done in several series throughout the season as the infestations appeared. The treatment of each successive series was dependent upon the results indicated in a previous series. As a result changes in rates of application were made as indicated in later discussion. In the discussion of these tests, the rate of application of each treatment is expressed in pounds of active ingredient in 100 gallons of water.

In selecting trees to be treated in a series, counts were made on a greater number of trees than were needed in the test. A sufficient number for the series were then selected from those on which counts were made. These were selected to provide as nearly the same degree of infestation as possible. From this group of trees the check trees and treatments were selected at random.

Azobenzene - A total of six trees were treated with Azobenzene at strengths of one-half, one and two pounds per 100 gallons of spray mixture in this test. On July 13, one tree in the Perkins orchard was treated at the half pound strength. A second tree in the same orchard was treated with the same strength on July 18. Two trees in the Entomology orchard were treated at the one pound rate on July 18. It was soon obvious that the lower rates were not controlling the mites, and on July 25 two additional trees in the Horticulture orchard were treated at the two pound rate. Counts were made before treatment and at intervals following application as indicated in Table VI. Untreated infested trees were selected from both orchards, and counts were made at the same time that counts were made on the treated trees.

Azobenzene at the rate of one-half pound per 100 gallons gave a poor control. There was an effective control of 53.2 percent on the fourth day after treatment, but there was no effective control at any time other than on the fourth day recorded in this test. Furthermore, the 53.2 percent control recorded was due to an abrupt increase in the check counts rather than a reduction in mites on the treated trees.

At one pound per 100 gallons, this material showed no better control. Again, the only control recorded was on the fourth day with an effective control of 68.8 percent. However, this peak of control was due to both a drop in infestation counts on treated trees and an increase in population on the check trees.

At two pounds per 100 gallons, the control was somewhat

TABLE VI - Results of Infestation Control Tests with A zobenzene.

			Average Mites Per Leaf									
Days Following Treatment			2	4	6	8	10	15	20	27	34	35
	No. Trees	Before Treatment										
1/2 lb/100 gal.	2	31.2	32.05	29.9	41.2	93.1	108.5	96.7				
Check	2	42.25	32.3	86.5	47.4	123.1	72.6	57.0				
Percent Effective Control			0	53.2	0	0	0	0				
1 lb/100 gal.	2	9.6	6.15	2.9	8.5	6.55	13.1	40.4	66.6	51.46	114.0	131.3
Check	3	33.04	17.4	32.03	27.3	13.7	27.36	72.67	78.4	56.1	70.87	76.9
Percent Effective Control			0	68.8	0	0	0	0	0	0	0	0
2 lb/100 gal.	2	23.05	10.85	4.2	8.15	20.6	16.67	11.85	8.05	24.05		
Check	2	34.35	42.35	28.7	21.82	54.4	22.1	15.8	10.9	14.2		
Percent Effective Control			61.8	78.2	44.3	43.6	0	0	0	0		

better but still far from satisfactory. A 61.88 percent effective control was recorded on the second day, and this increased to 78.2 percent on the fourth day, followed by a steady decrease in control. On the tenth day and after, there was no longer any effective control.

Azobenzene at the tested rates failed to provide a control for the spider mites. All of the trees treated in the test showed considerable mite damage by the end of the test period. There were also indications of chemical injury on the trees treated at the two pound rate.

Hexachlorocyclohexane - This material was used on six trees at rates of one-half, one and two pounds per 100 gallons. One tree in the Horticulture orchard was treated at the one-half pound rate on July 13, and a second tree in the same orchard received the same treatment on July 18. Two trees were also treated in the Entomology orchard on July 18 at the one pound per 100 gallons rate. Two additional trees in the Horticulture orchard were treated at the two pound rate on July 25 when it became obvious that the lower rate in that orchard was not controlling the mites. Check trees were designated in both orchards. Counts were made and the results recorded as shown in Table VII.

Hexachlorocyclohexane, at the rate of one-half pound per 100 gallons, gave very little control throughout the entire period of this test. At the end of ten days the populations on the treated trees had increased to such proportions that treatment with another material was necessary to prevent severe damage to the trees.

At one pound per 100 gallons, the results appeared to be considerably better. A high percent of mortality was recorded on the second day after treatment, and the effective control remained high for six days. However, this degree of control declined rapidly and by the fifteenth day had decreased to zero.

The two pounds per 100 gallon treatments showed very poor results by comparison with those from the one pound rate. The highest effective control was recorded on the

TABLE VII - Results of Infestation Control Tests with Hexachlorocyclohexane.

			Average Mites Per Leaf									
Days Following Treatment			2	4	6	8	10	15	20	27	34	35
	No. Trees	Before Treatment										
1/2 lb/100 gal.	2	34.5	19.0	15.0	45.5	75.8	127.3					
Check	2	42.25	32.3	86.5	47.4	123.1	72.6					
Percent Effective Control			27.9	78.7	0	24.6	0					
1 lb/100 gal.	2	7.55	.18	1.46	.54	1.46	4.3	43.7	17.45	38.95	129.1	149.4
Check	3	33.04	17.4	32.03	27.3	13.7	27.67	72.67	78.4	56.1	70.87	76.9
Percent Effective Control			95.4	80.1	91.3	53.5	31.2	0	2.6	0	0	0
2 lb/100 gal.	2	41.35	33.15	22.0	21.7	44.4						
Check	2	34.35	42.35	28.7	21.8	54.4						
Percent Effective Control.			64.1	36.32	17.3	32.2						

second day after treatment with 64.1 percent. The effective control deteriorated rapidly after the second day and remained low for the remainder of the test. Both treated trees were retreated after eight days to prevent further damage to the trees.

The discrepancy in controls exhibited by the one pound and two pound rates may be explained by the fact that the population was low at the time of treatment with the one pound per 100 gallon rate, and there were probably very few eggs deposited on the tree. The vast number of eggs on the heavily infested trees treated at the two pound rate would probably hatch in large numbers during the two-day period before the first count after treatment was made. This would tend to overcome an equally high kill of live mites present at the time of treatment.

At best, this material was far from satisfactory at the rates tested. The best control was maintained for a period of six days, and the increase in mites after that time was so rapid that the tree would suffer mite damage between cover sprays including this material.

There were some signs of foliage injury on the trees treated at the two pound rate, but it was not definitely established that the spray material was responsible. The hot dry weather prevalent during the test period made positive interpretation impossible.

Hydroxy-pentamethyl Flavan - A total of six trees were used in tests of Flavan as a miticide. This material was used at one-half, one and two pounds per 100 gallons rates in the test. On July 13, one mite-infested tree was treated at the half-pound rate in the Horticulture orchard. Five days later, on July 18, a second tree in the same orchard was treated at the same rate. On July 18, two trees in the Entomology orchard were also treated at the one pound rate. By July 25, it was evident that the lower rates were not controlling the mite population, so two more trees in the Horticulture orchard were treated with the two pounds per 100 gallons mixture.

All of the trees treated with Flavan had a heavy infestation at the time of treatment, as did the check trees selected in both orchards for comparison. Results of this test are shown in Table VIII. It was found that Flavan was not a satisfactory control for spider mites at the rates tested. At the rate of one-half pound per 100 gallons, this miticide did not reduce the mite populations enough to prevent serious damage to the trees at any time during the test. The population increased on the treated trees during the first two days following treatment. The highest control was not reached until the eighth day when an effective control of 66.2 percent was recorded. This high control was largely caused by a rapid increase in population on the check trees rather than a decrease in treated mites. No control was shown after the eighth day.

At one pound per 100 gallons, no great increase in

TABLE VIII - Results of Infestation Control Tests with Flavan.

			Average Mites Per Leaf									
Days Following Treatment			2	4	6	8	10	15	20	27	34	35
	No. Trees	Before Treatment										
1/2 lb/100 gal.	2	44.25	73.9	40.6	43.5	43.5	98.5	93.2				
Check	2	42.25	32.3	86.5	47.4	123.1	72.6	57.0				
Percent Effective Control			0	55.2	12.4	66.2	0	0				
1 lb/100 gal.	2	52.65	7.8	20.4	17.7	9.75	25.45	64.2	107.5	89.9	81.64	81.45
Check	3	33.04	17.4	32.03	27.3	13.7	27.36	72.67	78.4	56.1	70.87	76.9
Percent Effective Control			71.9	60.1	59.3	55.4	0	44.5	0	0	0	0
2 lb/100 gal.	2	34.9	10.8	10.15	16.2	46.15	20.2	13.0	7.8	5.8		
Check	2	34.35	42.35	28.7	21.82	54.4	22.1	15.8				
Percent Effective Control			74.9	65.1	0	16.5	10.1	16.7				

Dates of treatment:
1/2 lb - July 13 and 18 - Horticulture Orchard
1 lb - July 18 - Entomology Orchard
2 lb - July 25 - Horticulture Orchard

control was observed. The highest effective control of 71.9 percent was recorded on the second day after treatment, and there was a gradual decrease in control until it reached zero on the tenth day. On the fifteenth day, a 44.5 percent was recorded, but this was the last observed in this test, and the mites had reached a level of heavy infestation at that time.

The results obtained with the two pound rate were not significantly better than with one pound. Again, the highest effective control was 74.9 on the second day after application with a rapid decrease in control following. After the fourth day, there was very little control shown.

PC-11 - Tests were made with PC-11 on six trees in the two orchards at one-half and one pound per 100 gallons strengths. One tree was treated on July 13 in the Horticulture orchard at the one-half pound rate, and a second tree was treated in the same orchard at the same rate on July 18. Two trees in the Entomology orchard were also treated on July 18, but the one pound per 100 gallons rate was used on these trees. On July 25, two additional trees in the Horticulture orchard received a treatment at the one pound rate. All of the treated trees had a well established infestation at the time of treatment. Comparable checks were selected from each orchard for comparison. Results are shown in Table IX.

It is readily observed in Table IX that PC-11 was not effective at the rates tested as a mite control.

At the one-half pound rate the highest effective control was 56.6 percent on the fourth day after treatment. By the sixth day, the mite population had surpassed the original count and the trees were suffereing severe damage.

The test of the one pound rate on four trees gave slightly better results, but the control shown was far from satisfactory. The kill was more rapid with the highest effective control of 79.7 percent appearing on the second day, but this degree of control decreased rapidly. The mite population began increasing after the second day and continued to increase throughout the test period of 35 days.

All of the test trees ended the test period with heavy mite populations accompanied by bronzing of leaves and severe defoliation.

TABLE IX - Results of Infestation Control Tests with PC-11.

			Average Mites Per Leaf									
Days Following Treatment			2	4	6	8	10	15	20	27	34	35
	No. Trees	Before Treatment										
1/2 lb/100 gal.	2	41.1	16.1	36.55	59.25	58.1	55.1					
Check	2	42.25	32.3	86.5	47.4	123.1	72.6					
Percent Effective Control			48.7	56.6	0	51.5	21.9					
1 lb/100 gal.	4	46.3	7.65	11.0	16.1	16.5	17.2	45.0	62.15	58.4		88.2
Check	5	33.62	27.38	30.69	23.10	29.9	25.25	49.63	8.74	39.3		76.9
Percent Effective Control			79.7	73.98	49.4	59.95	51.0	37.4	0	0		16.7

Dinitro-o-cyclohexylphenol - A total of six trees were treated with DN-111 at the rate of one-fourth pound of active ingredient per 100 gallons in this test. One tree in the Horticulture orchard was treated on July 13. A second tree in the same orchard was treated at the same rate on July 18. On the same date, two additional trees were treated in the Entomology orchard at the same rate. Two more trees in the Horticulture orchard were treated on July 25. Check trees were designated in both orchards at the time of treatments to compare with the treated trees. Results are shown in Table X.

It is readily seen in Table X that DN-111 was far superior to any of the materials previously discussed in this series of tests. The kill was rapid, as evidenced by the 96.7 percent effective control on the second day following treatment. The control increased to 99.1 percent on the fourth day, and a high degree of effective control was maintained for ten days. The decrease in control after that time was gradual, and the mite population was held to below a dangerous level for 27 days after treatments.

Observations made during the test show that there was very little bronzing of leaves by the mites at 51 days after treatment even though the population had increased to 94.1 mites per leaf before that time. Apparently the protection afforded the trees by the prevention of mite populations during the growing season made them more resistant to late season mite damage.

There was a slight appearance of spray injury on two

TABLE X - Results of Infestation Control Tests with DN-111.

		Average Mites Per Leaf						
Days Following Treatment		2	4	6	8	10	15	
	No. Trees / Before Treatment							
1/4 lb/100 gal.	6 / 33.8	1.02	.48	0.83	3.4	3.2	6.6	
Check	7 / 31.3	28.8	49.2	33.4	57.8	41.5	58 .1	
Percent Effective Control		96.7	99.1	97.75	94.5	92.8	89.5	

Days Following Treatment	20	27	34	35	37	44	51
1/4 lb/100 gal.	8.2	12.19	31.5	31.9	44.06	94.1	29.45
Check	61.5	45.6	70.9	76.9			
Percent Effective Control	87.6	75.2	58.8	61.6			

trees in the Horticulture orchard, but this was not severe enough to be considered serious. The temperature reached a point over 90 degrees Fahrenheit every day during the entire test period. This lack of foliage injury was contrary to the expected results, as the manufacturer has recommended that this material not be used if the temperature is expected to go above 90 degrees Fahrenheit in the 24-hour period after application. The low relative humidity during this period of high temperature may have prevented foliage injury in this case.

Di(p-chorophenyl)methyl Carbinol - A total of 19 trees were treated with DMC at rates of one-eighth, one-fourth, one-half, three-fourths, and one pound per 100 gallons of spray mixture. Applications were made as listed below:

TABLE XI - Applications of DMC.

Date	Number of Trees	Rate	Orchard
July 13	1	1/2 lb/100 gal.	Horticulture
July 18	1	1/2 lb/100 gal.	Horticulture
July 18	2	1/2 lb/100 gal.	Entomology
July 18	1	3/4 lb/100 gal.	Horticulture
July 25	2	1 lb/100 gal.	Horticulture
Aug. 3	4	1/8 lb/100 gal.	Horticulture
Aug. 3	4	1/4 lb/100 gal.	Horticulture
Aug. 3	4	1/2 lb/100 gal	Horticulture

Counts were made before treatment on all trees treated during July. However, the series treated on August 3 was not counted before applications were made. As a result, there are no means of computing the degree of effective control in the interpretation of data from this series.

DMC was the most successful material used as a control for mites of all of the miticides tested when used at rates of one-half pound per 100 gallons or above.

One-eighth pound per 100 gallons reduced the mite population to 9.75 mites per leaf on the fourth day after application, and the infestation did not show an increase until the fifteenth day when it reached an average of 13.65 mites per leaf. The check counts did not increase during this period,

TABLE XII - Results of Infestation Control Tests with DMC.

			Average Mites Per Leaf						
Days Following Treatment			2	4	6	8	10	15	
	No. Trees	Before Treatment							
1/8 lb/100 gal.	4			9.75			9.5	13.65	
Check	1			14.5			11.4	11.6	
1/4 lb/100 gal.	4			5.3			4.5	4.89	
Check	1			14.5			11.4	11.6	
1/2 lb/100 gal.	8	26.2	3.6	.63	.36	.44	.7	1.72	
Check	7	33.46	29.3	49.2	33.4	57.8	41.5	58.1	
Percent Effective Control			84.35	98.4	98.6	99.0	97.8	96.2	

Days Follwoing Treatment	20	27	34	35	37	44	51
1/8 lb/100 gal.							
Check							
1/5/100 gal.							
Check							
1/2 lb/100 gal.	2.9	4.6	10.4	11.5	8.5	3.1	8.5
Check	78.4	56.6	70.87	76.9			
Percent Effective Control	95.3	89.5	81.2	76.5			

so it is assumed that the degree of control was slight.

At the one-fourth pound rate the population was reduced to 5.3 mites on the fourth day, and no increase was noted after that time for the period of observations. Again, the check tree failed to show an increase, but the original infestation in the treated trees was observed to be heavy at the time of application, and the population was obviously reduced to a great extent by the treatment.

DMC, at the one-half pound rate, gave an excellent control of the mites. The effective control on the second day after treatment was 84.35 percent. The degree of control increased until it reached a 99 percent control on the eighth day. The control was maintained at over 90 percent until the twenty-seventh day when it began a gradual decline to 76.5 percent on the thirty-fifth day. At that time, the average infestation on the treated trees was 11.5 mites per leaf as compared to 76.9 mites per leaf on the check trees. The check tree counts were discontinued on the thirty-fifth day, but it may be noted in Table XII that infestation on treated trees did not increase above the 35-day level after that time. In the eight trees treated with DMC at that rate, the mites did not reach a dangerous level of infestation during the entire 51 days of observation after treatment.

At three-fourths pound per 100 gallons, this material was even more effective than at the one-half pound rate. The mite population showed no signs of recovery during 34 days of observation. During the first ten days after treatment, when

check trees were counted, the degree of effective control did not fall below 99.2 percent.

Tests at the rate of one pound per 100 gallons showed plainly that this was a higher concentration than was necessary to control the mites. Throughout the entire 27 days of observation, the degree of effective control remained at 94.5 percent or above. There were no signs of increase in population at the end of this test.

DMC at the rate of one-half pound or more per 100 gallons was shown to effectively control spider mites for a period of at least 51 days. At this rate no signs of population occurred in the test trees untilthe 27th day after treatment, and the infestation did not reach a dangerous level during the period of the test.

There were no indications of foliage injury in any of the DMC tests.

The finish of the fruit and leaves was far superior on the trees receiving DDT and DMC than on the trees treated with the conventional lead arsenate cover sprays.

Summer Spray Oil - Three trees were treated with a one percent oil mixture with soybean flour added as a "safener". All of the trees were located in the Entomology orchard and were treated on August 23. This test was initiated late in the season and was designed primarily to give some information upon which to base the use of oil in future experimental work. Results of the test are shown in Table XIII.

TABLE XIII - Results of Infestation Control Tests with Summer Oil.

		Average Mites per Leaf	
Days following Treatment		8	15
	No. Trees	Before Treat.	
1 Gal/100 Gal	3	90.3	4.6	.84
Check	3	106.3	71.1	18.7
Percent Effective Control			92	94.7

Summer Spray Oil was apparently very effective as a mite control for the 15-day period in which observations were made. The degrees of effective control on the eighth and fifteenth days after treatment were 92 percent and 94.7 percent respectively. It will be noted, however, that there was a rapid decrease in the infestation on the check trees during the same period making the data of doubtful value until further work is done with this material.

There were no signs of foliage injury following the use of this material during the 15-day observation period.

INFESTATION PREVENTION TESTS AND VARIETY COMPARISON

This experiment was designed to compare the abilities of Hexachlorocyclohexane, Flavan, DMC, and DN-111 at various strengths to prevent the establishment of an infestation in uninfested mature trees. In addition, this experiment was confined to equal numbers of Winesap and Jonathan trees to make it possible to observe any varietal differences that might occur.

Each treatment was made on one tree of each variety, and one of each variety was treated with DDT at one pound to 100 gallons of water to serve as checks.

The first application was made on June 21. DDT at the rate of one pound to 100 gallons of water was added to each treatment to supplant the arsenical cover spray applied to the remainder of the orchard on the same date. All of the treatments were repeated on July 3 at the time of the next cover spray. No additional applications were made for 28 days. After that time, the experiment was terminated. Results are shown in Table XIV.

Hydroxy pentamethyl Flavan - Two trees were treated with Flavan at the rate of one-half pound of active ingredient to 100 gallons of water. The first observation at 16 days after the last application showed an average population of 9.8 mites per leaf. At 20 days the population had increased to 13.3 mites per leaf, and at 28 days it had increased to 31.8 mites per leaf. The check trees had an infestation of 30.2, 29, and 53.8 mites per leaf on the sixteenth, twentieth,

TABLE XIV

Results of Prevention and Variety Test

Treatment	Variety	Mites Per Leaf July 19	July 23	July 31
DDT (Check)	Winesap	57.9	43.0	56.4
	Jonathan	2.5	15.1	51.2
Flavan 1/2 lb/100 gal.	Winesap	16.3	19.8	31.0
	Jonathan	3.2	6.8	32.5
Flavan 1/4 lb/100 gal.	Winesap	2.2	7.2	10.9
	Jonathan	4.3	9.0	39.8
Flavan 1/8 lb/100 gal.	Winesap	1.9	24.5	62.2
	Jonathan	3.4	5.8	31.8
DMC 1/2 lb/100 gal.	Winesap	0	.36	.36
	Jonathan	0	0.	0.
DMC 1/4 lb/100 gal.	Winesap	.36	0	1.1
	Jonathan	0	0	.36
DMC 1/8 lb/100 gal.	Winesap	.08	.36	2.9
	Jonathan	.36	0	1.8
DN-111 1/8 lb/100 gal.	Winesap	1.1	2.5	18.0
	Jonathan	0	1.1	2.2
666 1/2 lb/100 gal.	Winesap	23.9	30.2	55.8
	Jonathan	.72	.72	28.0
666 1/4 lb/100 gal.	Winesap	18.4	31.3	61.4
	Jonathan	5.1	18.4	28.8
666 1/8 lb/100 gal.	Winesap	7.2	18.4	141.5
	Jonathan	4.3	7.3	29.7

and twenty-eighth days respectively.

Two trees treated with the same material at one-fourth pound to 100 gallons of water apparently gave a somewhat better control. The population level on the sixteenth day was at 3.2 mites per leaf and increased to 8.1 and 25.3 mites per leaf on the twentieth and twenty-eighth days respectively.

The population was still lower in the two trees treated with Flavan at one-eighth pound of active ingredient to 100 gallons of water. The first count on the sixteenth day showed an average of 1.3 mites per leaf. This count increased to 15.1 mites per leaf on the twentieth day and 23.5 mites per leaf on the twenty-eighth day.

The author is unable to explain why the decreased dosages resulted in a higher degree of apparent control. It can only be pointed out that the best control was far from satisfactory.

Hexachlorocyclohexane - Two trees were treated with this material at the rate of one-half pound to 100 gallons of water. The first observation on the sixteenth day following treatment showed a strong infestation present on the trees with an average of 12.3 mites per leaf. This population built up to 15.5 mites per leaf on the twentieth day and 41.9 mites per leaf on the twenty-eighth day. The check trees showed an infestation of 30.2, 29, 53.8 mites per leaf on the same respective dates.

Two trees treated with the same material at one-fourth pound to 100 gallons of water showed a very similar trend in

population. The infestation on the sixteenth was 11.8 mites per leaf and increased to 24.8 mites per leaf on the twentieth day and 45.1 mites per leaf on the twenty-eighth. This increase was slightly more than with the half-pound treatment but not significantly different.

When treated at the rate of one-eighth pound to 100 gallons of water two trees showed even less control. The initial count on the sixteenth day did show a low count of 5.7 mites per leaf, but this population increased rapidly to 12.8 mites per leaf on the twentieth day following treatment and to 85.6 mites per leaf on the twenty-eighth day. This experiment indicated that low concentrations of hexachlorocyclohexane will not retard the increase in spider mite population over an extended period of time.

Dinitro-o-cyclohexylphenol - This material was used only on two trees at the rate of one-eighth pound of active ingredient to 100 gallons of water. The first count taken on the sixteenth day after treatment showed a negligible infestation of .54 mites per leaf. The second count on the twentieth day showed that the infestation was still being held down to 1.8 mites per leaf. The last count on the twenty-eighth day showed a weakening of control as the population had increased to 10.1 mites per leaf. The results of this test compare very closely to other tests with this material which indicate that the residual effect of DN-111 at this rate will last for about 20 days. There were no signs of foliage injury on these test trees.

Di(p-chlorophenyl)methyl Carbinol - Two trees were treated with DMC at the rate of one-half pound of active ingredient to 100 gallons of water. There were no mites present on the trees on the sixteenth day. On the twentieth and twenty-eighth days following application, there were .81 mites per leaf present, indicating almost complete control for a period of twenty-eight days.

Two trees were treated at the rate of one-fourth pound to 100 gallons with very similar results. The initial count showed an infestation of .18 mites per leaf at sixteen days after treatment. The infestation was at zero and..74 mites per leaf on the twentieth and twenty-eight days respectively.

Two trees treated with DMC at one-eighth pound to 100 gallons of water showed slightly poorer results. The infestation counts were .22, .18, and 2.3 mites per leaf on the sixteenth, twentieth, and twenty-eighth days respectively. In this case the control was not as complete as was found with higher concentrations, but the mite population was obviously held below the point of serious damage to the trees as compared to the check plot population counts of 30.2, 29, and 53.8 mites per leaf on the same respective dates.

This test indicates that low concentrations of DMC will prevent a population of spider mites from increasing to a dangerous level for at least 28 days when applied before the infestation appears.

Summary - When applied at the low concentration of one-eighth pound per 100 gallons of water before the infestation appear-

ed, DN-111 prevented a serious population increase of spider mites for a period of 28 days. DMC at the same rate also prevented a serious increase for at least twenty-eight days. Both Flavan and hexachlorocyclohexane showed a slight control at sixteen days but a rapid build-up thereafter. When used at the higher rates of one-fourth and one-half pound to 100 gallons, DMC gave a very effective control for 28 days, but Flavan and hexachlorocyclohexane failed to show control other than a slight tendency on the sixteenth day after application.

A comparison was made between the infestations counts on 22 Jonathan and Winesap apple trees in the Horticulture orchard. Eleven pairs of Jonathan and Winesap trees were selected before a mite population appeared, and the members of each pair were treated similarly throughout the season. Results are shown in Table XV below.

TABLE XV

Date	July 19		July 23		July 31	
Variety	Winesap	Jonathan	Winesap	Jonathan	Winesap	Jonathan
Mites per leaf	11.76	2.17	16.24	5.84	40.14	22.38

It is obvious in the above table that the Winesaps had a consistently higher population through the entire period in which counts were made. In the total of 33 pair-counts, there were only six instances in which the Jonathans had the higher infestation counts.

Detailed data on this test are recorded in Table XIV.

SUMMARY

The results of the tests observed during this season show that:

1. Neither Hexachlorocyclohexane nor Hydroxy pentamethyl Flavan at two pounds or less of active ingredient per 100 gallons will effectively control Tetranychus biraculatus Harv. on apple trees.

2. PC-11 will give very little control at a concentration of one-half pound of active ingredients per 100 gallons of spray material. At one pound per 100 gallons, the controls are variable and ineffective but show promise of better results at higher concentrations.

3. Dinitro-o-cyclohexylphenol will effectively control mites on apple trees for a period of approximately 20 days when applied at the rate of one-fourth pound per 100 gallons.

4. Di(p-chlorophenyl) methyl Carbinol will give an effective control of the mites for a period of approximately 30 days when applied at the rate of one-half pound or more of active ingredients per 100 gallons.

5. Di (p-chlorophenyl) methyl Carbinol at one-fourth pound per 100 gallons will give more variable results but is still superior to other materials used at the same rate.

6. Hexachlorocyclohexane, Dinitro-ocyclohexylphenol and hydroxypentamethyl Flavan may cause foliage injury when used at high concentrations on apple trees.

7. There is a variation in mite populations between varieties of apples. Of those tested, Winesaps have a consistently higher population in mid-season than Jonathan trees.

8. Dinitro-o-cyclohexylphenol, when included in all cover sprays with DDT at the rate of one-fourth pound of active ingredients per 100 gallons, will effectively control the mites for the entire season.

9. The spider mites can be prevented from building up a dangerous population on apple trees following DDT sprays by two applications of either Dinitro-o-cyclohexylphenol or di-(p-chlorophenyl)methyl Carbinol at the rate of one-eight pound of active ingredients per 100 gallons before the mites appear on the trees.

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APPENDIX

TABLE XVI - Results of Tests on Mature Trees

		Average Mites Per Leaf										
Days Following Treatment			2	4	6	8	10	15	20	27	34	35	37
Treatment	No. Trees	Before Treatment											
Azobenzene	14-18	48.0	15.1	12.1	54.2	93.1	108.5	96.7					
1/2 lb/100 gal.	6-16	14.4	49.0	47.8	38.2								
Azobenzene	6-16	38.2	16.6	4.4	9.8	28.8	25.3	17.6	10.7	36.9			
2 lb/100 gal.	13-17	7.9	5.1	4.0	6.5	12.4	8.0	6.1	5.35	11.2			
666	11-16	56.6	1.4	14.9	46.2	75.8	127.3						
1/2 lb/100 gal.	15-16	11.5	36.6	15.1	44.7								
666	15-16	40.7	15.1	19.4	14.5	44.0							
2 lb/100 gal.	11-16	42.0	51.2	24.6	28.9	44.8							
Flavan	5-18	74.7	12.6	15.9	24.7	43.5	98.5	93.2					
1/2 lb/100 gal.	5-17	13.8	135.3	65.3	62.3								
Flavan	5-17	62.2	14.4	15.2	23.8	63.6							
2 lb/100 gal.	13-16	7.6	7.2	5.1	8.6	28.7	20.2	13.0	7.8	5.8			
BC-11	7-16	53.7	5.0	24.1	26.8	58.1	55.1						
1/2 lb/100 gal.	10-17	28.5	27.2	49.0	91.7								
PC-11	7-16	43.9	21.7	6.2	7.6	22.3	16.7	21.5	28.3	36.9			
1 lb/100 gal.	10-17	91.7	6.1	20.6	19.4	25.4	29.1	47.0	56.4	1.2			

TABLE XVI - Results of Tests on Mature Trees (CONTINUED)

			Average Mites Per Leaf										
Days Following Treatment			2	4	6	8	10	15	20	27	34	35	37
Treatment	No. Trees	Before Treatment											
	11-17	48.0	.72	.72	.36	1.1	5.2	15.95	16.5	17.1	31.6	35.6	43.6
DN-111	12-16	35.3	0	.36	0	1.8	2.7	10.6	15.85	12.4	34.7		
1/4 lb/100 gal.	14-16	40.4	1.8	0	0	10.1	5.7	2.93	1.0	1.4			
	14-17	64.2	0	0	1.4	5.8	4.0	5.1	6.85	2.9			
DMC	9-16	27	4.3	72	1.4	0	1.4	1.4	88	.36			
1 lb/100 gal.	9-17	109.7	.72	2.5	2.9	5.04	3.4	2.0	.96	.36			
DMC	5-16	341.7	3.6	0	.72	1.5	2.3	2.2	1.1	.29	.36	.36	
3/4 lb/100 gal.													
	10-16	44.0	2.9	.36	0	1.4	.46	2.8	4.5	10.6	15.8	15.0	
	3-17	44.9	4.3	2.9	1.1	0	2.3	4.5	4.6	2.0	8.3		
DMC	3-16			.32			.1	.25					
1/2 lb/100 gal.	16-17			.72			.48	.88					
	15-16			.32			.47	1.72					
	11-16			.43			.87	.55					
	5-18			1.73			1.2	1.6					
DMC	4-18			6.8			7.8	5.16					
1/4 lb/100 gal	2-18			2.5			1.6	3.6					
	5-17			10.3			7.5	9.2					
	15-18			14.4			10.9	20.9					
DMC	14-18			2.0			5.5	8.8					
1/8 lb/100 gal	10-18			13.3			13.1	17.2					
	7-18			9.3			8.4	7.7					

TABLE XVI - Results of Tests on Mature Trees (CONTINUED)

		Average Mites Per Leaf										
Days Following Treatment		2	4	6	8	10	15	20	27	34	35	37
Treatment	No. Trees Before Treatment											
	3-16 51.7	21.0	32.8	30.4	182.5	98.4	57.0					
DDT	3-16 32.8	43.6	140.2	64.4	63.7	46.9						
(Check)	15-17 30.4	33.2	22.4	2.17	29.0	22.1	15.8	10.9	14.2			
	16-17 38.3	51.5	53.2	35.5	88.2							

TABLE XVII - Results of Tests on Immature Trees.

			Average Mites Per Leaf										
Days Following Treatment			2	4	6	8	10	15	20	27	34	35	37
Treatment	No. Trees	Before Treatment											
Azobenzene	9-4	11.2	4.3	4.3	8.4	9.5	15.7	31.9	45.4	48.13	115.2	131.7	
1 lb/100 gal.	9-1	8.0	8.0	1.5	8.6	3.6	10.5	48.9	87.9	54.8	112.9	131.0	
666	8-2	6.5	.36	.72	.36	2.2	6.7	26.8	24.0	54.3	170.1	195.8	
1 lb/100 gal.	8-4	8.6	0	2 .2	.72	.72	1.9	60.6	10.9	23.6	88.2	103.0	
Flavan	2-4	56.3	7.6	23.8	20.9	13.7	20.2	65.0	98.2	75.45	113.3	125.2	
1 lb/100 gal.	2-7	49.0	8.0	17.0	14.5	5.8	30.7	63.4	116.8	104.4	49.98	37.7	
PC-11	6-2	42.7	1.4	14.8	31.0	13.7	17.6	80.5	111.2	140.4	91.9	76.6	
1 lb/100 gal.	6-3	6.9	1.4	2.5	6.5	4.7	4.7	31.0	58.7	55.2	90.8	99.8	

TABLE XVII - Results of Tests on Immature Trees. (CONTINUED)

			Average Mites Per Leaf						
Days Following Treatment			2	4	6	8	10	15	
Treatment	**No. Trees**	**Before Treatment**							
DN-111	6-4	12.6	3.6	1.8	3.2	1.8	1.5	3.7	
1/4 lb/100 gal.	4-5	2.5	0	0	0	0	-	1.45	
DMC	6-5	8.8	0	0	.36	0	.48	2.1	
1/2 lb/100 gal.	6-7	7.2	0	0	0	.36	.6	.98	

Days Following Treatment	20	27	34	35	37	44	51
DN-111	5.8	28.8	36.0	35.4	59.6	144.7	16.3
1/4 lb/100 gal.	3.2	10.53	22.6	24.6	29.0	43.5	42.6
DMC	.36	1.65	5.1	5.8	5.4	1.8	2.2
1/2 lb/100 gal.	.36	4.4	12.3	13.8	11.7	4.3	14.8

TABLE XVII - Results to Tests on Immature Trees. (Continued)

			Average Mites Per Leaf									
Days Following Treatment			2	4	6	8	10	15	20	27	34	35
Treatment	No. Trees	Before Treatment										
Untreated	8-1	.72	4.8	22.7	31.4	8.0	12.2	46.8	57	33.3	72.6	84.9
	2-1	4.0	19.0	14.8	17.0	7.9	24.3	80.3	83.1	62.5	66.3	69.4
	2-2	61.4	28.5	58.5	33.5	25.2	45.6	90.9	95.1	72.6	73.7	76.4

Typist:

Mrs. Eleanor H. Moore