COMPARATIVE CHEMICAL OR MITICIDAL CONTROL OF THE TWO-SPOTTED SPIDER MITE, TETRANYCHUS BIMACULATUS HARVEY, ON SNAP (BUSH) BEANS

by

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INTRODUCTION

The two-spotted spider mite, Tetranychus bimaculatus Harvey, is considered a major economic pest. It feeds on a large number of varieties of plants, both cultivated and wild.

Its presence every year on different host plants in Kansas and the damage done by this pest in cedar tree plantings, deciduous orchards, garden crops, flower gardens, greenhouse plants, and numerous other crops of economic importance warrants a study of the chemical control of this species of phytophagous mite in Kansas.

There are five common species of Tetranychids known to occur in Kansas. They are as follows: the two-spotted spider mite, Tetranychus bimaculatus Harvey; the European red mite, Paratetranychus pilosus Can. and Fanz.; the brown clover mite, Bryobia praetiosa Koch; the brown wheat mite, Petrobia latens Muller; and a tetranychid mite (no common name), Paratetranychus pratensis Banks.

The most prevalent species at Manhattan, Kansas is the two-spotted spider mite. Other phytophagous mites which are not Tetranychids but are known to occur in Kansas, include the tulip bulb mite, Aceria tulipae Kieffer belonging to the family Eriophyidae, which is known to transmit wheat streak mosaic and the cyclamen mite, Tarsonemus pallidus Banks of the family Tarsonemidae.

The ever-increasing importance of injury caused by the two-spotted spider mite on numerous economic plants nearly every year in Kansas prompted a study of the chemical control of this pest as a thesis problem. This thesis is based on the control of the two-spotted spider mite infesting bush beans which were grown at Insectary No. 1 of the Department of Entomology,

Kansas State College, Manhattan, Kansas during the summer of 1953.

REVIEW OF LITERATURE

There was no published, comprehensive study of the two-spotted spider mite and other Tetranychids of Kansas. Considerable information on spider mites in Kansas was obtained by reviewing biennial reports published by the Kansas Horticultural Society and the annual insect population summary reports of Kansas from 1931 to 1948, which were published in the Journal of the Kansas Entomological Society and the Transactions of the Kansas Academy of Science.

Most of the literature concerning spider mites in Kansas pertained to outbreak and control problems. Smith (1932) in his first annual summary of injurious insects in Kansas for 1931 reported that the first outbreak of the brown clover mite occurred in Kansas in 1923. In 1931 severe damage to wheat was done by the brown clover mite in south central Kansas during April and May. Dean (1922) reported spider mites occurred most abundantly in regions where the climate is dry and was most troublesome in seasons of drought. He recommended the use of nicotine sulfate at one-half pint per 100 gallons of water plus two pounds of liquefied laundry soap as a spray for controlling spider mites.

Baker (1936) stated that during 1934 and 1935 spider mites were present in large numbers and caused serious damage in a number of apple orchards in northeastern Kansas and northwestern Missouri.

Parker (1944) reported successful results in the control of the two-spotted spider mite on peach and lima beans without injury to foliage, using

DN-111, a dinitro-o-cyclohexylphenol salt, at the rate of one-half pound to 100 gallons of water. Smith et al. (1947) reported the two-spotted spider mite severely infesting red cedars during the summer of 1946 throughout nearly all parts of the state. This pest was considered to be in outbreak numbers in 1946 and 1947 in apple orchards in northeastern Kansas. Parker and Eshbaugh (1947) obtained favorable results by use of a DDT mixture (16.66% DDT and 20% hydroxypentamethylflavan) prepared for spider mite control in tests on codling moth and mite control on apples in Kansas.

The published reports on the biology and control of two-spotted spider mite in other states were rather numerous. The results of several comprehensive studies on the biology and control of two-spotted spider mites and other phytophagous mites which were published are significant.

Ewing (1914) studied color variations in the common red spider, Tetranychus telarius L., by conducting feeding experiments. He reached the conclusion that yellows, greens, and brown coloration of mites were variations resulting from nutritional factors but orange and red shades were constant and would not change even after death. Ewing (1914) reported that an involved and extensive synonymy had accumulated for Tetranychus telarius L. McGregor (1942) reported that for many years the term "common red spider" had been applied to what had been believed to be the Linden mite, Tetranychus telarius L., which was not present in the United States. Actually, the so-called common red spider which occurs in this country is the two-spotted spider mite.

Cagle (1949) reported on studies of the life history of the two-spotted spider mite in Virginia. He observed that the time required for development from hatching to adult was five days for each sex and the longest life cycle

was 20 days for males and 59 days for females. He reared nine generations in 1946 and 10 generations in 1947 during his life history studies.

McGregor (1950) listed 13 genera of this family of mites in his excellent summary of the family Tetranychidae.

Neiswander et al. (1950) during the course of their investigations on the control of the two-spotted spider mites noted a marked variation in the general appearance of the individuals of a species and a wide discrepancy in their reaction to chemical treatments. They concluded that a mite population feeding on roses was usually more resistant than one on beans, to acaricide treatments.

Keh (1952) carried on mating experiments under laboratory conditions with the two-spotted spider mite complex by interbreeding males and females of Tetranychus multisetis McG. with Tetranychus bimaculatus Harvey on yellow sorrel, Oxalis corniculata. He found that the F_1 generation was readily produced from these crosses and in some cases succeeding generations were obtained.

Davis (1952) using a spider mite, Tetranychus multisetis McG., reared on the fruit of banana squash showed that dense population resulted in a lower egg production per female and a higher percentage of non-viable eggs, than occurred in a sparse population.

Davis (1952) also stated that the two-spotted spider mite, as is currently determined, is a complex of species or strains which differ from one another in color, host range, ability to cross breed, and some small morphological characters.

McGregor (1950) recommended the use of Berlese's fluid for preparing permanent slide mounts of spider mites for morphological studies. Pritchard

and Baker (1952) used Hoyer's medium as a practical mounting medium for spider mites.[1] Others have used polyvinyl alcohol and balsam with some success.

For many years sulfur dusts have been used against the two-spotted spider mites, but the results have been variable. External factors such as temperature and humidity have long been recognized by entomologists to affect the toxic action of sulfur.

Then came the use of DDT as an insecticide. Orchard mites, particularly the two-spotted spider mite, have developed into a pest of prime importance in deciduous orchards sprayed with DDT, because of the reduction of the population of mite predators in the orchards. Michelbacher et al. (1952) stated there was some evidence indicating that DDT also might alter factors in the environment in some physical or physiological manner favorable to the mite.

Koone and Lancaster (1952) obtained favorable results in controlling the two-spotted spider mite on cotton and watermelons by using Aramite (beta-chloroethyl beta-(p-tertiarybutylphenoxy)-alpha-methylethyl sulfite), Ovotran (p-chlorophenyl, p-chlorobenzene sulfonate), and R242 (p-chlorophenyl sulfone).

Borden and Madsen (1951) published results of the control of the brown clover mite, the European red mite, the two-spotted spider mite, and the Pacific mite, Tetranychus pacificus McG. on pears and apples. They found that several acaricides vary greatly in their toxicity to different species of mites under varying conditions.

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[1] Hoyer's medium consists of the following ingredients: 50 grams of distilled water, 30 grams of gum arabic, 200 grams of chloral hydrate, and 20 grams of glycerine.

Dowdy and Sleesman (1952) obtained good control of the two-spotted spider mite by using two systemics, namely Schradan (octamethyl pyrophosphoramide) and Systox (a systemic trialkyl thiophosphate). These systemics were applied as foliage sprays on egg plants at the rate of one pint and one and one-half pints per 100 gallons of water respectively.

Reynolds et al. (1952) obtained good control of Tetranychus multisetis McG. on snap (pole) beans using sulphenone (R242) and Aramite as dusts.

Siegler (1947) developed a leaf-disc technique for laboratory tests of miticides. A leaf is removed from the plant and a suitably infested area is placed on a cork cutting block and cut out by means of a short cork borer having a diameter of 0.87 inch. The leaf discs were immersed in a petri dish containing the test materials for about three seconds and removed for counts of living and dead mites.

Reynolds et al. (1952) made mite counts on leaves of snap (pole) beans, lima beans, cantaloupes, and watermelons by stamping a circular area (0.6 square inch) out of each leaf with a 7/8 inch diameter punch and counting the mites in that area. Approximately the same location in each leaf was stamped out in each of their experiments. This procedure was followed by the writer during the course of this work.

There have been other organic compounds tested by numerous workers in the field during the past 10 years. They included compounds such as Neotran, Genite 923, Vapotone, DN-111, and Dimite, which have proved successful in some tests and only partially successful in other tests.

REVIEW OF THE BIOLOGICAL FEATURES, CHARACTERS, AND MORPHOLOGY OF THE TWO-SPOTTED SPIDER MITE

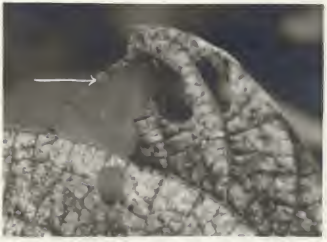
Seasonal Occurrence

In general, mites of the family Tetranychidae have been known to reach their peak in populations during late spring and summer. Severe infestations normally take place during July and August. This is especially true of the two-spotted spider mite. As a rule, the optimum conditions for rapid multiplication of this mite is high temperatures during periods of drought. Reports of observations have shown that under suitable conditions and presence of host plants, the two-spotted spider mite can live and reproduce all year long. This species over-winters as female adults in protected areas such as ground trash in regions where the winters are cold.

Feeding

Feeding injury by this mite results in distinctive stippling, discoloration, and eventual killing of the leaves on host plants. Generally, they feed, mate, oviposit, and colonize on the underside of the leaves of various host plants. McGregor (1950) stated that the feeding operation is accomplished by the mandibular stylets which puncture the tissues, and by the oral cavity which is located near the distal tip of the rostrum. The extraction of the chlorophyll by the mites causes the stippling effect on leaves.

A



B

Fig. 1. A - A severely infested bean leaf showing stippling and mite webbing on margins as indicated by arrow.

B - A mass of mites in webbing on a bean leaf as indicated by arrow.

Webbing

The characteristic webbing of plants can be observed in areas where severe infestations of this mite occur. The exact function of these webbings is not known, but it is probable that it is used primarily as a defense mechanism against predatory forms of mites and insects. The writer during the course of his work on the miticide control of the two-spotted spider mite in California noticed numerous predacious bugs (Triphleps insidiosus Say) not being able to penetrate the dense webbings of spider mites on heavily infested peach leaves. Generally the adults are the web spinners but Ewing (1914) noticed the deutonymph stage of the mites being capable of spinning webs also.

Coloration

The color variation in this species of mites and other mites of the family Tetranychidae have led to much confusion in their taxonomic identity and relationship. Variations in color within species are probably due to host plants, type of instars, and the time of the year in which they occur. Ewing (1914) and Cagle (1949) made some excellent studies on the color variations of the two-spotted spider mite.

Dispersion and Distribution

This mite disperses by crawling on the soil surface, as a result of the interlacing of branches, by wind, water, and numerous other mechanical means. It is distributed throughout the United States. It occurs also in parts of

Mexico, Canada, and the Hawaiian Islands.

Characters and Description

The spherical eggs of the two-spotted spider mite are clear when first deposited by the female on the host plant, but as embryonic development progresses, they become pale yellow. Prior to hatching, the purplish-red eyespots of the embryo are noticeable. They measure in size from about 0.13 mm to 0.15 mm in diameter.

The larva, when first hatched, is round, being about the size of the egg, and nearly colorless except for the eyes. At this stage, the larva has only six legs. The larva begins to show color changes from the time it begins feeding on the host. The colors vary from pale green to yellow and brownish green. The two distinct black spots on the abdomen appear at this stage, one on each side of the dorsal surface.

During the protonymph stage, the mites grow larger and a fourth pair of legs is developed. The two spots are more distinct than during the larval stage.

Cagle (1949) reported that the female mites measure about 0.42 mm long from the front of the cephalothorax to the tip of the abdomen, and about 0.27 mm in width at the widest point. Observations by other workers and confirmed by the writer indicates that the adult male mites are much smaller and more active than the female mites. The two large black spots are very pronounced in the adult stage on each side of the body and the body pigmentation varies from pale yellow to dark green and brownish green.

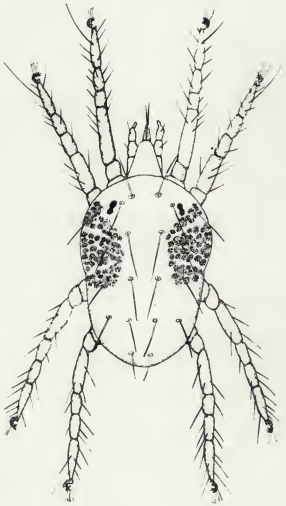


Fig. 2. The adult female of Tetranychus bimaculatus Harvey (after L. R. Cagle).

Morphology

The following is the description of the female and male two-spotted spider mites by McGregor (1950).

Female. - Color very variable, depending on food plant and season. Body from above, ovate-elliptic. Legs shorter than body to front of cephalothorax. Striations on dorsum of abdomen on a rhombic area between inner lumbales and sacrales setae transverse, striations laterad and behind this area mostly longitudinal. Thirteen pairs of dorsal body setae; these linear-lanceolate strongly developed, finely setose, not arising from tubercles. One perfect eye cornea each side. Mandibular plate with a slight emargination in front. Tarsus 1 bearing dorsally 2 sets of duplex setae, these well separated; 4 or 5 setae borne proximad of proximal pair of duplex setae. Onychial claw cleft deeply into 6 spinelike divisions, the proximal pair strongest basally. Last segment of palpus ("thumb") with its length about equal to its greatest thickness; the terminal sensilla averaging three-fourths again as long as thick; dorsal sensilla spindle-shaped, narrower but nearly as long as terminal "finger"; "thumb" bearing 5 additional setae, about as usual. Collar trachea U-shape, the inner arm usually shorter than main arm. Leg 1 with segments arranged in decreasing order of length as follows: Tarsus, femur, tibia, coxa, patella, trochanter. Eggs spherical, at first colorless. A rather copiously web-spinning species.

Male. - Much smaller than female, body from rhombic-sagittate. Forelegs about equalling length of body to front of cephalothorax. Palpus with second segment bearing dorsally a hornlike spur. Onychial claw of leg 1 stout, not strongly bent, with a straightish, narrow spur arising dorsally from mid-point, and the main claw cleft terminally into 6 short, dentate divisions. Aedeagus with inner lobe expanding abruptly dorsally to the basilar lobe which projects slightly backward as a sharply rounded point; shaft narrowing caudad, about two-thirds again as long as its greatest thickness, bent upward about 90° to form the hook; posterior projection of barb inconspicuous, at times seemingly lacking; anteriorly with a more noticeable acute projection.

OBSERVATIONS OF TWO-SPOTTED SPIDER MITE ON DIFFERENT HOST PLANTS AT MANHATTAN, KANSAS

During the month of September, 1952, a general survey of backyard gardens in the Manhattan area was made and it was interesting to note that beans of all varieties, from pole beans to bush beans were infested with the two-spotted spider mite.

A more extensive survey of different host plants of this species of mite was started by the writer early in the summer of 1953 at Manhattan. General field surveys in this area have shown that this species of mite thrives just as well on wild plants as it does on cultivated plants. Generally, plants with soft leaf tissues are favored by this mite. Under greenhouse conditions in Kansas, with favorable temperature and a wide range of cultivated host plants prevailing throughout the year make it very suitable for mite activity. Migrations of mites within the greenhouses usually start from the soil floor of the greenhouse where an abundant supply of yellow sorrel and barnyard grass serve as hosts before they disperse to the ornamentals and numerous other test plantings in the greenhouses.

A rather incomplete list of the numerous host plants infested with two-spotted spider mites upon which they were collected are given in Table 1.

The course of this problem being primarily on the two-spotted spider mite, no extensive survey of food plants of the other species of Tetranychids occurring at Manhattan, Kansas was undertaken.

Table 1. List of host plants from which various stages of two-spotted spider mites were collected at Manhattan, Kansas during September 1952 and June and July 1953.

Host plant	Plant location and use
Alfalfa	Hay crop
Barnyard grass	Greenhouse weed
Beans	Garden crop
Bindweed	Orchard weed
Brome grass	Orchard weed
Chrysanthemum	Greenhouse flower
Cucumber	Garden crop
Eggplant	Garden crop
Elderberry	Roadside
Elm	Shade tree
Field corn	Farm crop
Giant ragweed	Orchard weed
Henbit	Lawn weed
Johny-jump-ups	Flower garden
Jonathan apple	Orchard crop
Morning glory	Flower garden
Peaches	Garden crop
Pigweed	Orchard weed
Red cedar	Ornamental plant
Smilax	Greenhouse ornamental
Snapdragon	Flower garden
Sour dock	Orchard weed
Strawberry	Greenhouse
Tomato	Greenhouse
Verbena	Greenhouse
Vetch	Seed crop
Violets	Flower garden
Watermelon	Garden crop
Wheat	Farm crop
Wild oats	Orchard weed
Woodbine	Ornamental on buildings
Yellow sorrel	Greenhouse weed
Yellow sweetclover	Roadside

The brown clover mite was observed to be abundant during April and early May of 1953 on numerous wild and cultivated plants. Many of these mites were observed to be migrating during their period of peak populations especially into homes with basement rooms having windows near the ground level. The

European red mite, which was not common in the Manhattan area continued to be a problem in orchards in Doniphan County, Kansas. At the present time a considerable amount of work is being done on the biology and control of the brown wheat mite in southwest Kansas as a part of the investigations problem concerned with wheat pests.

MITICIDE CONTROL TESTS

Since the discovery of the "wonder insecticide", DDT, chemists have formulated many new organic compounds to control insects and mites. New organic compounds have been produced especially for the control of mites. The two-spotted spider mite has developed into a pest of prime importance in deciduous orchards and on other farm crops which have been sprayed with DDT. Mite populations often increase after DDT spraying of orchards. Wingo and Thomas (1948) reported that this increase in mite populations was caused by the reduction of the predators. Some of these new miticides were tested for the control of the two-spotted spider mite during the summer of 1953.

Materials and Procedures

Materials. The miticides used were Aramite-15 per cent wettable powder, Malathion-25 per cent wettable powder, Ovotran-50 per cent wettable powder, Chlorobenzilate-25 per cent wettable powder, Diazinon-25 per cent wettable powder, EPN 300-25 per cent wettable powder, and Malathion-57 per cent emulsifiable liquid. All sprayings were applied to the following varieties of bush beans: Wade, Burpee, and Green Stringless Pod. The concentrations of

the wettable powders used in these tests are shown in Tables 2 through 11 as pounds per 100 gallons of water. The test with the emulsion is shown in Table 12 as tablespoon per gallon of water.

Procedures. The general spraying procedure was the same for all the miticides used. An undetermined number of mites were transferred to bush beans to produce an infestation. The beans were grown in beds and earthenware pots. Due to the lack of plot space only four beds of beans were established, one untreated and three treated. The mites for infesting the uninfested test bean plants were obtained from leaves of field bindweed which were heavily infected with mites and from stock cultures reared on bush beans grown in wooden flats.

Mites were transferred from infested leaves to uninfested bean plants by using a two-inch-wide camel's hair brush. The mites were brushed from the underside of the infested leaves to the upper surface of the leaves of the test plants, but within a short time they migrated to the underside of the leaves, the preferred area, to start their feeding and reproductive cycles. The mites were introduced to the potted test plants when they had 10 to 12 fully expanded leaves. The same procedure was followed with the beans grown in beds. The miticides were applied when the stage of growth of the plants averaged 24 to 26 mature leaves per plant in order to have ample leaf samples and a high mite mount which can be obtained only by having a heavy uniform infestation of the plants.

A strip of one-half-inch-wide adhesive tape was rolled around the upper outside edge of each pot to prevent migration of mites from one potted test plant to another. A thin layer of tanglefoot was smeared on the tape to stop invasions by other crawling insects. All the test plants grown in pots were put under cages made from windowscreens. This method was followed to prevent

Fig. 3. One of the beds of bush beans used in the small plot treatments.

numerous other injurious insects from feeding on the bean leaves.

Each miticidal test consisted of six potted bean plants, unless indicated otherwise in the tables. The control pots also consisted of six potted plants, unless indicated otherwise in the tables. The test beds were two and one-half feet wide and seven and one-half feet long, consisting of 24 bean plants, two rows per bed.

Spraying. The miticides were applied as a spray by the use of a three-gallon pressure sprayer. The spray was applied at a distance of about one and one-half feet from the test plant to the point of the spray nozzle. The materials were applied as a fine mist to the plants to the point of dripping. A special shield was used while spraying each individual potted test plant to prevent any possible drift of the spray to other plants. In beds, a divider board, three by six feet was used to prevent drift of the spray to the neighboring beds.

Sampling. Sampling of bean leaves for population counts was done by punching out a circular disc, 0.6 of a square inch in area, from three leaves per potted test plant of six replicates in each miticidal test. A 7/8 inch diameter cork punch was used to punch out the discs by placing a piece of balsa under the leaf to be sampled and forcing the cork punch through the leaf to cut out the circular disc sample. All disc samples were obtained from the basal part of the bean leaf where mite populations were generally heaviest. Direct counts of the mites were made immediately under the microscope, with all living stages except the egg being counted.

Some difficulty was encountered in determining if the mites were dead. This was especially true of the mites which were in their quiescent stage, which precedes each molting period. This difficulty was overcome while in

EXPLANATION OF PLATE I

Leaf samples and sampling equipment.

Fig. 1. A leaf sample showing area from where disc cut out.

Fig. 2. A leaf disc sample, 0.6 of a square inch in area, used in population counts.

Fig. 3. A piece of balsa wood used for back support of leaf during stamping out of leaf disc.

Fig. 4. A 7/8 inch diameter cork punch used for stamping out disc.

PLATE I

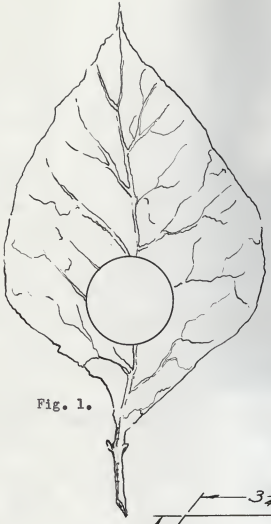


Fig. 1.

Fig. 2.

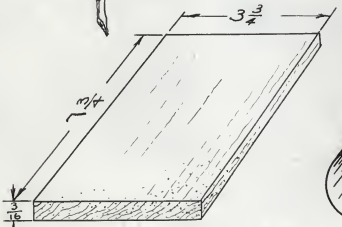


Fig. 3.

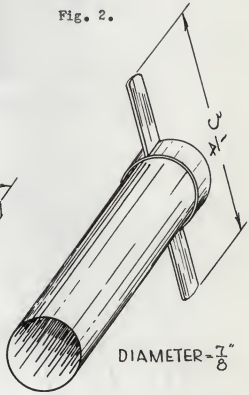


Fig. 4.

the quiescent stage by probing them with a dissecting needle and if they showed any signs of movement they were counted as live mites.

For the sampling of the test plots in beds, 10 leaves per bed were obtained from each sample date for population counts. Three circular discs, 0.6 of a square inch in area, were punched out from the basal, middle, and apical part of each leaf sample in these tests.

Experimental Results

Aramite-15 per cent W.P. Two series of experiments were conducted with the miticide Aramite-15W. Aramite is relatively non-toxic to a great many plants of economic importance. During the course of experiments with Aramite at the insectary, no injury was noted on bean plants sprayed with this chemical.

The first experiment with Aramite was made on the bean plants of the Green Stringless Pod variety of bush beans grown in beds. A single bed was treated with Aramite at the rate of two pounds per 100 gallons of water (9.1 grams or 0.3177 ounces per gallon of water) on August 5, 1953 at 2:15 P.M. The following afternoon after an interval of 24 hours, a survival count was made but the results showed a poor kill (Table 2). This was probably the result of the extremely heavy rainfall from 3:30 A.M. to 4:30 A.M. on August 6, 1953, resulting in the washing off of the spray deposit. The following morning, August 7, 1953, Aramite was applied at the same concentration and a large kill was obtained as compared to the prespray counts. There was no increase in the mite population up to the closing of this experiment on August 24, 1953. The treated plot showed 99.1 per cent control on the final sampling day and the untreated plot showed a great increase.

Table 2. The effect of 15 per cent w.p. aramite on two-spotted spider mites infesting beans grown in beds, which was applied at a rate of 2 lbs. per 100 gallons of water on August 5, 1953.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per leaf for 10 leaves											
	Date:	8/4	8/6		8/8[2]		8/11		8/16		8/24	
	Leaf No.:	Prespray	n.a.[1]	% s.[1]	n.a.	% s.	n.a.	% s.	n.a.	% s.	n.a.	% s.
Treated bed	1	105	84	80.0	0	0.0	0	0.0	0	0.0	3	2.9
	2	151	34	22.5	5	3.3	0	0.0	11	7.3	0	0.0
	3	161	186	115.5	2	1.2	0	0.0	4	2.5	0	0.0
	4	97	3	3.1	11	11.0	0	0.0	1	1.0	0	0.0
	5	158	11	6.9	0	0.0	2	1.3	0	0.0	0	0.0
	6	168	123	73.2	0	0.0	1	0.6	0	0.0	0	0.0
	7	138	65	47.1	5	3.6	0	0.0	0	0.0	2	1.4
	8	34	51	150.0	0	0.0	0	0.0	1	2.9	2	5.9
	9	80	115	143.8	0	0.0	0	0.0	0	0.0	3	3.8
	10	46	2	43.4	0	0.0	0	0.0	0	0.0	0	0.0
		1,138	674	59.2	23	2.0	3	0.3	17	1.5	10	0.9
Untreated bed	1 (8/5)	59	--	--	29	49.0	148	250.8	88	149.2	425	720.3
	2	55	--	--	86	156.4	71	129.1	74	134.5	252	458.2
	3	125	--	--	24	19.2	171	136.8	68	54.4	121	96.8
	4	204	--	--	64	31.4	36	17.6	25	12.3	47	23.5
	5	233	--	--	206	88.4	25	10.7	41	17.6	74	31.7
	6	230	--	--	34	14.8	17	7.4	102	44.4	48	20.8
	7	105	--	--	3	2.9	30	28.6	26	24.8	114	108.6
	8	164	--	--	222	135.4	10	6.1	65	39.6	101	61.6
	9	111	--	--	119	107.2	32	28.8	41	36.9	324	291.9
	10	65	--	--	34	52.3	35	53.8	71	109.3	200	307.7
		1,351	--	--	821	60.8	575	42.6	601	44.5	1,706	126.3

[1] n.a. equals number alive; % s. equals per cent survival.

[2] A second application was necessary following the excessive rainfall on August 6, 1953 and was applied on August 7, 1953.

EXPLANATION OF PLATE II

Fig. 1. A potted bean plant treated with Aramite-15W showing reduction of plant injury.

Fig. 2. An untreated potted bean plant showing severe damage by mites.

PLATE II

Fig. 1.

Fig. 2.

Table 3. The effect of aramite 15 per cent w.p. on two-spotted spider mites infesting beans grown in pots, which was applied on September 7, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times							
	Date:	9/6	9/8		9/11		9/16	
	Pot No.	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.
Treated pots	76A	160	67	41.9	1	0.6	5	3.1
	77A	88	20	22.6	0	0.0	23	26.1
	78A	82	78	95.1	1	1.2	0	0.0
	79A	141	29	20.6	13	9.2	18	12.8
	80A	184	29	15.8	9	4.8	40	21.7
	81A	195	68	34.9	8	4.1	5	2.6
		850	291	34.2	32	3.8	91	10.7
Untreated pots	94A	94	86	91.5	145	184.3	416	442.6
	95A	69	87	126.1	70	101.4	284	411.6
	96A	100	95	95.0	82	82.0	251	251.0
	97A	145	143	98.6	44	30.3	186	128.3
	98A	90	151	167.8	120	133.3	170	188.9
	99A	120	20	16.7	110	91.2	182	151.7
		618	582	94.2	571	92.4	1,489	240.9

[1] n.a. equals the number alive, and % s. equals the per cent survival.

The second experiment with Aramite was carried on in early September. The treatment was carried out on bush beans of the Wade variety grown in pots. The initial kill was low but as the days progressed, the long term residual value of the miticide was evident (Table 3). The final counts of the six untreated plants totalled 1,489 mites as compared to a total of 91 on the sprayed plants.

Malathion-25 per cent W.P. Two series of experiments were conducted with Malathion-25 per cent wettable powder (formerly called Malathon) on these mites infesting bush beans of the Green Stringless and Wade varieties. Chemically it is known as O, O-dimethyl dithiophosphate of diethyl mercapto-succinate. This miticide is an organic phosphate compound, allied to tetra-ethyl pyrophosphate and parathion (O, O-diethyl-O-p-nitrophenyl thio-phosphate). A slight case of phytotoxicity was noted on bush beans of the Green Stringless Pod variety which were sprayed with this wettable powder. A few leaves showed signs of yellowing which was thought to have been caused by the spray.

The first experiment with Malathion was conducted on the bean plants of the Green Stringless Pod variety grown in beds. This experiment coincided with the tests on Aramite and Ovotran. Malathion was applied on the afternoon of August 5, 1953 at a rate of two pounds per 100 gallons of water. The following day a 24-hour survival count was taken to note if a rapid kill of mites was obtained. Results showed a poor initial kill of mites in this treatment as was the case with Aramite on August 6, 1953 (Table 4). This was probably due to the spray deposits being washed off by the excessive rain on August 6, 1953. The following morning, August 7, 1953, the plot was sprayed again with Malathion at the same concentration. The 24-hour survival

Table 4. The effect of malathion 25 per cent w.p. applied as a spray for the control of two-spotted spider mites infesting beans grown in beds, which was applied at a rate of two pounds per 100 gallons of water on August 5, 1953.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per leaf for 10 leaves											
	Date:	8/4	8/6		8/8[2]		8/11		8/16		8/24	
	Leaf No.	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.	n.a.	% s.	n.a.	% s.
Treated bed	1	119	40	33.6	0	0.0	42	35.3	10	8.4	44	37.0
	2	166	53	31.9	0	0.0	46	27.7	10	6.0	250	150.6
	3	126	113	89.7	25	19.8	42	33.3	19	15.1	56	44.4
	4	204	71	34.8	0	0.0	24	11.8	32	15.7	442	216.6
	5	141	61	43.3	30	21.3	39	27.7	55	39.0	106	75.1
	6	160	10	6.3	1	0.6	14	8.8	58	36.3	128	80.0
	7	72	124	172.2	2	2.8	21	29.2	5	6.9	92	127.8
	8	284	28	9.9	14	4.9	18	6.2	18	6.3	128	45.1
	9	95	26	27.4	3	3.2	44	46.3	25	26.3	114	120.0
	10	134	151	112.7	13	9.7	28	20.1	17	12.7	115	85.8
		1,501	677	45.1	88	5.9	318	21.2	249	16.6	1,475	98.3
Untreated bed	1 (8/5)	59	---	---	29	49.0	148	250.8	88	149.2	425	720.3
	2	55	---	---	86	156.4	71	129.1	74	134.5	252	458.2
	3	125	---	---	24	19.2	171	136.8	68	54.4	121	96.8
	4	204	---	---	64	31.4	36	17.6	25	12.3	47	23.5
	5	233	---	---	206	88.4	25	10.7	41	17.6	74	31.7
	6	230	---	---	34	14.8	17	7.4	102	44.4	48	20.8
	7	105	---	---	3	2.9	30	28.6	26	24.8	114	108.6
	8	164	---	---	222	135.4	10	6.1	65	39.6	101	61.6
	9	111	---	---	119	107.2	32	28.8	41	36.9	324	291.9
	10	65	---	---	34	52.3	35	53.8	71	109.3	200	307.7
		1,351	---	---	821	60.8	575	42.6	601	44.5	1,706	126.3

[1] n.a. equals number alive, and % s. equals per cent survival.

[2] A second application was made on August 7, 1953 following the excessive rainfall on August 6, 1953.

Table 5. The effect of malathion 25 per cent w.p. on two-spotted spider mites infesting beans grown in pots, which was applied at a rate of two pounds per 100 gallons of water on August 13, 1953.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times[1]							
	Date:	8/12	8/14		8/17		8/22	
	Pot No.	Prespray	n.a.	% s.[2]	n.a.	% s.	n.a.	% s.
Treated pots	10A	116	0	0.0	74	63.8	19	16.4
	12A	119	2	1.7	10	8.4	7	5.9
	14A	85	0	0.0	20	23.5	8	9.4
		320	2	0.6	104	32.5	34	10.6
Untreated pots	16A	32	114	356.3	111	346.9	232	725.0
	17A	68	41	60.3	79	116.2	157	230.9
	9A	341	389	114.1	448	131.4	---	---
		441	544	123.3	638	144.7	389	88.2

[1] The treatment was replicated 3 times due to the fact that a sufficient amount of potted beans were not available to make 6 replicates of check pots so comparison of the treated and untreated pots were made on a basis of 3 replicates each.

[2] n.a. equals the number alive, and % s. equals per cent survival.

percentage after this application was 5.9. While making population counts on the leaf disc samples from the Malathion plot, it was noted that the majority of the mite eggs appeared viable. This was evident when the counts after three days showed a rapid increase in the number of live mites. They were mostly in the larval stages, and must have hatched after the treatment was applied. As the season progressed, a rapid increase in mites was noted in this plot which continued up to closing of the experiment on August 24, 1953. The final counts totalled 1,475 mites in the treated plot and a total of 1,706 in the untreated bed.

The second experiment with Malathion was done on bush beans of the Wade variety grown in pots. This treatment showed an excellent initial kill but there was a population increase four days after the application was made (Table 5). There was a slight decrease in the mite population nine days after the application.

Ovotran-50 per cent W.P. Three series of experiments were conducted with Ovotran on bush beans of the Green Stringless Pod variety grown in beds. This coincided with the treatments mentioned in Tables 2 and 4 respectively. Ovotran was applied on the afternoon of August 5, 1953 at a rate of two pounds per 100 gallons of water. After a 24-hour period, a survival count was taken. The counts showed a poor kill of mites by this treatment probably the result of spray deposits being washed off by the excessive rain on August 6, 1953. This plot was sprayed again on the morning of August 7, 1953 with Ovotran at the same rate of application. Another count was taken after 24 hours and a fair control was obtained. It was noted that the majority of the eggs appeared non-viable. Many of the adults, after being exposed to the spray residue for 24 hours, showed some activity. Three more counts were made in this

plot as the season progressed, and it was of interest to note that the live mite population and the live mites counted were mostly in the adult stage. This was obvious proof that Ovotran had definite ovicidal effect on the eggs of the two-spotted spider mite. The final counts totalled two mites in the treated plot and 1,706 in the untreated plot (Table 6).

The second experiment which was carried on with Ovotran was conducted during the latter part of August 1953, gave unsatisfactory results in the control of the mites infesting bush beans of the Wade variety planted in pots. The results from this treatment proved that the test was unsatisfactory when compared to the excellent control obtained in the first and third experiments with this material (Table 7). The final counts totalled 287 mites in the six treated pots as to a count of 2,514 in the untreated pots.

The third experiment with Ovotran on bush beans of the Burpee variety infested with these mites was conducted during the first week in September. This treatment gave excellent control. The initial kill was not rapid but a gradual decline in mite populations occurred as compared to the rapid increase in the mite populations in the untreated pots (Table 8). The final counts totalled 34 mites in the six treated pots and 1,489 in the untreated pots.

Chlorobenzilate-25 per cent W.P. A single experiment was carried on with Chlorobenzilate, 25 per cent wettable powder (formerly called Geigy 338). Chemically this material is known as 2-hydroxy-2,2-bis (4-chlorophenyl) ethyl acetate.

Chlorobenzilate was applied on bush beans of the Burpee variety. The test plants were examined on three different sampling dates after the application of the material on September 7, 1953. This miticide showed some residual value during the nine days that this experiment was in progress (Table 9).

Table 6. The effect of ovotran 50 per cent w.p. on two-spotted spider mites infesting beans grown in beds, which was applied on August 5, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per leaf for 10 leaves											
	Date:	8/4	8/6		8/8[2]		8/11		8/16		8/24	
	Leaf No.:	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.	n.a.	% s.	n.a.	% s.
Treated bed	1	174	203	116.7	76	43.7	13	7.5	3	1.7	0	0.0
	2	135	106	78.5	6	4.4	7	5.2	3	2.2	1	0.6
	3	240	38	15.8	21	8.8	2	0.8	0	0.0	0	0.0
	4	133	78	58.6	27	20.3	20	15.0	0	0.0	0	0.0
	5	174	116	66.7	1	0.6	2	1.1	3	1.7	1	0.6
	6	134	83	61.9	12	8.9	0	0.0	3	2.2	0	0.0
	7	68	14	20.6	25	36.8	0	0.0	1	1.5	0	0.0
	8	413	85	20.6	36	8.7	1	0.2	1	0.2	0	0.0
	9	272	59	21.7	3	1.1	1	0.4	0	0.0	0	0.0
	10	118	67	56.8	21	17.8	6	5.1	0	0.0	0	0.0
		1,861	849	45.6	228	12.3	52	2.8	14	0.8	2	0.1
Untreated bed	1	(8/5) 59	—	—	29	49.0	148	250.8	88	149.2	425	720.3
	2	55	—	—	86	156.4	71	129.1	74	134.5	252	458.2
	3	125	—	—	24	19.2	171	136.8	68	54.4	121	96.2
	4	204	—	—	64	31.4	36	17.6	25	12.3	47	23.5
	5	233	—	—	206	88.4	25	10.7	41	17.6	74	31.7
	6	230	—	—	34	14.8	17	7.4	102	44.4	48	20.8
	7	105	—	—	3	2.9	30	28.6	26	24.8	114	108.6
	8	164	—	—	222	135.4	10	6.1	65	39.6	101	61.6
	9	111	—	—	119	107.2	32	28.8	41	36.9	324	291.9
	10	65	—	—	34	52.3	35	53.8	71	109.3	200	307.7
		1,351	—	—	821	60.8	575	42.6	601	44.5	1,706	126.3

[1] n.a. equals number alive, and % s. equals per cent survival.

[2] A second application was made on August 7, 1953 following the excessive rainfall on August 6, 1953.

Table 7. The effect of ovotran 50 per cent w.p. on two-spotted spider mites infesting beans grown in pots, which was applied on August 21, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times.								
	Date:	8/20	8/22			8/25		8/22	
	Pot No.	Prespray	n.a.	% s.[1]		n.a.	% s.	n.a.	% s.
Treated pots	52A	65	89	136.9		85	130.8	38	58.5
	53A	63	64	101.6		12	19.0	67	106.3
	54A	44	50	113.6		14	31.8	17	38.6
	55A	55	32	91.4		19	54.3	75	214.3
	56A	64	37	57.8		40	62.5	8	125.0
	57A	80	49	61.3		28	35.0	82	102.5
		351	321	91.5		198	56.4	287	81.8
Untreated pots	7C	71	110	154.9		84	118.3	323	454.9
	8C	77	79	102.6		203	263.6	616	800.0
	9C	62	77	124.2		89	143.5	246	396.8
	10C	70	86	122.9		46	65.7	532	760.0
	11C	53	53	100.0		40	75.5	299	564.2
	12C	29	81	279.3		113	389.7	498	1717.2
		362	486	134.3		575	158.8	2,514	694.5

[1] n.a. equals number alive, and % s. equals per cent survival.

Table 8. The effect of ovotran 50 per cent w.p. on two-spotted spider mites infesting beans grown in pots, which was applied on September 7, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times.								
	Date:	9/6	9/8		9/11		9/16	
	Pot No.	Prespray	n.a.	% s.	n.a.	% s.	n.a.	% s.
Treated pots	88A	127	99	78.0	14	11.0	4	3.1
	89A	111	59	53.2	0	0.0	3	2.7
	90A	76	44	57.9	10	13.2	6	7.9
	91A	42	38	90.5	14	33.3	0	0.0
	92A	115	60	52.2	3	2.6	1	0.8
	93A	105	35	33.3	7	5.7	20	19.0
		576	335	58.2	48	8.3	34	5.9
Untreated pots	94A	94	86	91.5	145	154.3	416	442.6
	95A	69	87	126.1	70	101.4	284	411.6
	96A	100	95	95.0	82	82.0	251	251.0
	97A	145	143	98.6	44	30.3	186	128.3
	98A	90	151	167.8	120	133.3	170	188.9
	99A	120	20	16.7	110	91.7	182	151.7
		618	582	94.2	571	92.4	1,489	240.9

[1] n.a. equals number alive, and % s. equals per cent survival.

Table 9. The effect of chlorobenzilate 25 per cent w.p. on two-spotted spider mites infesting beans in pots, which was applied on September 7, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times.							
	Date:	9/6	9/8		9/11		9/16	
	Pot No.	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.
Treated pots	82A	101	4	4.0	0	0.0	3	3.0
	83A	78	13	16.7	0	0.0	30	38.5
	84A	107	54	50.5	4	3.7	18	16.8
	85A	104	11	10.6	3	2.9	0	0.0
	86A	89	1	1.1	2	2.2	20	22.5
	87A	98	9	9.2	2	2.0	13	13.3
		577	92	15.9	11	19.1	84	14.6
Untreated pots	94A	94	86	91.5	145	154.3	416	442.6
	95A	69	87	126.1	70	101.4	284	411.6
	96A	100	95	95.0	82	82.0	251	251.0
	97A	145	143	98.6	44	30.3	186	128.3
	98A	90	151	167.8	120	133.3	170	188.9
	99A	120	20	16.7	110	91.7	182	151.7
		618	582	94.2	571	92.4	1,489	240.9

[1] n.a. equals number alive, and % s. equals per cent survival.

Diazinon-25 per cent W.P. Diazinon is a new phosphate compound which has been used experimentally as a control measure against house flies and has shown promise in laboratory and field tests. Diazinon is O, O-diethyl-O-(2-isopropyl-4-methyl-pyrimidyl (6) thiophosphate).

A single experiment was conducted with this material as a miticide to control this mite, infesting pot bed bush bean plants of the Burpee variety. This material was formulated as a 25 per cent wettable powder and was applied at the rate of two pounds per 100 gallons of water. The initial kill was excellent in this test but nine days after the application of the spray material, an increase in mite population was noted as shown by the results in Table 10. This material may have given a rapid reduction of adult mites but did not affect the mite eggs to any observable extent.

EPN 300. This wettable powder is designated "EPN 300 Insecticide". It contains 25 per cent p-nitrophenyl thionobenzenephosphate. A single experiment was carried on using EPN 300 as a miticide and the results from this test showed it to be unsatisfactory in the control of this mite infesting bush beans of the Wade variety grown in pots (Table 11).

Malathion-57 per cent E.L. This emulsifiable liquid was applied on August 13, 1953 at a rate of one tablespoon (14.7 ml) per gallon of water or 3.1 pints per 100 gallons of water on bush beans of the Wade variety grown in pots. The emulsion gave a fair degree of control as the counts show in Table 12.

Table 10. The effect of diazinon 25-W on two-spotted spider mites infesting beans grown in pots, which was applied on September 8, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times.							
	Date:	9/7	9/9		9/12		9/17	
	Pot No.	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.
Treated pots	100A	49	0	0.0	1	2.0	87	177.6
	101A	73	0	0.0	12	16.4	110	150.7
	102A	124	0	0.0	4	3.2	2	1.6
	103A	161	0	0.0	18	11.2	24	14.9
	104A	122	0	0.0	11	9.0	106	86.9
	105A	201	0	0.0	0	0.0	27	13.4
		730	0	0.0	46	6.3	356	48.8
Untreated pots	106A	53	224	442.6	103	194.3	83	156.6
	107A	145	182	125.5	92	63.4	110	75.9
	108A	82	162	197.6	102	124.4	45	54.9
	109A	24	74	308.4	91	379.2	44	183.3
	110A	189	197	104.2	190	100.5	129	68.3
	111A	63	171	271.4	96	152.4	98	155.6
		556	1,010	181.7	674	121.2	509	91.5

[1] n.a. equals number alive, % s. equals per cent survival.

Table 11. The effect of EPN 300 on two-spotted spider mites infesting beans grown in pots, which was applied on August 21, 1953 at a rate of two pounds per 100 gallons of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times							
	Date:	8/20	8/22		8/25		8/30	
	Pot No.	Prespray	n.a.	% s.[1]	n.a.	% s.	n.a.	% s.
Treated pots	58A	54	35	64.8	22	40.7	177	327.7
	59A	34	8	23.5	12	35.3	63	185.3
	60A	102	87	85.3	30	29.4	76	74.5
	61A	30	3	10.0	8	26.7	25	83.3
	62A	37	5	13.5	21	56.8	36	97.3
	63A	44	26	59.1	104	236.6	9	20.5
		301	164	54.5	197	65.4	386	128.2
Untreated pots	7C	71	110	154.9	84	118.3	323	454.9
	8C	77	79	103.6	203	263.4	616	800.0
	9C	62	77	124.2	89	143.5	246	396.7
	10C	70	86	122.9	46	65.7	532	760.0
	11C	53	53	100.0	40	75.5	299	564.2
	12C	29	81	279.2	113	389.7	498	1717.2
		362	486	134.3	575	158.8	2,514	694.5

[1] n.a. equals number alive, % s. equals per cent alive.

Table 12. The effect of malathion 57 per cent emulsifiable liquid on two-spotted spider mites infesting beans grown in pots, which was applied on August 13, 1953 at a rate of one tablespoon per gallon of water.

Treatment	Sampling dates, live mite counts, and per cent survival per 3 standardized leaf disc samples per 3 leaves per plant replicated 6 times.[1]								
	Date:	8/12	8/14		8/17		8/22	
	Pot No.	Prespray	n.a.	% s.[2]	n.a.	% s.	n.a.	% s.
Treated pots	18A	133	27	20.3	43	33.0	16	12.0
	20A	85	2	2.4	0	0.0	21	24.7
	22A	139	0	0.0	0	0.0	11	10.8
		357	29	8.1	43	12.0	48	13.4
Untreated pots	16A	32	114	356.3	111	346.9	232	725.0
	17A	68	41	60.3	79	116.2	157	230.9
	9A	341	389	114.1	448	131.4	--	--
		441	544	123.3	638	144.7	389	88.2

[1] The treatment was replicated 3 times due to the fact that a sufficient number of potted bean plants were not available to make 6 replicates of check pots, so, a comparison of the treated and untreated pots were made on a basis of 3 replicates each.

[2] n.a. equals number alive, % s. equals per cent survival.

DISCUSSION

Effective control of the two-spotted spider mite and other phytophagous mites of the family Tetranychidae is made rather difficult by the variation in toxicity of miticides to different species of mites under varying conditions. This is evident in the State of Kansas according to unpublished reports and statements made by entomologists. The two-spotted spider mite, for example, is not now effectively controlled by Parathion under greenhouse and orchard conditions in eastern Kansas. While in western Kansas entomologists report that Parathion gives indications of being the best miticide, up to the present date, in the control of the brown wheat mite, Petrobia latens Muller.

The tests conducted at the insectary during the summer of 1953 on the control of the two-spotted spider mite on bush beans with several miticides showed some indications, that in the use of miticides, there was a variation in control results by chemicals under Manhattan, Kansas conditions. Aramite and Ovotran were the most effective miticides in controlling this mite under small field plot conditions. All the miticides, in wettable powder form, were applied at the rate of two pounds (9.1 grams or 0.3177 ounce per gallon) per 100 gallons of water. As indicated in Table 2, Aramite reduced the percentage survival to 0.9 per cent which is 99.1 per cent control over a period of 19 days as compared to the rapid increase in mite population in the untreated plot. In Table 6, results show that where Ovotran was used the survival of mites was reduced to 0.1 per cent or 99.9 per cent control over a period of 19 days.

Malathion, which was also tested under small field plot conditions did

not equal the effectiveness of Aramite and Ovotran. Malathion applied at the same rate of application as Aramite and Ovotran gave poor results under these small field plot conditions. This chemical gave a survival of 98.3 per cent or 1.7 per cent control of mites over a period of 19 days. The general condition of the plants in the plots after treatment with Aramite and Ovotran showed definite evidence of having recovered from the mite infestation. The Malathion plot and untreat plot showed rapid dropping and discoloration of foliage due to the increased feeding of the increasing mite populations. It was noted that after the closing of the experiments under small field plot conditions, the plants in the Aramite and Ovotran plots developed new growth of leaves to a greater extent than the plants in the Malathion and untreated plots.

The treatments of potted plants at the insectary showed some variation in the control of the mites. Aramite, Malathion, Ovotran, Chlorobenzilate, Diazinon, and EPN 300, all in wettable powder form were applied at the same rate as in the small field plots. The experiments extended for a period of nine days from the day of application of the miticide to the final sampling day. The Aramite treatment in this test reduced the mite population to a 10.7 per cent survival or 89.3 per cent control. Malathion wettable powder gave a 10.6 per cent survival or 89.4 per cent control of mites. There might have been some variation in the results of this treatment since the test plants were not available to replicate the treatment six times. In two tests with Ovotran under potted plant conditions, one test gave a 81.8 per cent survival or 18.2 per cent control of mites. A later test in September reduced the survival population to 5.9 per cent or 94.1 per cent control over a period of nine days. The Chlorobenzilate treatment showed a 14.6 per cent survival or

85.4 per cent control. Diazinon gave 51.2 per cent control of mites. It was noted while observing the leaf disc samples from this treatment 24 hours after the application of Diazinon, a quick kill of adult mites was evident but the mite eggs appeared viable. This was probably the cause of an increase in mite population after an excellent initial kill was obtained. The following statement is made as a suggestion for some future research work. The compatibility of Diazinion, 25 per cent wettable powder when mixed with other miticides is not known but if it can be mixed with miticides such as Aramite and Ovotran which possess long-term residual values, there is a possibility of obtaining excellent control results, with Diazinon giving the quick initial kill of mites and either Aramite or Ovotran killing the nymphs hatching from the eggs. Of all the six wettable powders applied as miticides, EPN 300 showed indications of being the least promising material in the control of mites on beans. The percentage survival and resulting increased population in this test was increased to 128.2 per cent or a 28.2 per cent increase in population over the prespray count in a nine-day period. Malathion emulsifiable liquid sprayed beans resulted in 13.4 per cent survival or 86.6 per cent control of mites.

Treatments carried on under conditions where the test plants were planted in pots showed some variations in the effectiveness of the miticides in controlling the two-spotted spider mite, yet the overall results indicated that Aramite and Ovotran were the most effective compounds in controlling the mite.

Observations of test plants of all three varieties of beans indicated susceptibility to mite infestations of the same degree. There was no significant indication of miticides varying in toxicity to mites on different varieties of bush beans during the course of the experiments.

There has been no specific work done in Kansas on the life history of the

two-spotted spider mite. A more effective control of this mite can possibly be obtained by knowing the seasonal cycle of the mite in Kansas. With the several miticides giving either excellent or partial control of the mite in different regions, a study of the resistance of spider mites to various miticides should be conducted. Reports in the literature indicate that numerous workers in entomology have studied the control phase of this mite but few have investigated what is the actual effect of this pest on the yield of various food-bearing crops on which it thrives. A greater detailed study of this problem can possibly be made.

SUMMARY

The two-spotted spider mite, Tetranychus bimaculatus Harvey, was generally distributed throughout the State of Kansas. It was prevalent in great abundance practically every year in Kansas both under greenhouse and natural field conditions.

Observations on the host plants and control of this mite at Manhattan, Kansas was conducted during the fall of 1952 and the summer of 1953. Observations of this mite on 34 different host plants were made in the Manhattan area and a partial list of host plants, both cultivated and wild, was recorded. A more extensive survey of the area probably would indicate more host plants because various reports in the literature indicate that some 200 cultivated and wild plants are hosts to the two-spotted spider mite. The more common host plants of economic importance here in the Manhattan area were snap beans (both bush and pole), tomatoes, apples, and numerous other plants susceptible to mite infestations. Experimental miticidal control tests were

conducted during the summer of 1953 on bush beans infested with this mite. The test plants were grown in beds and earthenware pots.

A single treatment each of Aramite, 15 per cent wettable powder; Malathion, 25 per cent wettable powder; and Ovotran, 50 per cent wettable powder were conducted in the beds planted to beans. These miticides were all applied at a rate of two pounds (9.1 grams or 0.3177 ounce per gallon) per 100 gallons of water. Results indicated that of these three miticides tested under small field plot conditions, only Aramite and Ovotran were effective in controlling the mite. A control of 99.1 per cent and 99.9 per cent was obtained from Aramite and Ovotran respectively in these treatments over a period of 19 days. Malathion gave a 1.7 per cent control of mites as compared to the excellent results obtained with Ovotran and Aramite.

The tests conducted with potted plants showed some variation in the percentage control of mites. The treatments extended over a period of nine days, from the day of application to the final day of sampling. Aramite in a single test gave 89.3 per cent control of mites. This was in contrast to the almost perfect control obtained with this miticide in the small field plot treatment. Likewise Malathion gave 89.4 per cent control as compared to the bed treatment of 1.7 per cent control. There was some variation in the two tests conducted with Ovotran under potted plant conditions. The first test in mid-August gave 18.2 per cent control of mites, while the second test in early September resulted in a 94.1 per cent control of mites. The test with Chlorobenzilate, 25 per cent wettable powder, resulted in 85.4 per cent control of mites. The treatment with Diazinon, 25 per cent wettable powder, indicated that this miticide gave a quick initial kill of mites but had short residual value as shown in the 51.2 per cent control obtained through a period of nine days.

EPN 300, a 25 per cent wettable powder, used in a single test gave a low percentage control of mites and was the least promising of the miticides used. All the above materials used on potted plants were applied at the rate of two pounds (9.1 grams or 0.3177 ounce per gallon) per 100 gallons of water, using a three-gallon capacity sprayer. A 13.4 per cent survival or 86.6 per cent control was obtained with Malathion, 57 per cent emulsifiable liquid applied at a rate of one tablespoon (14.7 ml) per gallon of water.

According to evidence obtained in the miticides tested, with proper application methods, at the present time, best results in controlling the two-spotted spider mite can be obtained by using Aramite and Ovotran as a spray at the rate of two pounds per 100 gallons of water.

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COMPARATIVE CHEMICAL OR MITICIDAL CONTROL OF THE TWO-SPOTTED SPIDER MITE, TETRANYCHUS BIMACULATUS HARVEY, ON SNAP (BUSH) BEANS

by

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The two-spotted spider mite, Tetranychus bimaculatus Harvey, is considered a crop pest of prime importance. This mite feeds on a large number of varieties of plants, both cultivated and wild. Feeding injury results in stippling, discoloration, and eventual defoliation of host plants. This results from the removal of chlorophyll and cell contents from the leaves by the liquid sap-sucking activities of this pest.

Its presence nearly every year in great abundance on different host plants of economic importance in Kansas especially during the hot summer months warrants a chemical control study of this species. It is known at times to cause great damage where this pest is in outbreak numbers both under greenhouse and natural field conditions.

During September 1952, a general survey of backyard gardens was made in the Manhattan area and it was noted that all varieties of snap beans were heavily infested. A more extensive survey of different host plants of the two-spotted spider mite was conducted during June 1953 at Manhattan. General field surveys showed that this pest thrives just as well on wild plants as it does on cultivated plants. Under greenhouse conditions at Kansas State College, these mites occurred in abundance this past year on yellow sorrel growing on the soil floor of the greenhouses.

The studies on the host plants of the two-spotted spider mite resulted in confirming some of the information reported in the literature other than from Kansas in reference to the host plants of this mite. It was observed on 34 different host plants in the Manhattan area. This is an incomplete list of host plants since a more extensive survey of the area would show more host plants because various reports in the literature indicate that about 200 cultivated and wild plants are hosts to this mite.

Experimental miticidal control studies on the two-spotted spider mite were conducted at the insectary during the summer of 1953. The miticides used in the tests were Aramite, 15 per cent wettable powder; Malathion, 25 per cent wettable powder; Ovotran, 50 per cent wettable powder; Chlorobenzilate 25W; Diazinon 25W; EPN 300; and Malathion, 57 per cent emulsifiable liquid (E.L.).

Test plants of bush beans were grown in beds and in earthenware pots. The mites were transferred to bush beans to produce an infestation. The mites for infesting test bean plants were obtained from leaves of field bindweed which were heavily infested with two-spotted spider mites and from stock cultures reared on bush beans grown in flats. Mites were transferred from infested leaves to uninfested plants by using a two-inch-wide Camel's hair brush. The procedure was to brush off the mites from the underside of the infested leaves to the upper surface of the leaves of the test plants. Within a short time the mites migrated to the underside of the leaves to begin their feeding and reproductive cycles. The mites were introduced to the potted test plants when they had 10 to 12 full sized leaves. The miticides were applied when the plants averaged 24 to 26 full-sized leaves per plant and showed signs of being heavily and uniformly infested with mites.

Each miticidal test generally included six potted bean plants. The test beds were two and one-half by seven and one-half feet long, and consisted of 24 bean plants in two rows per bed.

The miticides were applied as a spray, using a three-gallon pressure sprayer. The materials were applied as a fine mist to the plants to a point where the spray commenced to drip from the leaves. A special shield was used while spraying each individual potted test plant to prevent any possible drift of the spray mists to other plants. A divider board between beds was

used in the spraying of the bean plants grown in beds to prevent drift of the spray mists to the neighboring beds.

Sampling of the bean leaves for population counts was done by punching out a circular disc, 0.6 of a square inch in area, from three leaves per potted test plant of six replicates in each miticidal test. A 7/8 inch diameter cork punch was used to punch out the discs. In the tests under potted conditions, all disc samples were obtained from the basal part of the bean leaf where mite populations were generally heaviest. Direct counts of the mites were made immediately under a binocular microscope, with all live stages of the mites except the eggs being counted. For the sampling of the test plots in beds, 10 leaves per bed were obtained at each sampling date for population counts. In these tests three circular discs, 0.6 of a square inch in area, were punched out from the basal, middle, and apical parts of each leaf sample.

Aramite, 15 per cent wettable powder; Ovotran, 50 per cent wettable powder; and Malathion, 25 per cent wettable powder were tested under small field plot conditions. These miticides were applied at a rate of two pounds (9.1 grams or 0.3177 ounce per gallon) per 100 gallons of water. The treatment covered a period of 19 days, from the day of application of the materials to the final day of sampling. Aramite and Ovotran gave indications of being the most effective chemicals in the control of these mites. A 99.1 per cent control of mites was obtained in the Aramite treatment, while 99.9 per cent control of mites was obtained in the Ovotran plot. The untreated plot showed high population counts throughout the period of the experiment. Malathion gave unsatisfactory results in these tests since only a 1.7 per cent control was obtained.

The treatments under potted plant conditions at the insectary showed some variation from bed treatments. In a single test with Aramite under potted plant conditions, 89.3 per cent control of mites was obtained. In two tests with Ovotran under potted plant conditions, one test gave 18.2 per cent control of mites and a test later in the season reduced the percentage survival to 5.9 per cent or 94.1 per cent control. A single test with Malathion gave 89.4 per cent control of mites. The treatment with Chlorobenzilate resulted in 85.5 per cent control of mites. Diazinon showed indications of giving a high initial kill of mites but no residual effectiveness as evidenced by the 51.2 per cent control observed during the entire length of the experiment. EPN 300 gave very unsatisfactory results in the control of the mite under potted plant conditions. All of the above-mentioned miticides used on test plants under potted plant conditions were applied at a rate of two pounds (9.1 grams or 0.3177 ounce per gallon) per 100 gallons of water. The observations covered nine days, from the day of application to the final sampling day.

Malathion, 57 per cent emulsifiable liquid, was applied at a rate of one tablespoon per gallon of water. Malathion emulsion resulted in 86.6 per cent control.

Over-all results in the miticide treatments conducted at the insectary during the summer of 1953 indicated that Aramite, 15 per cent wettable powder and Ovotran, 50 per cent wettable powder, gave the most effective control of the two-spotted spider mite on bush beans.