EFFECTS OF VARIOUS DDT FORMULATIONS ON THE CONTROL OF INSECTS COMMON TO POTATOES AND BEANS

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This is to certify that the

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Effects of Various DDT
Formulations on the Control of
Insects Common to Potatoes
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presented by

Arthur Warren Bloomer

has been accepted towards fulfillment
of the requirements for

M.S. degree in Entomology

Ray Hutson
Major professor

Date July 30, 1953

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By

Arthur Warren Bloomer

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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Year 1953

Approved Ray Hutson

Arthur Warren Bloomer

Studies were made during the growing season of 1952 to determine the effects of various formulations of DDT in the control of insects common to potatoes and beans. Five different wettable powders were tested in these studies. Three of the formulations were 75 percent DDT wettable powders prepared and furnished by the Michigan Chemical Corporation. Another formulation was E. I. du Pont de Nemours and Company's 75 percent DDT wettable powder sold under the trade name of Deenate. The fifth formulation was Sherwin-Williams Company's 50 percent DDT wettable powder. All sprays were applied at the rate of one pound of actual DDT per hundred gallons of water.

Sprays were applied to the potato plots with a tractor drawn sprayer which received its power from the "power take-off" mechanism of the tractor. Two hand-drawn, gasoline powered sprayers were used to apply sprays on the bean plots. Sweeping counts were made at various periods after spraying to determine the amount of insect control obtained. Yield determinations were made on the potato plots, but none were made on the bean plots.

The populations of insects were generally smaller on the beans and larger on the potatoes. This was probably due to the great differences in the rates of application of the spray materials. The potatoes received an average of 115 gallons of spray material per acre whereas the beans received from 225 to 250 gallons of spray material per acre.

Drift had a greater effect on the potatoes than it did on the beans.

No apparent difference was great enough in the control obtained by any of the formulations used to allow the recommendation of any one of them over the rest collectively, or any one singly.

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A THESIS

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CONTENTS

INTRODUCTION

Insects have long been pests of man. They have damaged his health, his home, his animals and his food. Much work has been done to find control measures for injurious insects, and much more will be done in the future.

Perhaps one of the most important types of insect damage is the harm they cause to field crops. Modern methods of agriculture produce conditions favorable for insects. The resulting infestations cause inestimable damage to farm products every year.

At present the largest field of research for insect control is with insecticides. The advent of DDT and the numerous other synthetic insecticides which followed have stimulated unpredictable interest in this field. Industry as well as governmental agencies spend much money every year on research.

The advent of these modern insecticides has helped agriculture as well as many other branches of human livelihood. Recommendations for the use of insecticides usually refer to the insects involved. Various factors other than insects must also be taken into consideration when making these recommendations. Two of the more important ones are the formulations used and the host plants to be treated. This paper deals with the control of insects common to both potatoes and beans with DDT. Five formulations of DDT wettable powders were used to see if any differences in control resulted from the differences in formulations.

REVIEW OF LITERATURE

POTATOES:

Prior to DDT there was no one insecticide which would control the majority of potato insects. Muncie and Morofsky (20) have written a report of their findings which partially summarizes potato insect control before the advent of DDT.

With the discovery of DDT and the large amount of publicity that accompanied it, much experimental work was carried out to see what insects it was effective against. Granovsky (8), reported in 1944 that DDT gave very good control of the potato flea beetle, *Eqitrix cucumeris* (Harr.), and showed promising results in the control of the Colorado potato beetle, *Leptinotarsa decemlineata*, (Say); tarnished plant bug, *Lygus lineolaris* P. deB.); and other mirids. Swingle and Mayer (25) reported that DDT as a spray at the rate of one pound per hundred gallons of water, caused complete mortality of all instars of Colorado potato beetle infesting potato plants in an outdoor garden. Weigel (31) stated that in laboratory tests with potato cuttings DDT gave complete kill of Colorado potato beetles and potato flea beetles. Roark and McIndoo (22 & 23) stated that DDT was very effective against the potato flea beetle and the Colorado potato beetle. They also said that it gave good control of the six-spotted leafhopper, *Macrosteles divisus* (Uhl.) and the potato leafhopper, *Empoasca fabae* (Harr.).

In 1945 workers added more data to that of previous years. Thompson (26) attributed large increases in potato yeild to the control of the potato leafhopper by DDT. Fox and Perron (7) reported that DDT gave the best control of potato leafhopper nymphs, while the arsenicals the poorest control of nymphs. The plots protected by DDT also gave them the best yields. Gyrisko, Jodka, and Rawlins (9) found that DDT produced very favorable reductions in infestations of Colorado potato beetle, aphids, flea beetles, and leafhoppers. They further reported that insect populations remained at low levels for ten or more days after application. In their work, dusts did not have the residual power that sprays did, and they noticed no phytotoxicity. Bruce and Tauber (3) stated that DDT not only controlled the potato leafhopper and flea beetle, but also controlled the potato aphid, Macrosiphun solanifolii (Ashmead) as well.

In 1946 Gyrisko, Wene, and Rawlins (10) reported that DDT gave better control of the potato aphid and the green peach aphid, Myzus persicae (Sulzer) than such standard aphicides as rotenone, nicotine, and thiocyanates. They found that only nicotine fumigation gave better control than DDT. These workers reported that at least two pounds of DDT, as a spray or dust, was necessary for good control. Bronson and Smith (2) found that DDT applied as an emulsion, aerosol, dust mixture, or suspension was effective in reducing aphid populations. They found that the dust was more effective, but more DDT per acre was applied with the dust.

Morofsky and Muncie (16), and Muncie and Morofsky (19) reported in 1947 that DDT applied either as a spray or dust gave the best control of potato insects. Kulash (13) reported the same year that DDT gave good control of Colorado potato beetle larvae. He also found that chlordane and benzene hexachloride gave good control of the larvae but that benzene hexachloride did not have the residual power of DDT. Kulash (14) also found that DDT gave good control of the potato flea beetle and the tobacco flea beetle, Epitrix hirtipennis (Mels.). The DDT dusts proved to have more residual power than did the sprays of DDT and benzene hexachloride.

Heuberger and Stearns (12) investigated the apparent growth-promoting effects of DDT and reported their findings in 1948. They decided that the better growth might result from leafhopper control. In their work they found that DDT gave excellent control of leafhoppers and high yield responses, DDT had no fungicidal value, and DDT caused no apparent injury to potatoes. Voss and Andre (30) found that DDT oil emulsion gave better control of aphids than DDT wettable powder. Campbell and Pepper (4) reported in 1948 that parathion was outstanding in aphid control and resulted in the highest yield, whereas plots sprayed with DDT and benzene hexachloride were similar in yield and these yields were not significantly lower than that produced by the use of parathion. They also found the DDT oil emulsion gave better aphid control than DDT wettable powder. Turner and Woodruff (28) found that DDT provided better flea beetle control

on potatoes than chlordane, methoxychlor, and toxaphene. They also stated that DDT spray powder of fine particle size provided significantly better control of flea beetles and higher yields than did DDT spray powder of coarse particle size. Morofsky and Muncie (17) found that DDT gave better potato leafhopper control, in general, than did benzene hexachloride although DDT varied greatly in its effects upon the six-spotted leafhopper. Doyle and Duncan (6) in comparing the effects of DDT with calcium arsenate, chlordane, and Lethane "B-72" found that DDT was the most effective insecticide in controlling potato insects and that it significantly increased potato yields.

Tuner and Woodruff (29) reported in 1949 that yields from fields sprayed with DDT wettable powder were significantly higher than yields from fields sprayed with DDT emulsion even though the DDT emulsion gave better control of aphids. The DDT wettable powders gave better flea beetle control.

Mitchene (15) reported in 1950 that when potatoes were heavily infested with both potato leafhoppers and Colorado potato beetles, DDT gave the best control and yields as compared with aldrin, dieldrin, toxaphene, and calcium arsenate. Morofsky and Muncie (18) reported that while DDT emulsion and wettable powder gave good control of potato flea beetles and leafhoppers, an emulsion of 25% DDT and 3% parathion gave better aphid control than either of the preceding.

Many other workers have investigated the control of potato insects, the above being a small representation. It is felt

that most of the findings and views are shown by the sources cited.

BEANS:

Various workers have tested DDT on beans with nearly the same results. Weigel reported in 1944 that DDT caused no mortality to the Mexican bean beetle, Epilachna varivestis (Muls) adults or larvae when applied as a spray or dust on plants in a greenhouse. Nelson (21) and Roark and McIndoo (22 & 23) also reported that DDT was not very effective in controlling the Mexican bean beetle. Harries (11) reported that bean leaves dusted with DDT killed 36 percent of the third instar Mexican bean beetle larvae that fed on them.

Bjornseth (1) reported in 1946 that DDT, if properly applied, gave adequate and economical control of leafhoppers on beans and substantially increased the yield. Turner (27) stated that DDT was much less effective than methoxychlor or rotenone in Mexican bean beetle control.

In 1948 Ditman and Cory (5) reported that DDT as an aerosol was ineffective in controlling the Mexican bean beetle.

Not much work has been done with DDT on beans because of its inability to control the major pest, the Mexican bean beetle.

PROCEDURE

POTATOES:

On May 26, 1952, twelve hundred pounds of certified Sebago seed potatoes were planted on approximately two-thirds of an acre of muck located at the Michigan State College Experimental Muck Farm in Clinton County, Michigan. They were planted in forty-eight rows, two hundred feet long, the rows being three feet apart. The rows ran in a northerly and southerly direction. On the north and west sides the potato field was bounded by a sugar-beet field. The sugar beets were later plowed under because of the extreme weediness of the field. The south side of the field was bounded by a willow hedgerow and the east side by a weed-filled ditch. A gravel road was located east of the ditch.

Six plots were established with two four-row replicates in each plot. The plots ran from east to west in a consecutive order (see Fig. 1). One plot was designated as the check plot and was sprayed with fungicide only. The other plots were sprayed with a fungicide and one of the insecticides.

The insecticides used consisted of five formulations of wettable powder DDT. Three of the formulations were 75 percent DDT wettable powders furnished by the Michigan Chemical Corporation of St. Louis, Michigan. One formulation was E. I. du Pont de Nemours and Company's 75 percent DDT wettable powder sold under the trade name of Deenate. The other formulation was Sherwin-Williams Company's (abbreviated in Figures and Tables as Sher-Will) 50 percent DDT wettable powder. All of these formulations were applied at the rate of one pound of DDT per hundred gallons of water.

Tribasic Copper Sulfate was used as the fungicide for these tests and was applied to all of the plots. The rate of application for the fungicide was three pounds per hundred gallons of water. Approximately 110 gallons of spray material were applied per acre.

All plots were sprayed on the same day with two hours elapsing from the time of starting to the time of finishing. The sprayer used in these tests was a tractor-drawn John Bean sprayer with double tanks (see Fig. 3). Each tank could be emptied separately and was capable of holding one hundred gallons. Both tanks were used to speed up the process of spraying. Enough of the chemicals were weighed in advance to make twenty-five gallons of spray material for each plot. Material for two consecutive plots was mixed in the sprayer simultaneously. The hoses and boom were thoroughly flushed out to eliminate errors due to any other chemicals which might have been present in the system. The sprayer tanks were always thoroughly flushed before any materials were added. By taking these precautions it was felt that errors were kept at a minimum.

The sprayer received its power through the "power take-off" mechanism of the tractor. A four-row potato boom was used with three nozzles per row. Number three spray discs were used in the nozzles, and these discs were changed after every three days of spraying. This was done to prevent too great a variance in the rate of application. The material was applied at 225 pounds of pressure.

All plots were sprayed five times with the applications being made on the following dates:

June 19 & 30.

July 7, 21 & 28.

Two strips in each replicate were left unsprayed on July 7. This was accomplished by laying a 15' x 20' tarpaulin on the potato plants and running the sprayer over it. The tarpaulin shielded the plants from the spray and a fifteen-foot skip spot was left. The purpose of this added variation was to see if the insects would build up on the skipped areas.

Sweepings were made with a standard insect sweeping net. They were taken immediately before spraying and three days after spraying. By not spraying on July 14 sweepings were also obtained for ten, fourteen, seventeen and twenty-one days after spraying. Only the middle two rows of each replicate were used in making the sweeping counts. This was done to remove the influence of spray drift from the other plots.

The sweeping procedure used was to make five complete oscillations through the center two rows of each replicate with a standard size sweeping net. Each oscillation was accompanied by a step forward thus making one complete oscillation per step. The sweepings were taken from randomized areas in the replicates each time. Sweepings were taken on the following dates:

June 25 & 30.

July 3, 7, 10*, 14*, 17*, 21*, 24, 28 & 31.

August 7, 11, & 13.

* Sweepings also taken in strips protected from spray on July 7.

The insects collected by sweeping were killed in cyanide jars and placed in labelled paper bags. The insects were identified and counted in the laboratory.

Yield data were taken on September 19, 1952. Two forty-foot strips were dug in each replicate, one strip in each of the center two rows of the replicate. All of the U. S. No. 1 and No. 2 grade potatoes from these strips were gathered and weighed. The weights of each grade were recorded separately. This gave a total of four yield samples for each plot.

BEANS:

On June 10, 1952, Red Kidney beans were planted on a part of the Michigan State College farm located in Ingham County, Michigan. They were planted in five replicates of twenty-five rows each. The rows were twenty feet long and two feet apart. The replicates were separated by eight-foot aisles of bare soil. Later, two replicates were disced under because of their extreme weediness.

The rows ran in an easterly and westerly direction (see Fig. 2). The area was bounded on the north side by five rows of beans. The west side was bounded by a field of ensilage corn, and the south and east sides by the dirt service road.

Six plots were established in this field with three replicates per plot. Each spray plot replicate contained four rows each, and the check plot replicates contained five rows each. The spray materials for the beans were the same as those used on the potatoes with one exception; no fungicide was used on the beans. The DDT was applied at the rate of one pound of actual DDT per hundred gallons of water, the same as the potatoes. The rate of application per acre was between 225 and 250 gallons.

All of the plots were sprayed on the same day with two hours elapsing from the time of starting to the time of finishing. Two different sprayers were used in spray applications. The first three sprays were applied with a Lowell Cyclone wheelbarrow sprayer (see Fig. 4). It had a capacity of fifteen gallons and sprayed with fifty pounds of pressure. The rest of the sprays were applied with a John Bean Spartan sprayer (see Fig 5). It also had a fifteen-gallon capacity, but it sprayed at a pressure of 200 pounds. Both sprayers were hand-drawn with motors supplying power for spraying. The spray guns were hand operated. Sprays were applied on the following dates:

August 1, 8, 15, 22 & 29.

September 5 & 12.

Sweeping counts were taken immediately before and three days after spraying. The sweeps were taken lengthwise of the rows sampled. To eliminate as much as possible the effects of drift, only the middle two rows of the spray replicates and any two of the middle three rows of the check replicates were sampled. Four sweeps per row or eight per replicate were taken at each sweeping.

Sweeping counts were made on the following dates:

July 17*.

August 1*, 4, 8, 12, 15, 18, 22, 25 & 29.

September 3, 5, 8 & 12.

* Counts made preliminary to any spraying.

The insects collected in the sweeping counts were killed in cyanide bottles and placed in paper bags. The bags were labelled and the insects were later classified and counted in the laboratory.

No yield samples were taken on the beans as the pods had been picked for chemical analysis.

[illegible]

EXPERIMENTAL DATA

FIG. 1. ARRANGEMENT OF POTATO PLOTS.

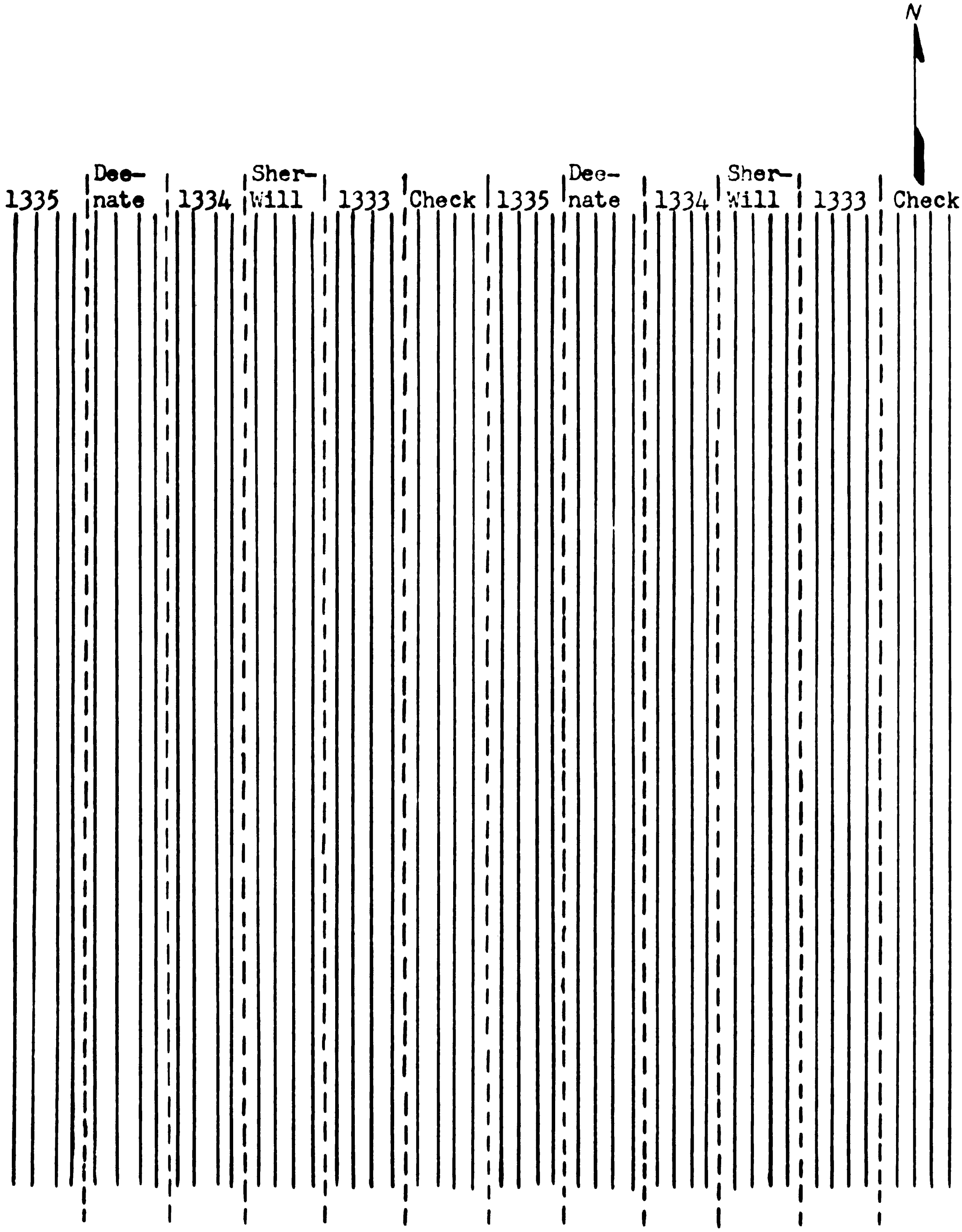


FIG. 2. ARRANGEMENT OF BEAN PLOTS.

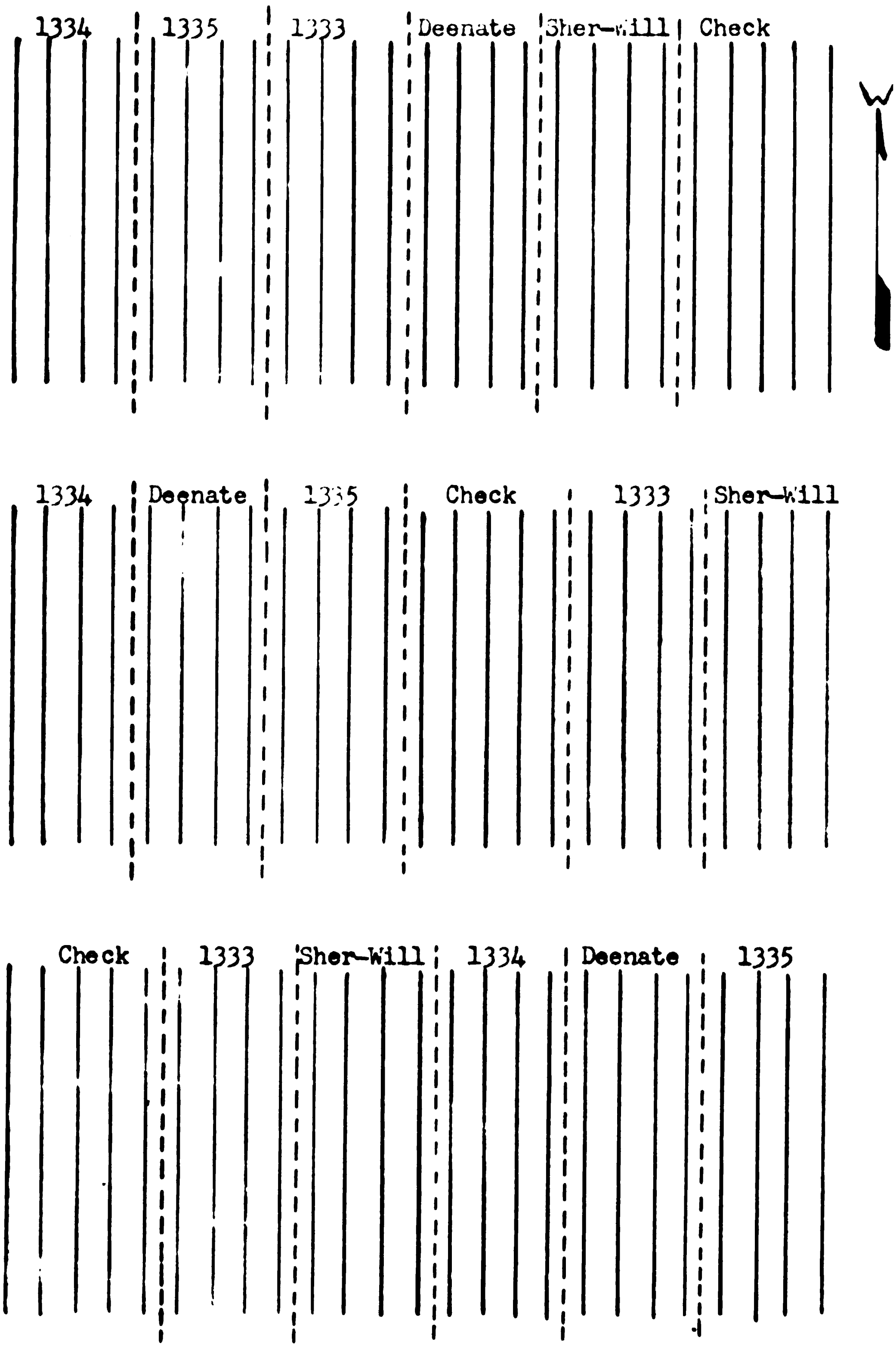


FIG. 3. JOHN BEAN SPRAYER USED FOR SPRAYING POTATOES.

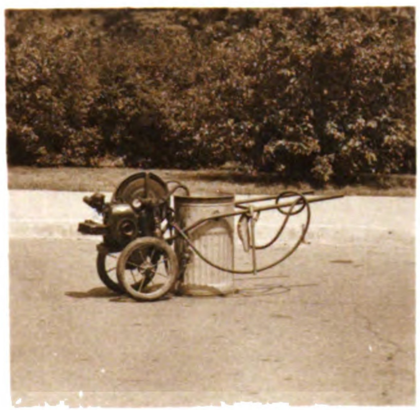


FIG. 4. LOWELL WHEELBARROW SPRAYER USED FOR SPRAYING BEANS.

FIG. 5. JOHN BEAN SPARTAN SPRAYER USED FOR SPRAYING BEANS.

FIG. 6. NUMBER OF POTATO LEAFHOPPERS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

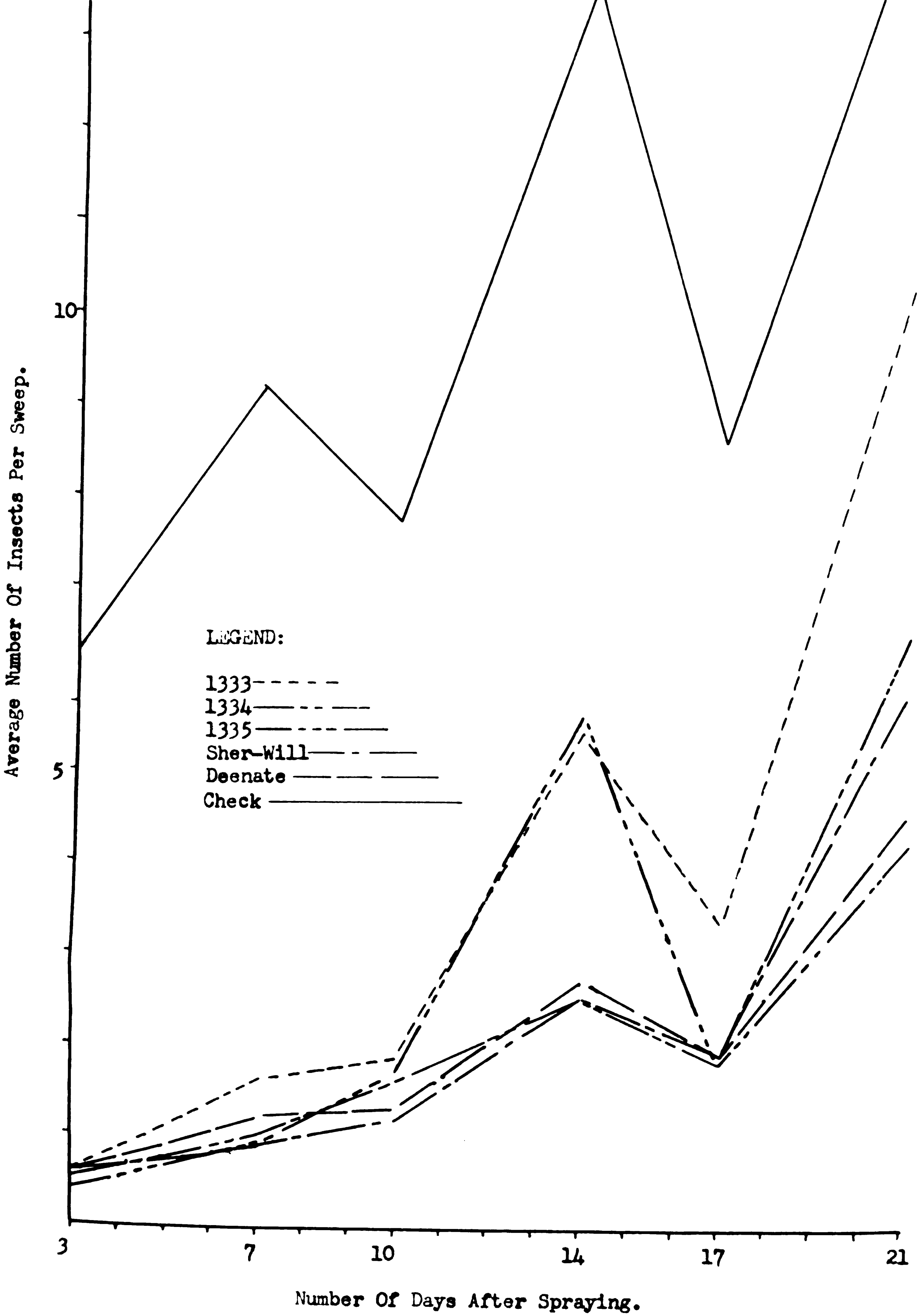


FIG. 7. NUMBER OF SIX-SPOTTED LEAFHOPPERS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

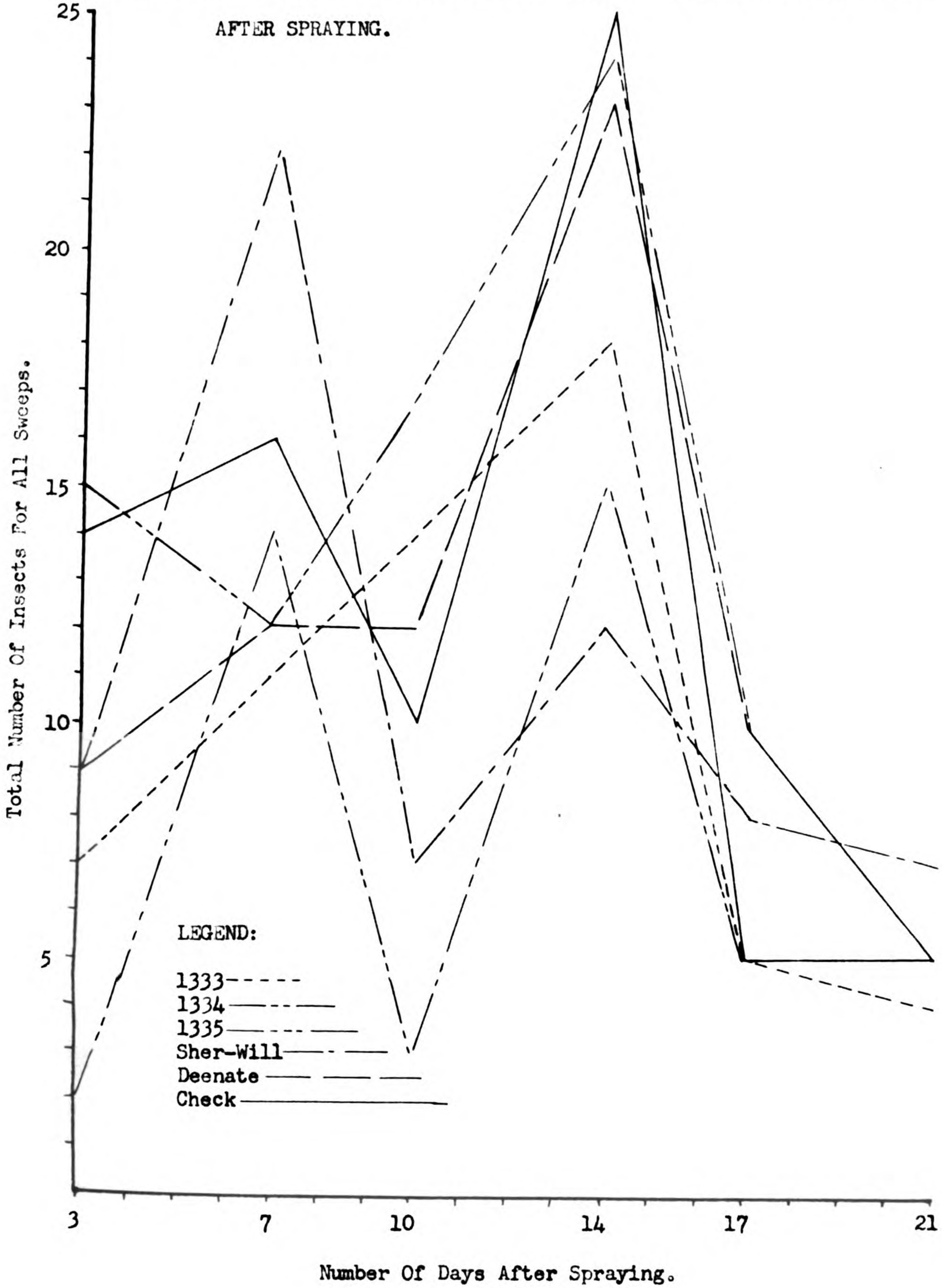


FIG. 8. NUMBER OF OTHER LEAFHOPPERS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

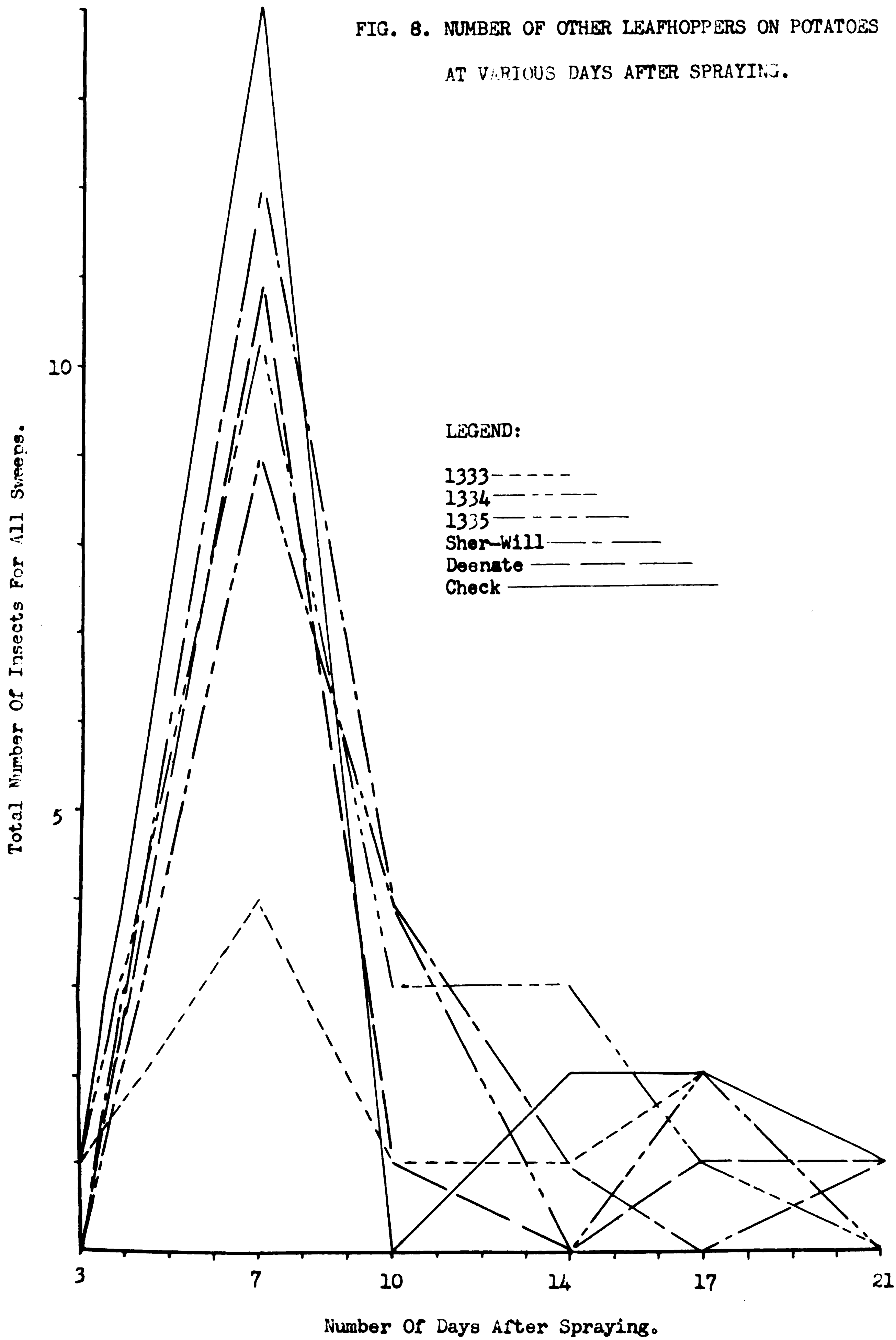


FIG. 9. NUMBER OF SPITTLE-BUGS ON POTATOES

AT VARIOUS DAYS AFTER SPRAYING.

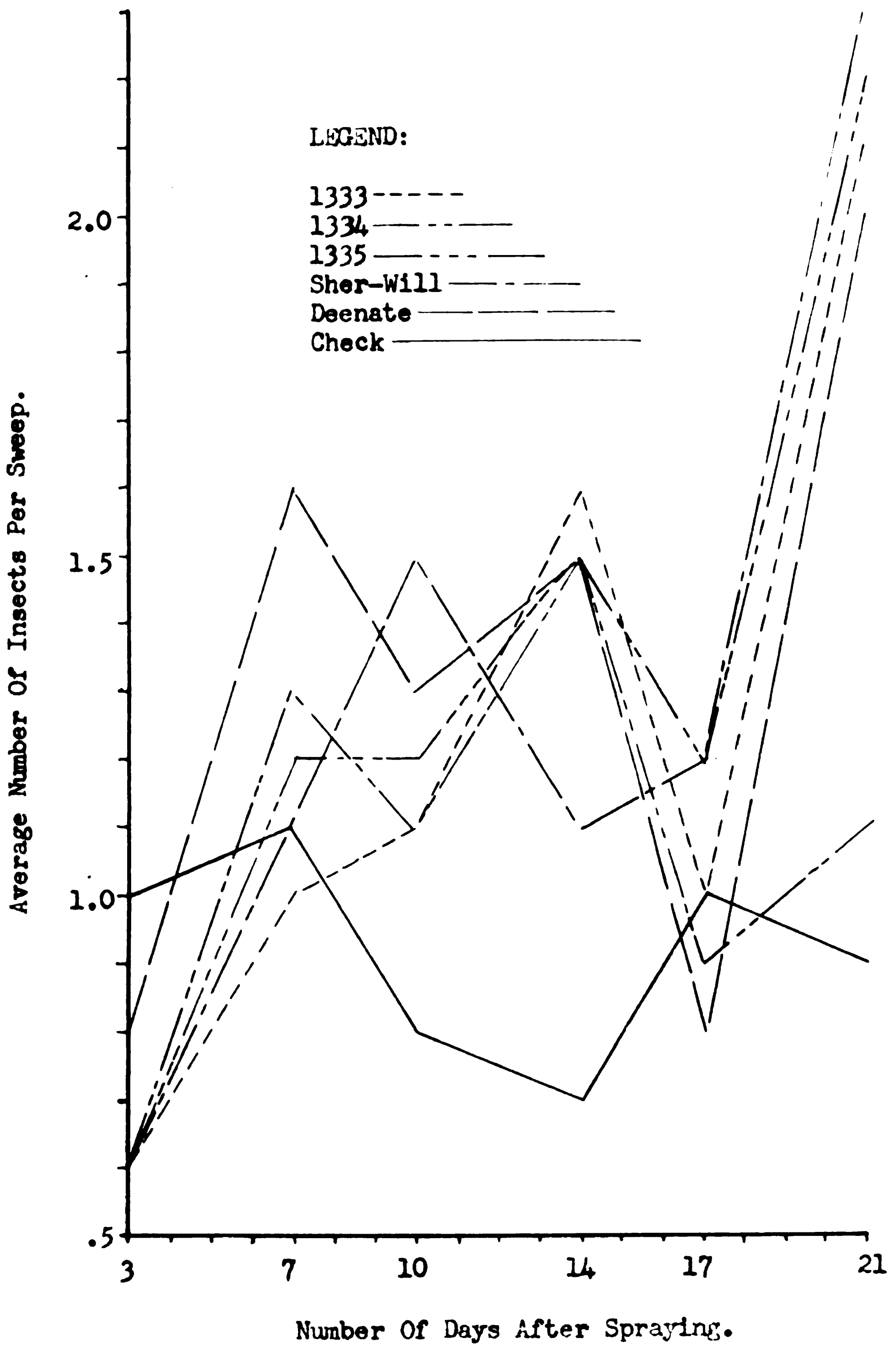


FIG. 10. NUMBER OF TARNISHED PLANT BUGS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

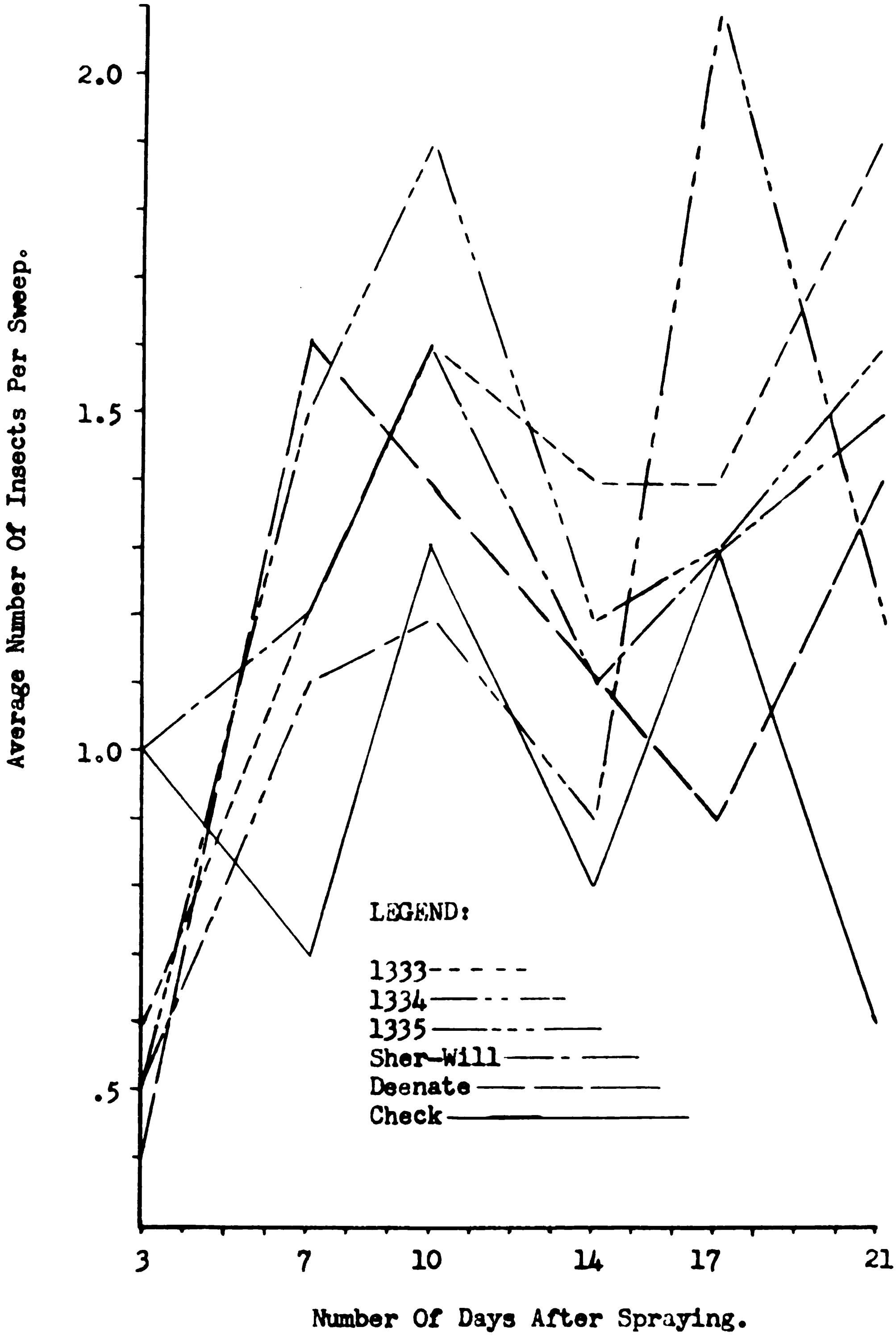


FIG. II. NUMBER OF OTHER PLANT BUGS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

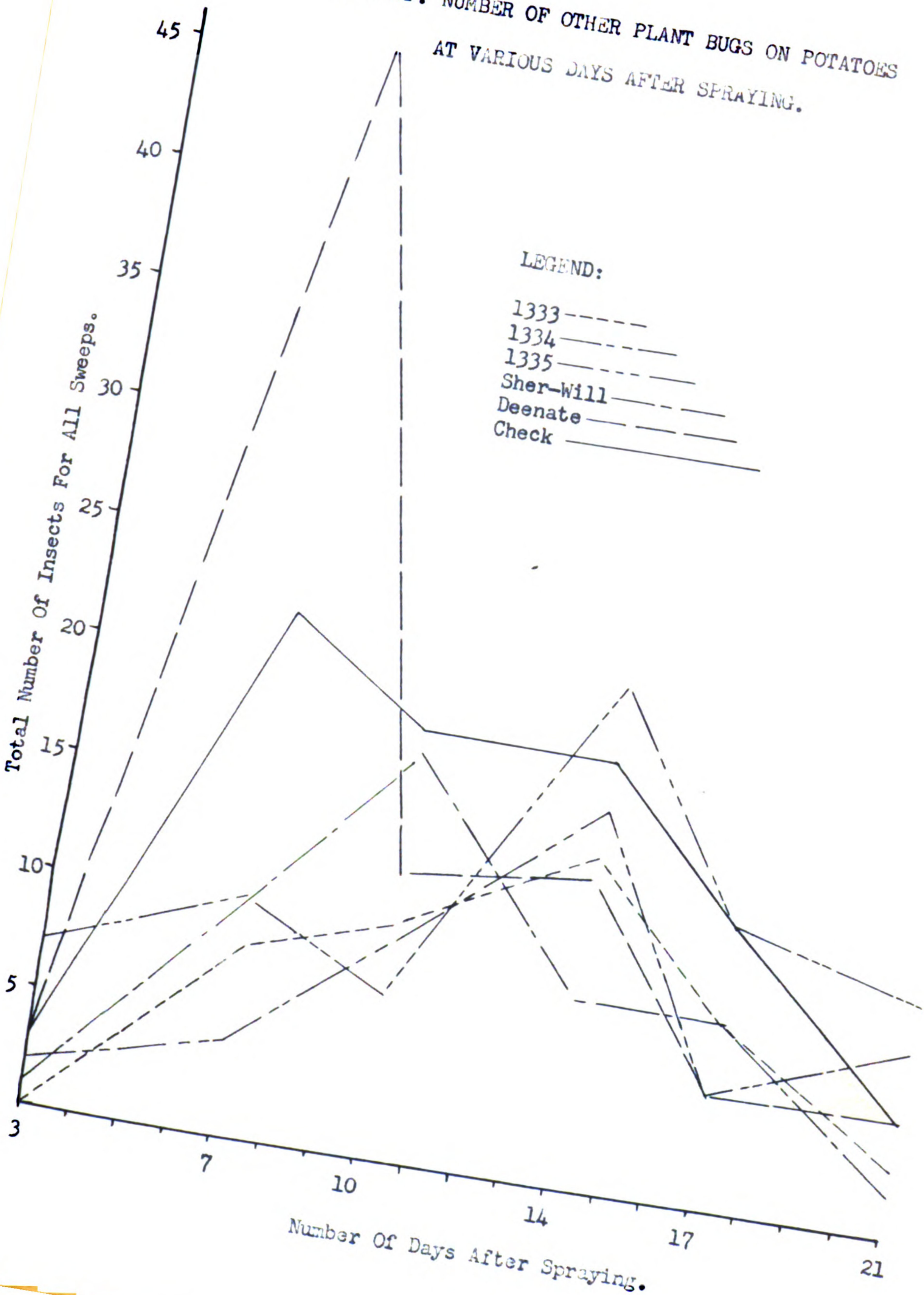


FIG. 12. NUMBER OF APHIDS ON POTATOES AT VARIOUS DAYS AFTER SPRAYING.

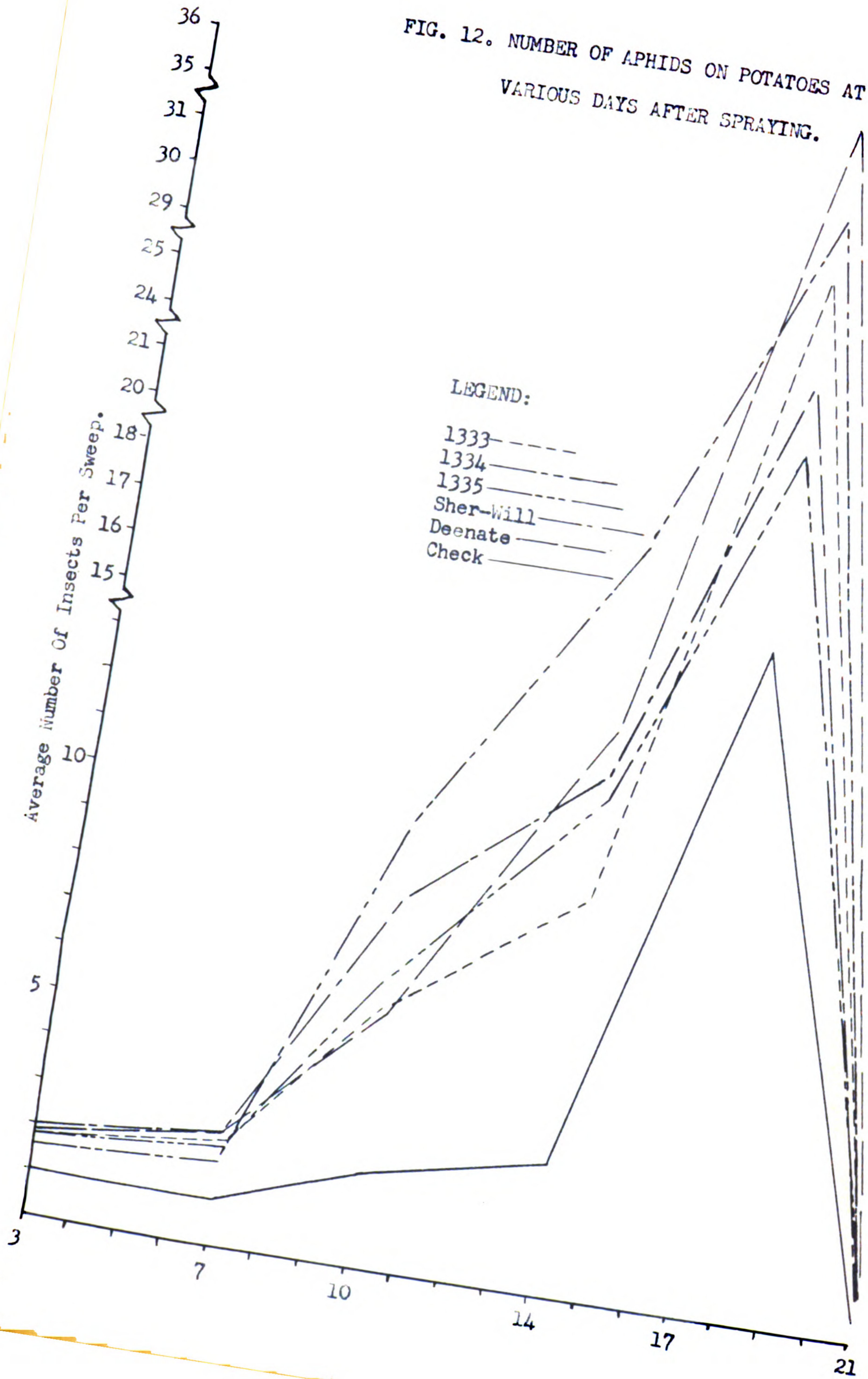


FIG. 13. NUMBER OF FLEA BEETLES ON POTATOES

AT VARIOUS DAYS AFTER SPRAYING.

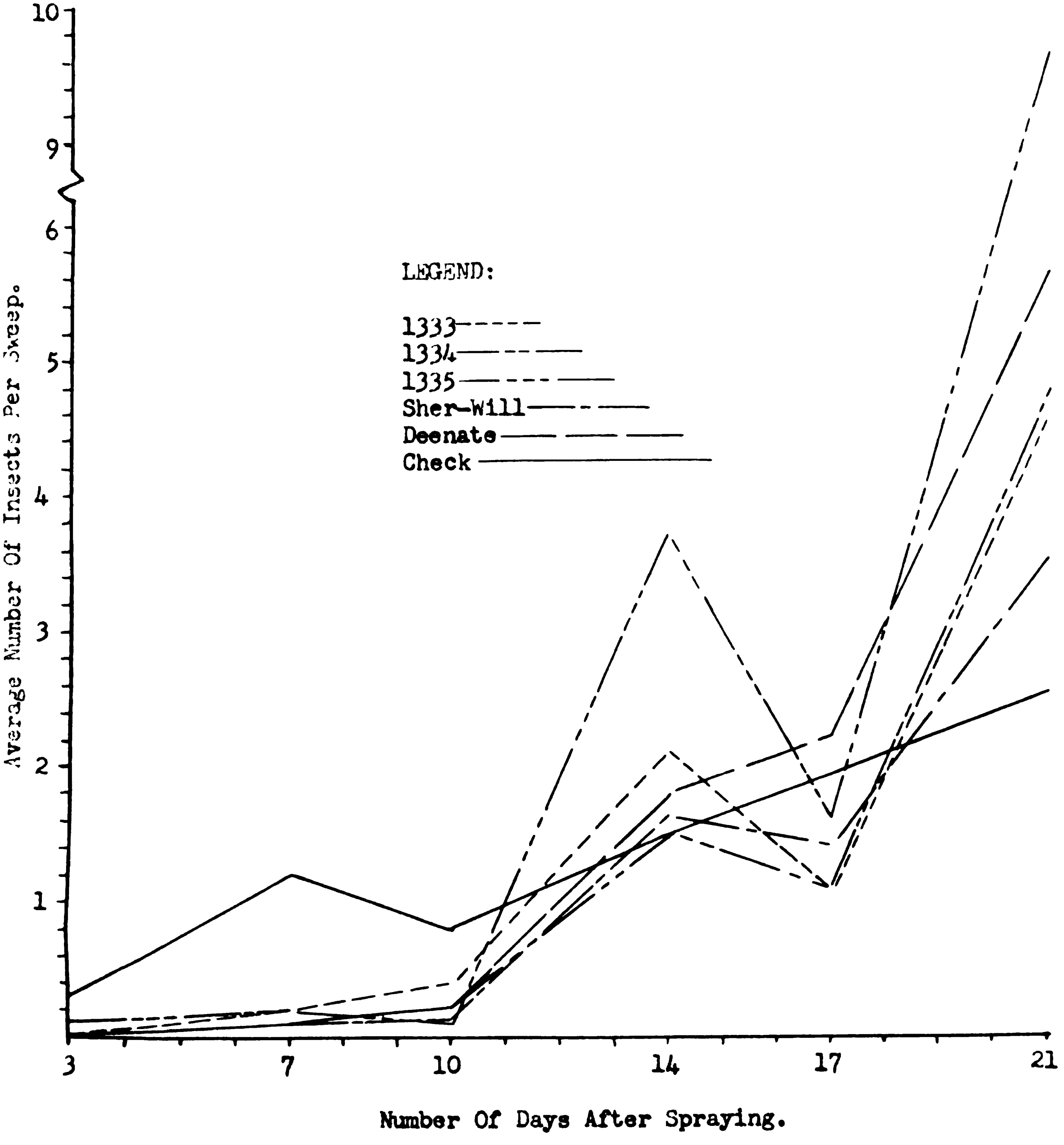
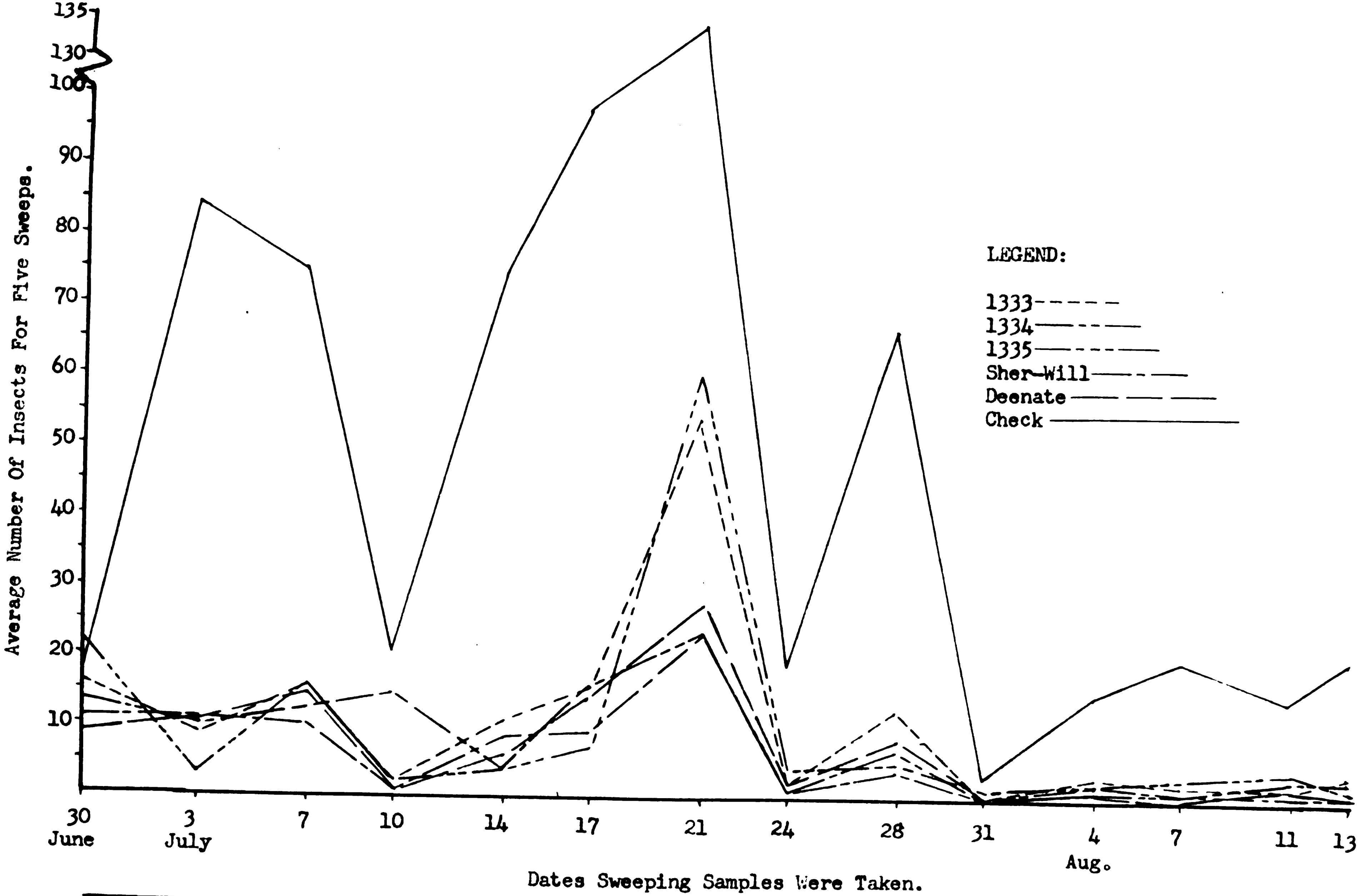
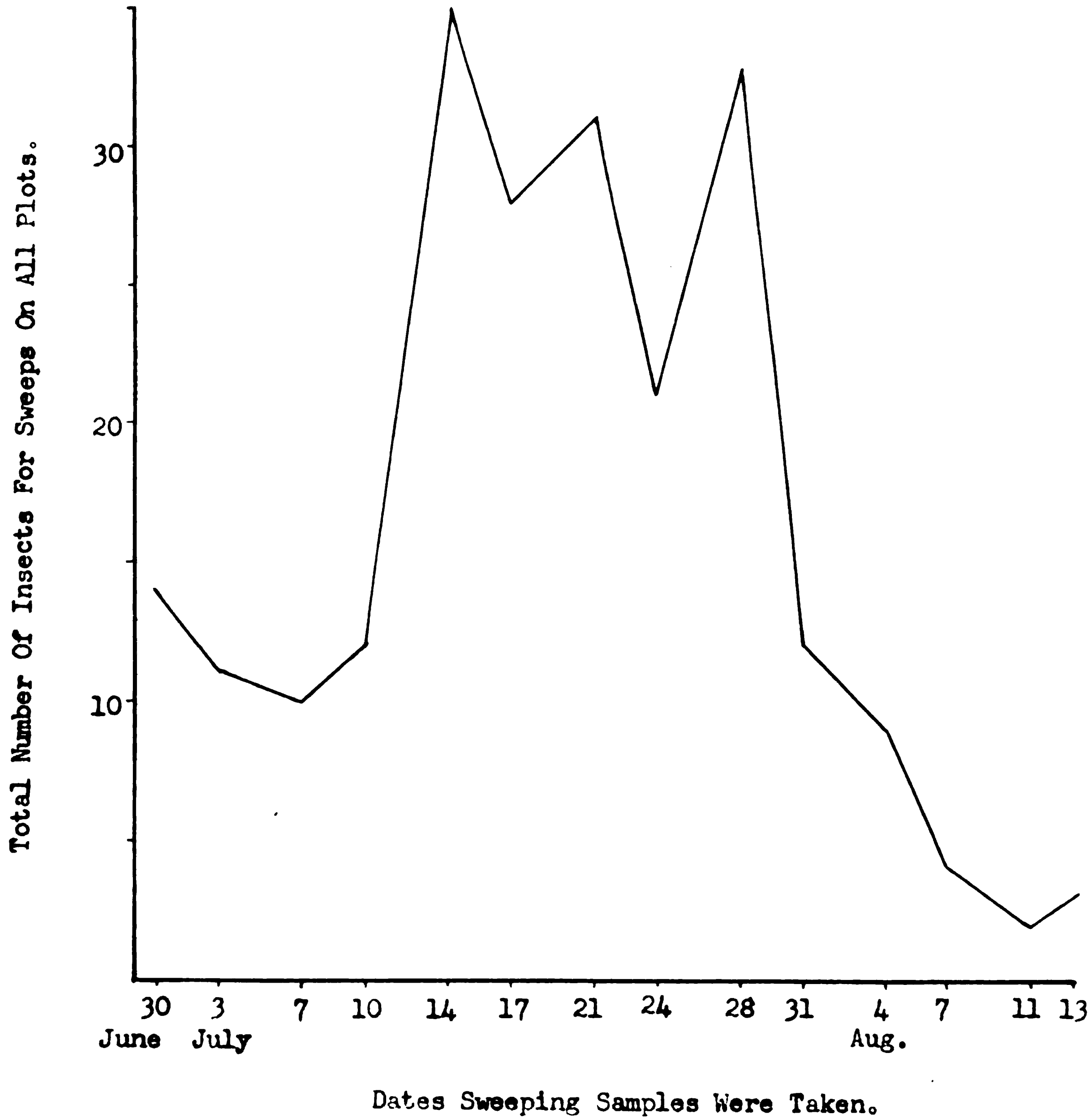


FIG. 14. NUMBER OF POTATO LEAFHOPPERS ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 15. NUMBER OF SIX SPOTTED LEAFHOPPERS ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



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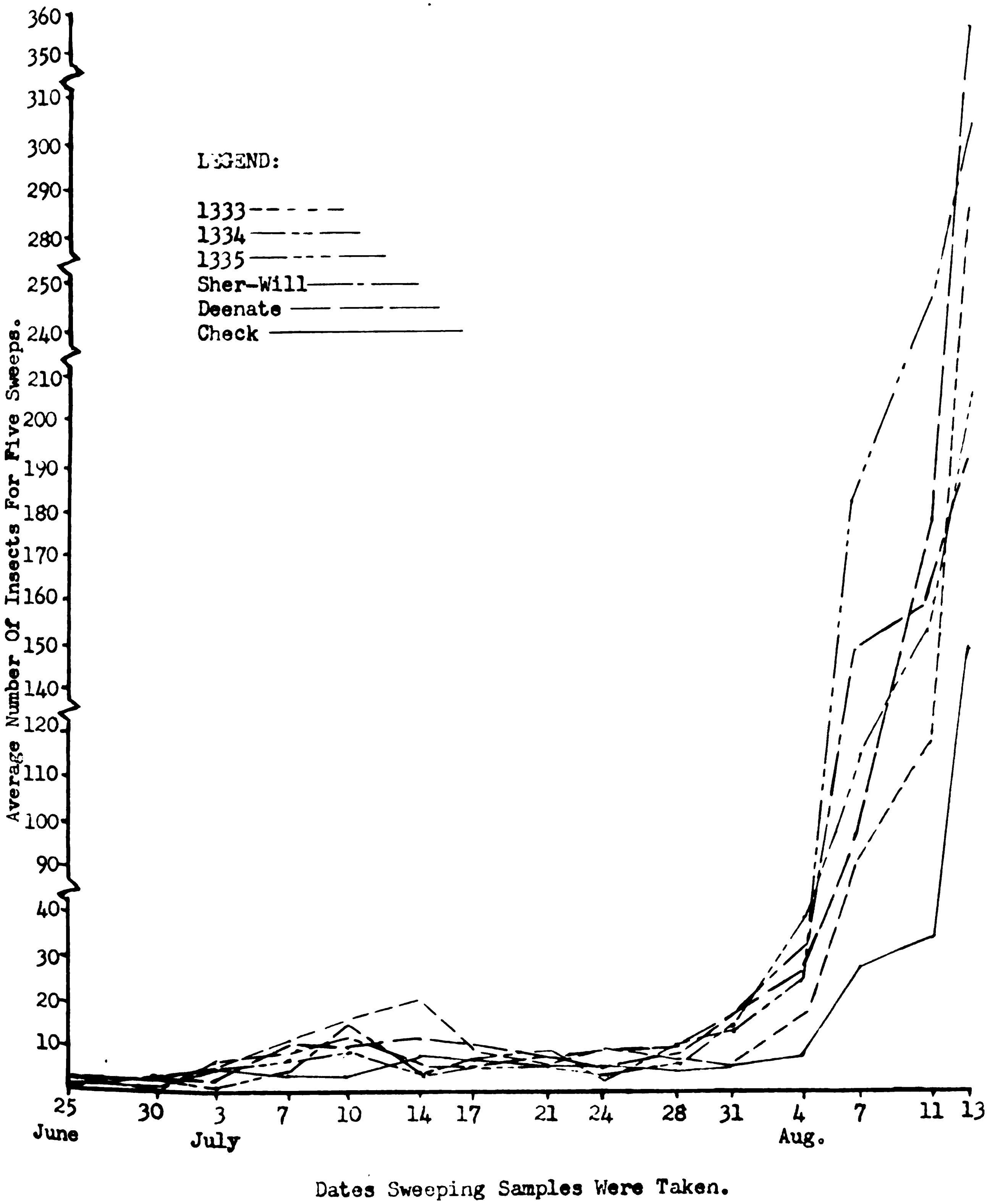
* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 16. NUMBER OF APHIDS ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



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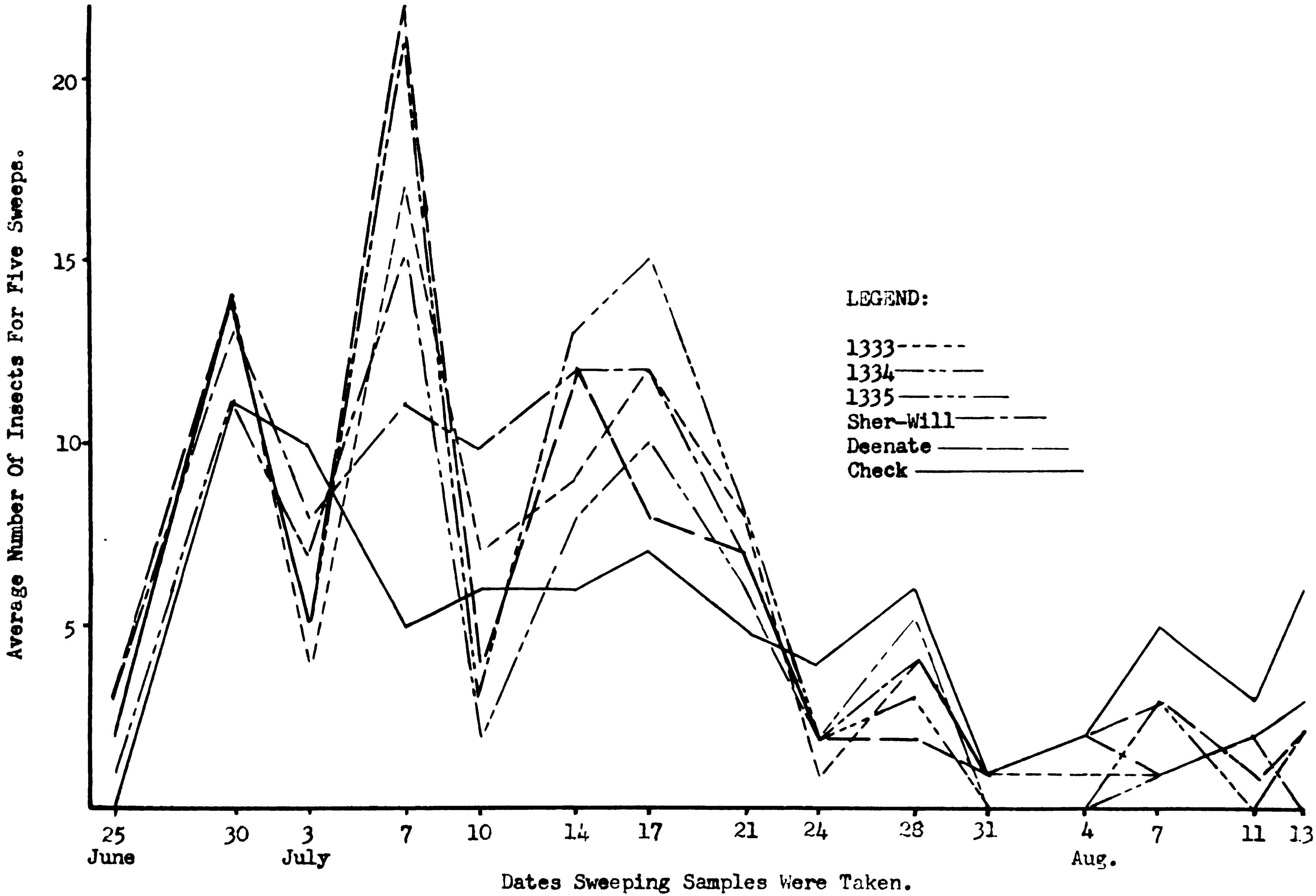
* Spray application dates: June 19 & 30; July 7, 21 & 28.

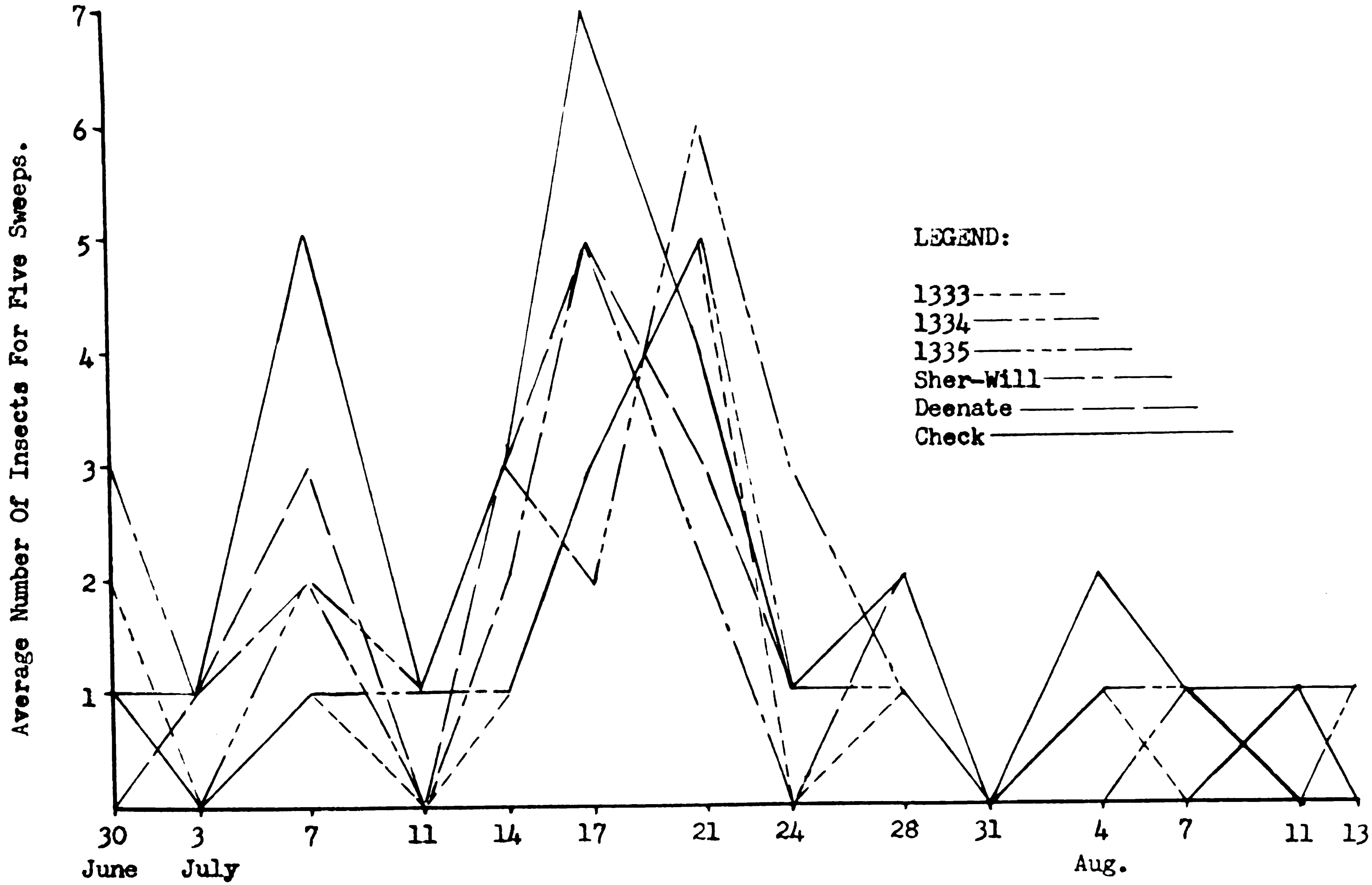
FIG. 17. NUMBER OF TARNISHED PLANT BUGS ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 18. NUMBER OF PLANT BUGS OTHER THAN TARNISHED PLANT BUGS

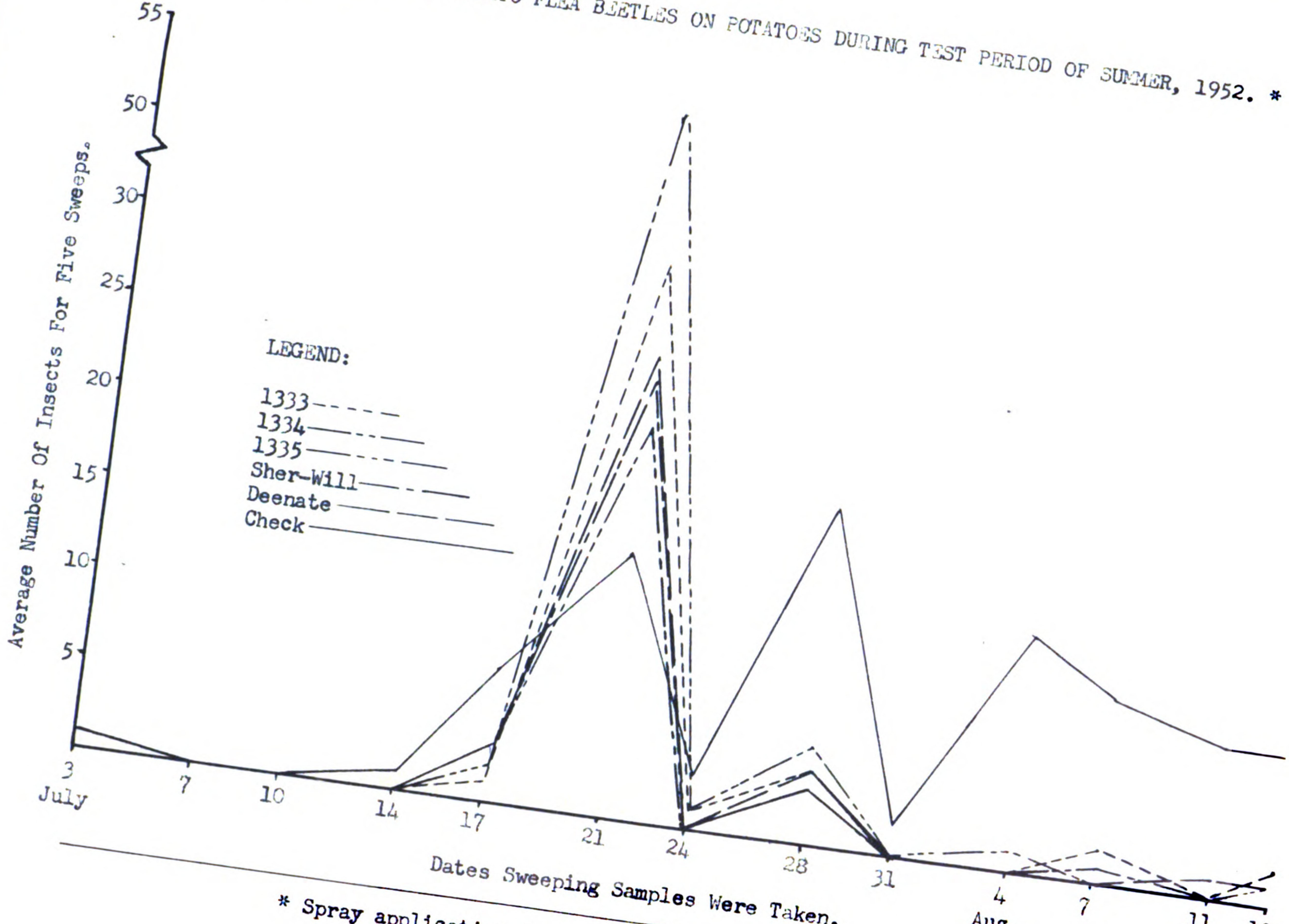
ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



Dates Sweeping Samples Were Taken.

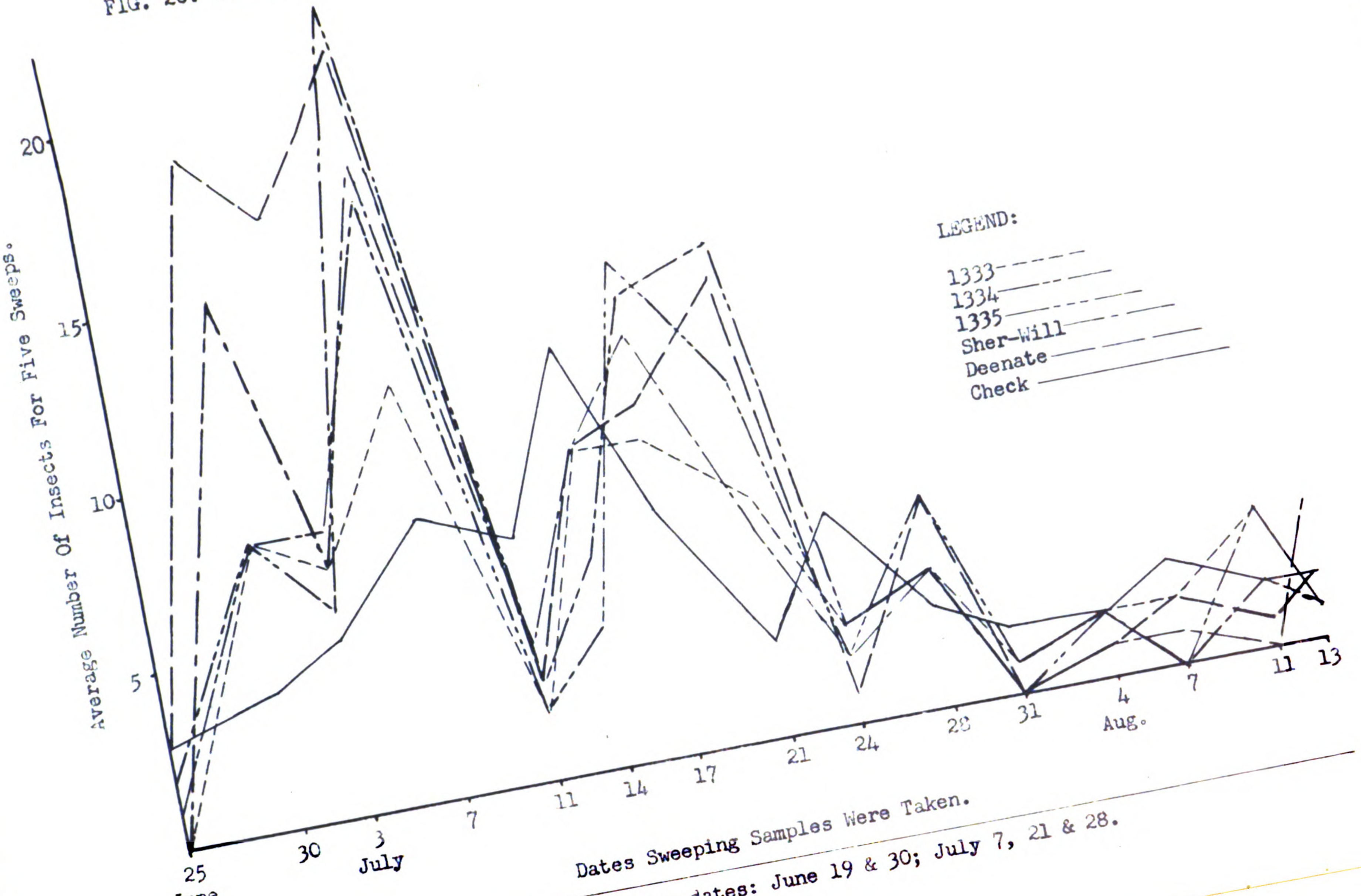
* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 19. NUMBER OF POTATO FLEA BEETLES ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 20. NUMBER OF SPITTLE BUGS ON POTATOES DURING TEST PERIOD OF SUMMER, 1952. *



* Spray application dates: June 19 & 30; July 7, 21 & 28.

FIG. 21. NUMBER OF POTATO LEAFHOPPERS ON BEANS AT VARIOUS DAYS AFTER SPRAYING.

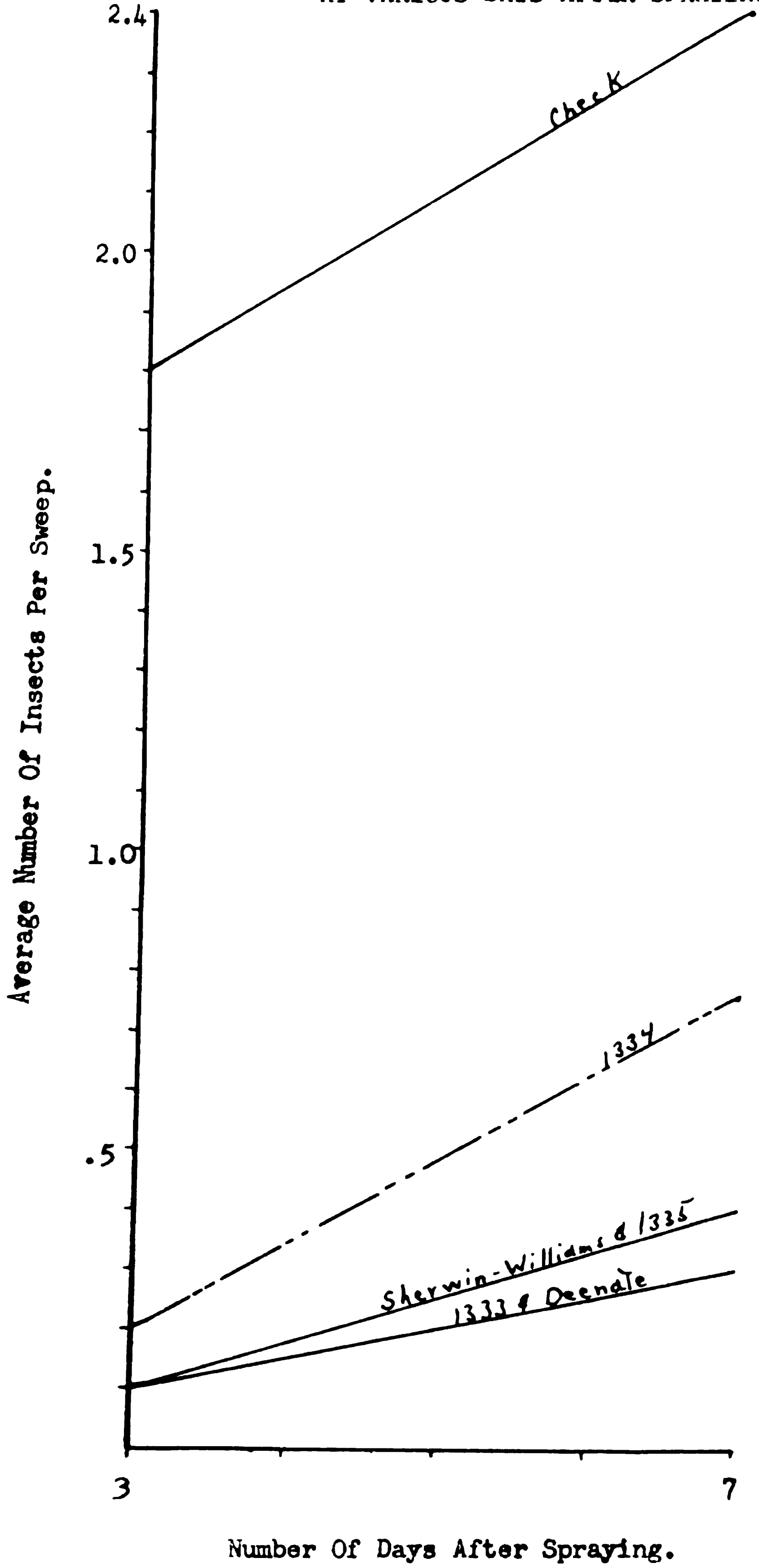


FIG. 22. NUMBER OF SIX-SPOTTED LEAFHOPPERS ON BEANS AT VARIOUS DAYS AFTER SPRAYING.

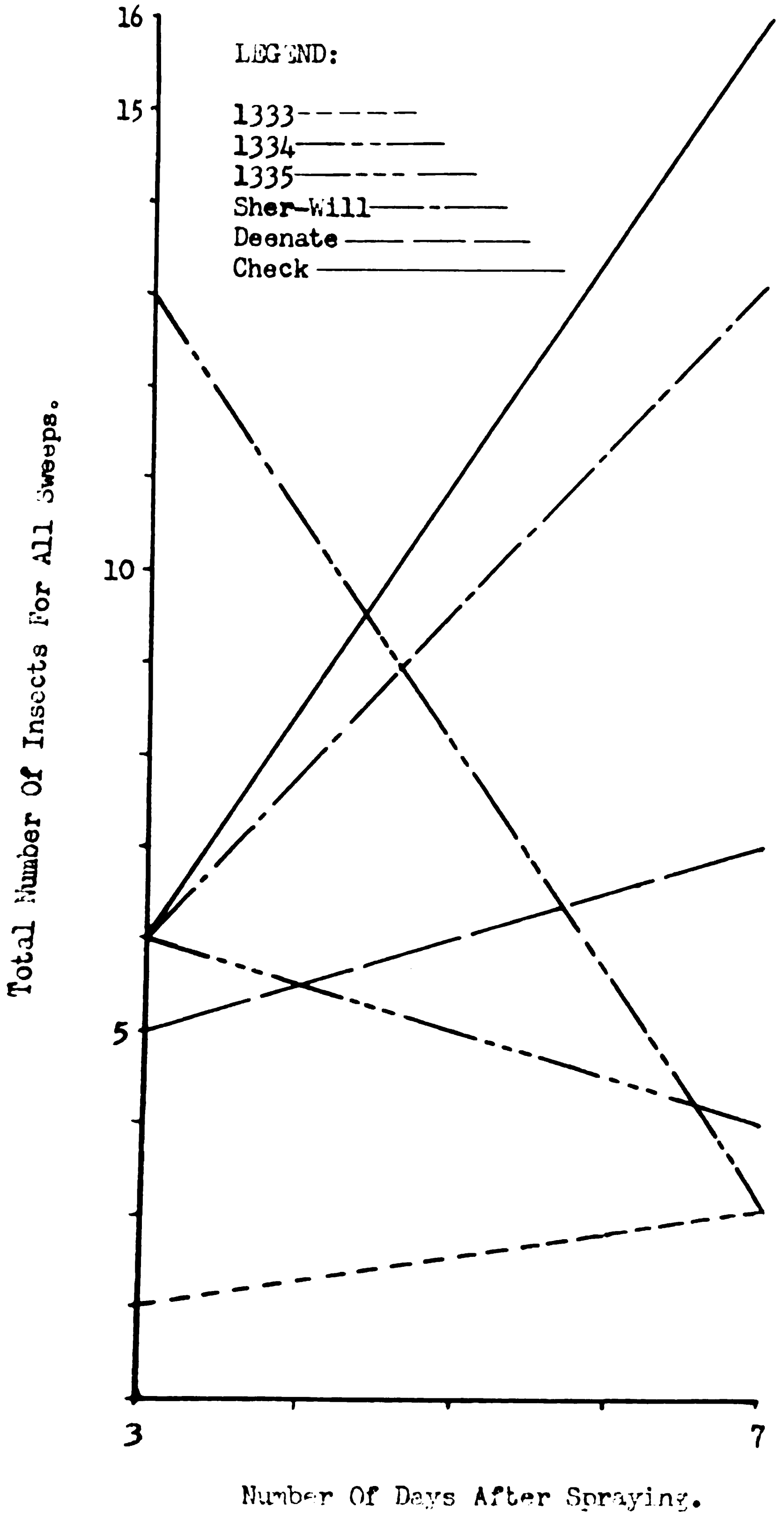


FIG. 23. NUMBER OF OTHER LEAFHOPPERS ON BEANS AT VARIOUS DAYS AFTER SPRAYING.

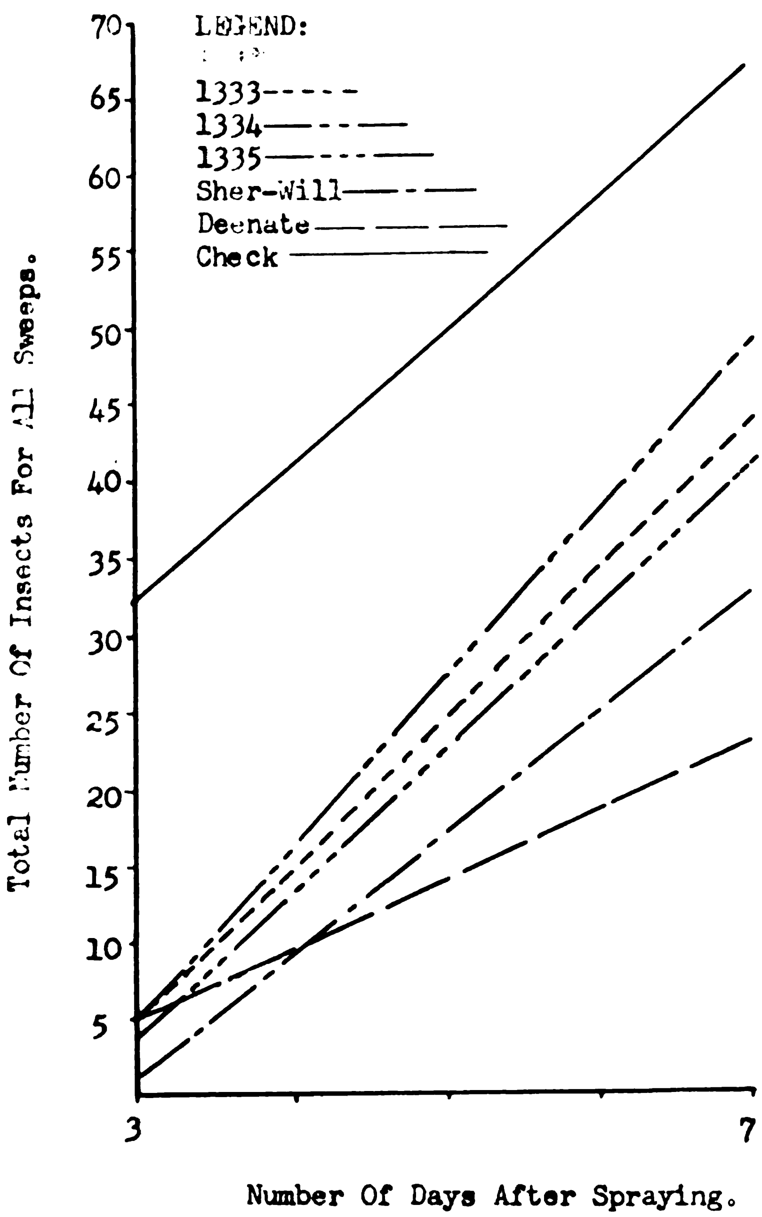


FIG. 24. NUMBER OF SPITTLE BUGS ON BEANS AT VARIOUS DAYS AFTER SPRAYING.

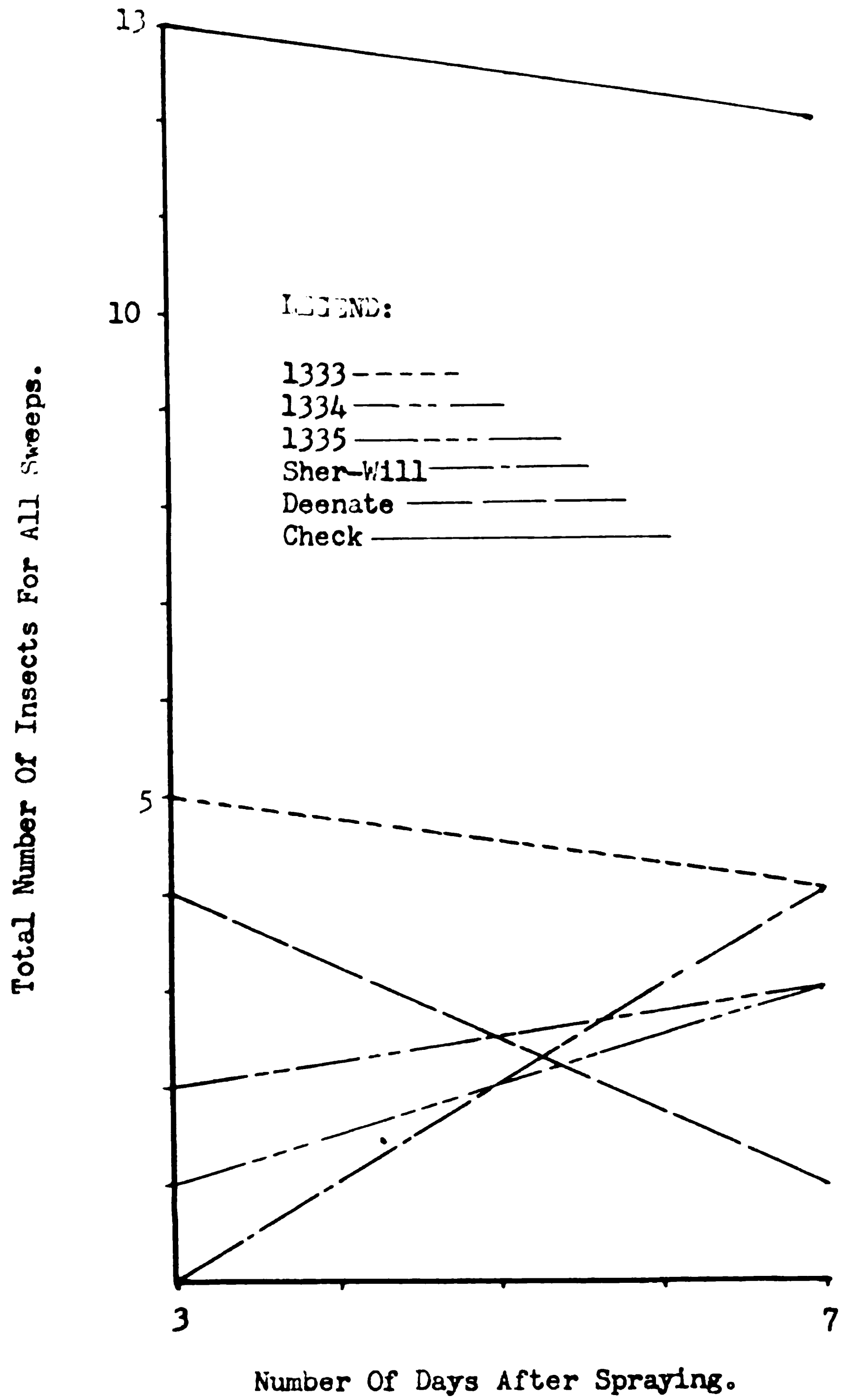


FIG. 25. NUMBER OF TARNISHED PLANT BUGS ON BEANS

AT VARIOUS DAYS AFTER SPRAYING.

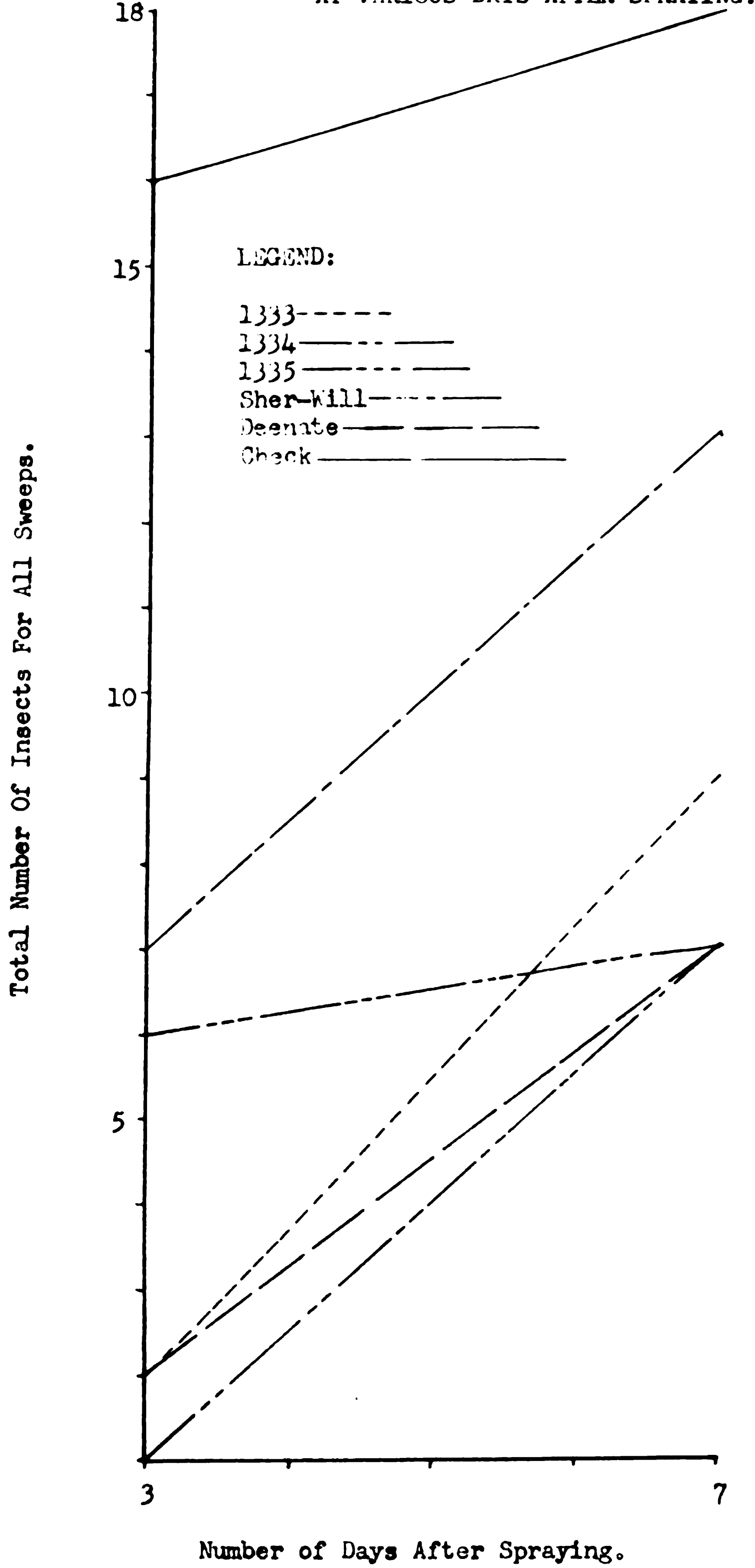


FIG. 26. NUMBER OF OTHER PLANT BUGS ON BEANS AT VARIOUS DAYS AFTER SPRAYING.

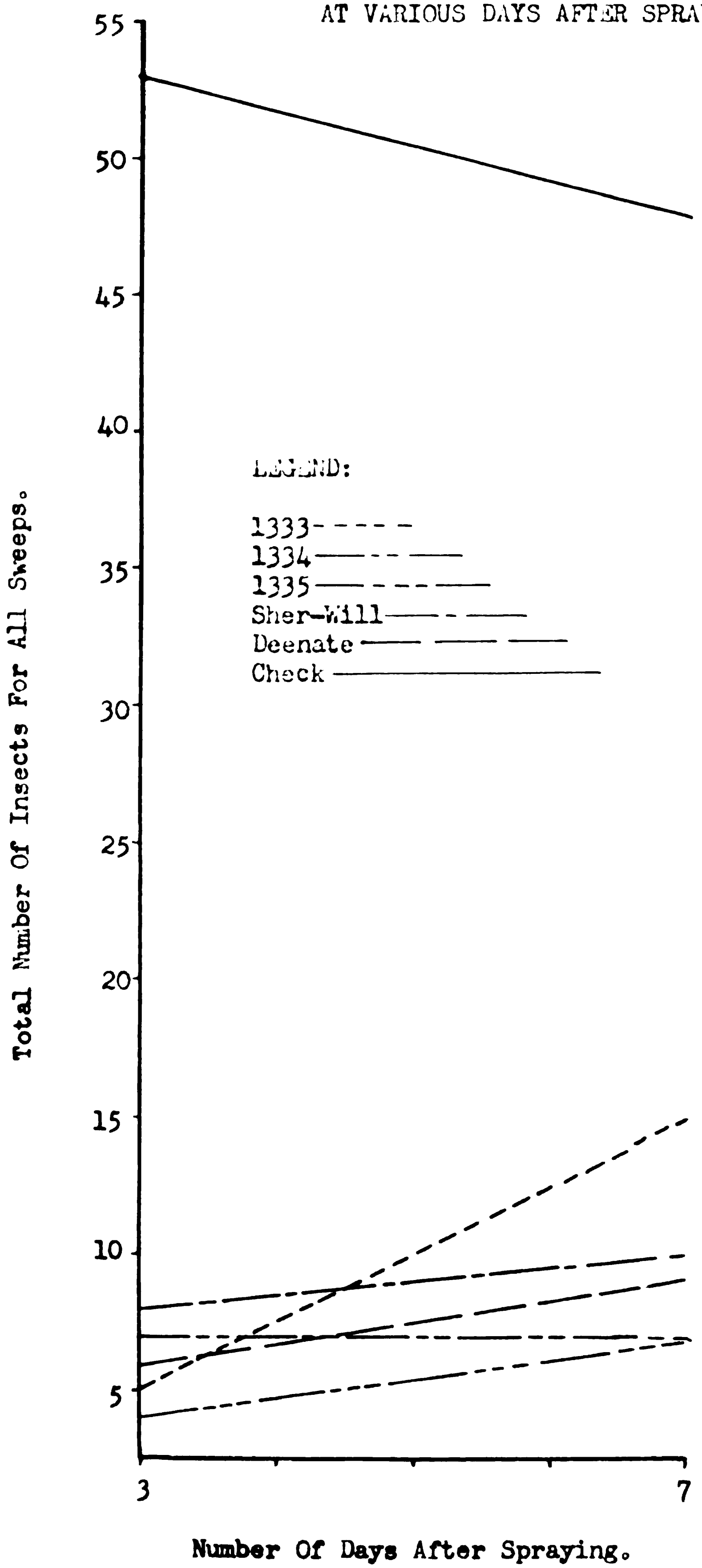


FIG. 27. NUMBER OF APHIDS ON BEANS

AT VARIOUS DAYS AFTER SPRAYING.

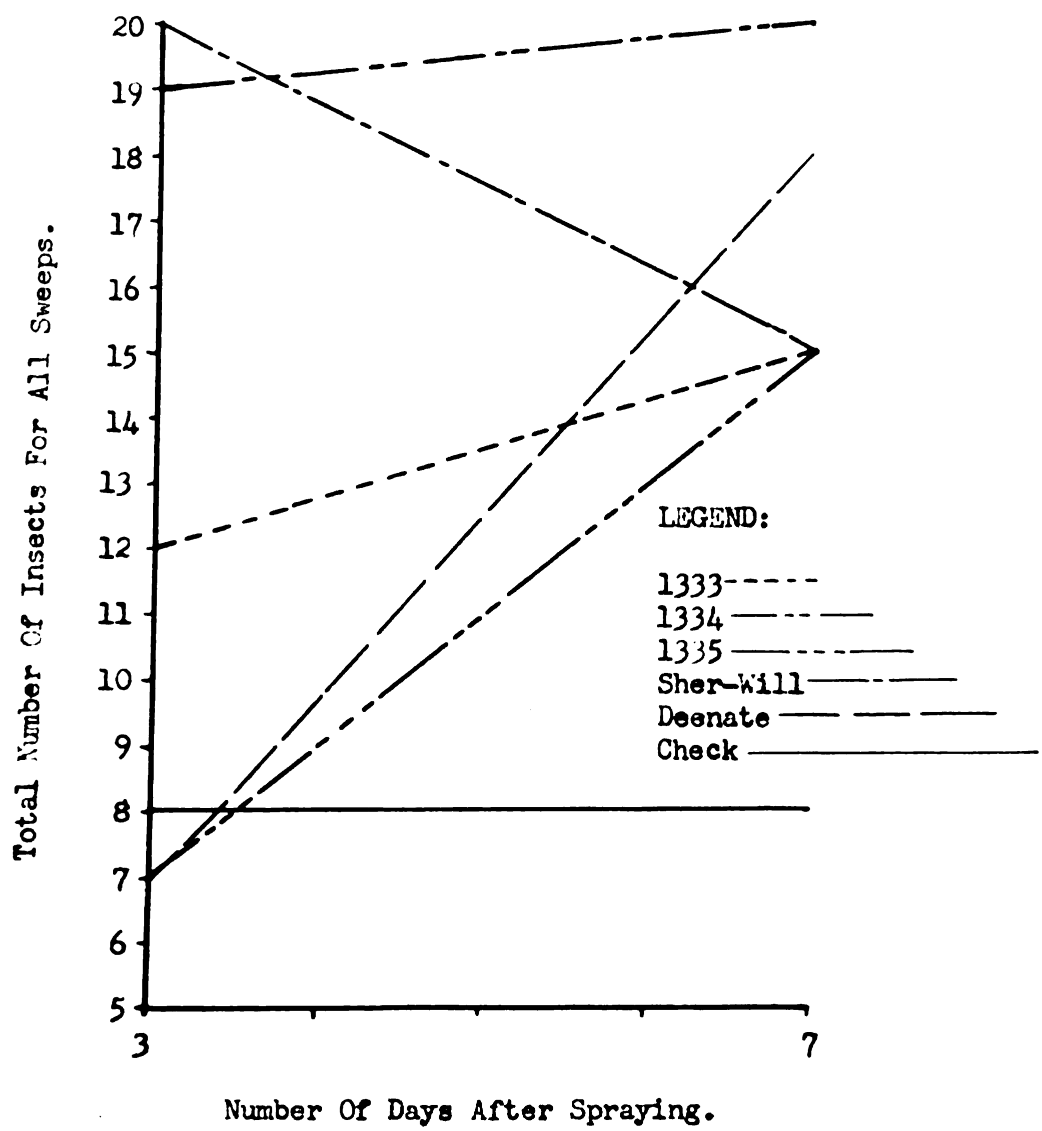


FIG. 28. NUMBER OF FLEA BEETLES ON BEANS

AT VARIOUS DAYS AFTER SPRAYING.

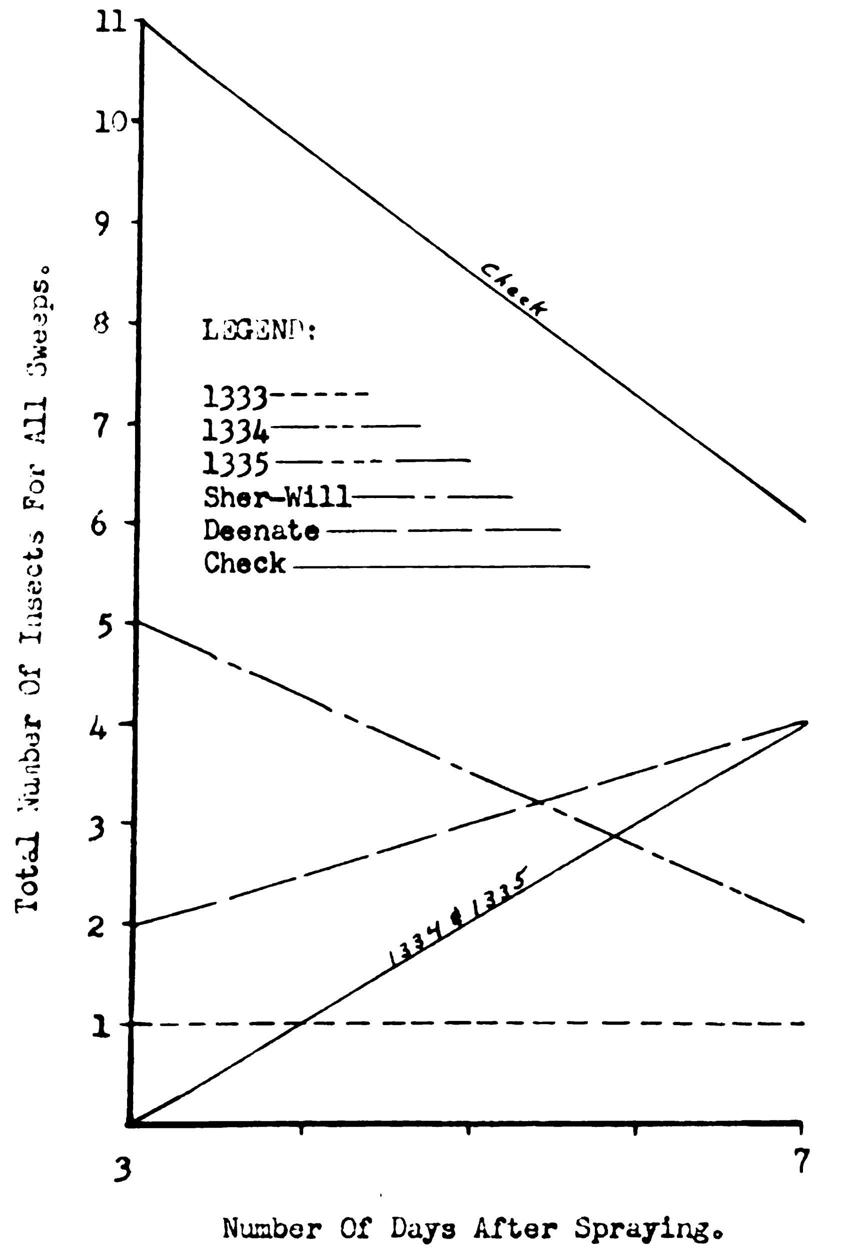
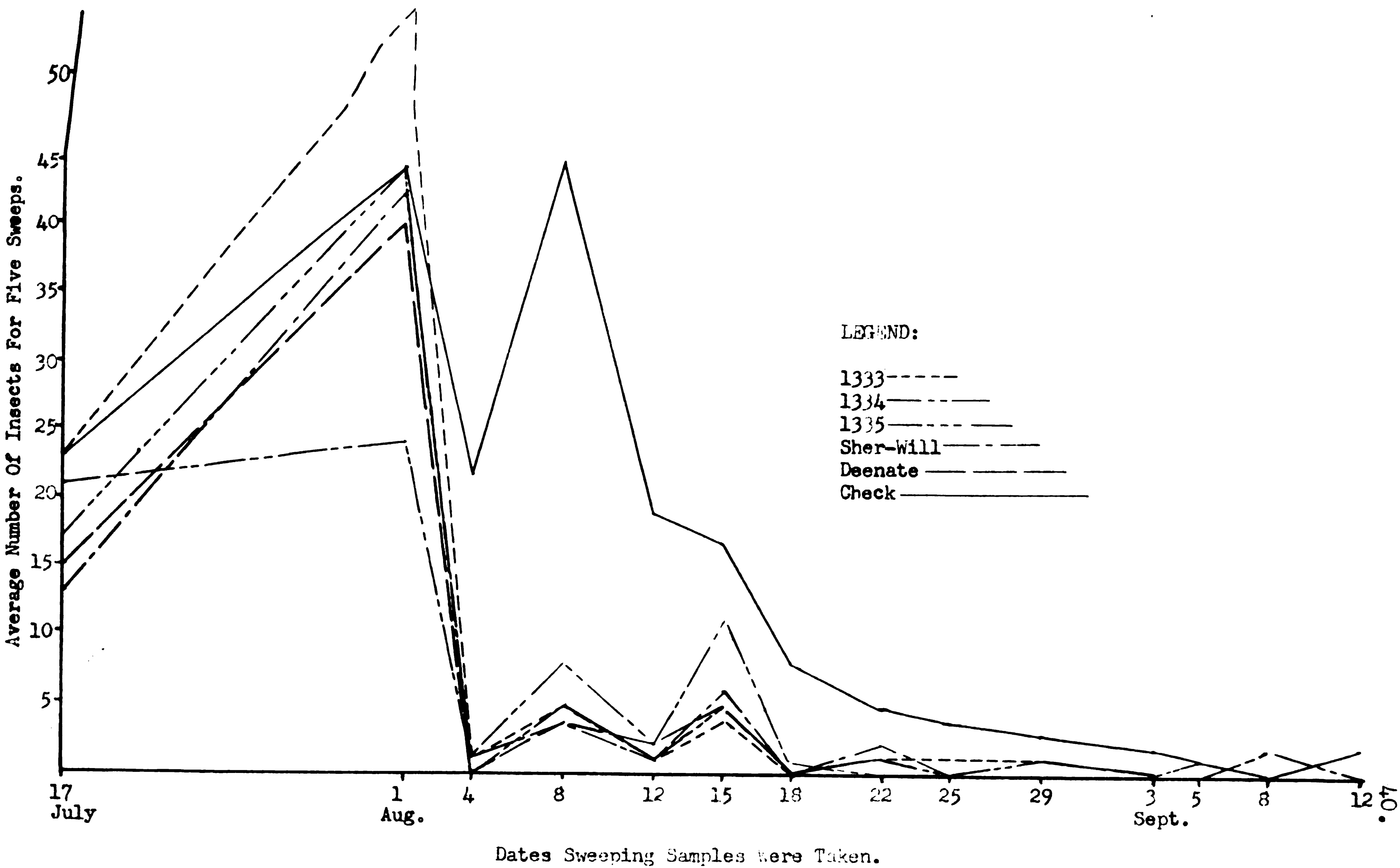


FIG. 29. NUMBER OF POTATO LEAFHOPPERS ON BEANS DURING TEST PERIOD OF SUMMER, 1952. *



* Spray application dates: August 1, 8, 15, 22 & 29; September 5 & 12.

TABLE I

PHYSICAL DATA OF FORMULATIONS TESTED

Obtained from Michigan Chemical Corporation, L.E. Pauling, representive. 9-23-52.

	1333	1334	1335	Deenate	50% Sherwin-Williams
% DDT	75.1	75.3	75.8	76.2	50.4
Average mean particle Diameter (microns)[1]	2.3	2.32	2.41	3.33	1.99
-200 mesh (dry)	100%	99.98%	99.98%	99.66%	100%
Suspension[2]	1.56%	0.35%	2.18%	0.055%	1.36%
pH[3]	7.20	7.30	7.24	7.92	7.98
Wettability[4]	-	Floc.	-	Floc.	-

[1] As determined by Fisher Sub-Sieve Sizer (Air Permeation Method).

[2] Figures show the actual % DDT left in suspension 30 minutes after the formation of a 2.5% DDT by weight suspension.

[3] Reaction of a 4% suspension (5g of the powder suspended in 120 gr. of distilled water).

[4] Appearance of scum or flocculation in a 4% suspension with tap water.

TABLE II

POTATO INSECTS

Days After Spraying	Total Number of Sweeps	Average Number Of Insects Per Sweep					
		PLOTS					
		Check	1333	Sher-Will	1334	Deenate	1335
		Potato Leafhoppers					
3	40	6.3	.6	.6	.5	.6	.4
7	50	9.2	1.6	.9	1.0	1.2	.9
10	40	7.7	1.9	1.2	1.6	1.3	1.7
14	30	13.6	5.4	2.5	2.5	2.7	5.6
17	20	8.6	3.3	1.9	1.8	1.9	1.8
21	10	14.6	10.2	5.8	4.2	4.5	6.4
		Six-Spotted Leafhoppers					
3	40	.4	.2	.2	.1	.2	.4
7	50	.3	.2	.4	.3	.2	.2
10	40	.3	.4	.2	.1	.3	.4
14	30	.8	.6	.4	.5	.8	.8
17	20	.3	.3	.4	.3	.5	.5
21	10	.5	.4	.7	.5	.5	.5
		Other Leafhoppers					
3	40	0	0	0	0	0	0
7	50	.3	.1	.2	.2	.2	.2
10	40	0	0	.1	.1	0	.1
14	30	.1	0	0	0	0	.1
17	20	.1	.1	0	.1	.1	.1
21	10	.1	.1	.1	0	.1	0

TABLE II CONTINUED

Days After Spraying	Total Number of Sweeps	Check	1333	Sher-Will	1334	Deenate	1335
		Average Number Of Insects Per Sweep					
		PLOTS					
		Spittle Bugs					
3	40	1.0	.6	.6	.6	.8	.6
7	50	1.1	1.0	1.1	1.3	1.6	1.2
10	40	.8	1.1	1.5	1.1	1.3	1.2
14	30	.7	1.6	1.1	1.5	1.5	1.5
17	20	1.0	1.0	1.2	.9	.8	1.2
21	10	.9	2.1	2.3	1.1	2.0	2.2
		Tarnished Plant Bugs					
3	40	1.0	.6	1.0	.5	.4	.5
7	50	.7	1.2	1.2	1.1	1.6	1.5
10	40	1.3	1.6	1.6	1.2	1.4	1.9
14	30	.8	1.4	1.1	.9	1.1	1.2
17	20	1.3	1.4	1.3	2.1	.9	1.3
21	10	.6	1.9	1.5	1.2	1.4	1.6
		Other Plant Bugs					
3	40	.1	0	0	.1	.1	.2
7	50	.4	.2	.2	.1	.9	.2
10	40	.5	.3	.4	.2	.3	.2
14	30	.6	.5	.3	.5	.4	.7
17	20	.6	.4	.4	.3	.3	.6
21	10	.5	.3	.2	.8	.5	1.0

TABLE II CONTINUED

Days After Spraying	Total Number of Sweeps	Average Number Of Insects Per Sweep					
		PLOTS					
		Check	1333	Sher-Will	1334	Deenate	1335
		Aphids					
3	40	1.0	1.8	2.0	1.6	1.9	1.7
7	50	1.0	2.3	2.3	1.8	2.4	2.2
10	40	2.0	5.7	8.0	9.7	5.5	6.3
14	30	2.9	8.6	11.4	17.3	12.3	10.8
17	20	15.4	29.5	24.3	30.7	35.9	20.6
21	10	.4	.8	1.0	1.2	1.5	1.4
		Flea Beetles					
3	40	.3	0	0	0	0	.1
7	50	1.2	.2	.1	.1	.1	.2
10	40	.8	.4	.1	.2	.2	.1
14	30	1.5	2.1	1.6	1.5	1.8	3.7
17	20	1.9	1.1	1.4	1.1	2.2	1.6
21	10	2.5	4.5	3.5	4.7	5.6	9.6

TABLE III

NUMBER OF POTATO LEAFHOPPERS ON POTATOES

Average Number Of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	----------------	----------------	No Record	----------------	----------------	----------------
June 30	18	16	11	13	9	22
July 3	84	9	11	10	10	3
July 7	75	16	10	12	15	16
July 10	21	2	1	15	1	2
July 14	74	11	8	4	6	5
July 17	97	16	9	16	14	7
July 21	133	54	23	23	28	60
July 24	19	2	1	1	2	4
July 28	67	12	4	7	8	5
July 31	3	0	0	0	0	1
Aug. 4	15	3	2	1	1	2
Aug. 7	20	2	1	1	0	3
ług. 11	15	2	1	3	2	4
ıg. 13	20	4	1	3	1	2

TABLE IV

NUMBER OF SIX SPOTTED LEAFHOPPERS ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	------------------No Record------------------					
June 30	0	2	0	0	2	2
July 3	2	1	1	1	1	1
July 7	1	2	1	0	1	2
July 10	2	0	1	1	1	3
July 14	2	2	4	5	3	3
July 17	3	4	2	0	2	4
July 21	4	3	2	2	2	4
July 24	2	3	2	0	3	2
July 28	5	1	6	2	2	2
July 31	2	1	1	0	1	3
Aug. 4	1	1	1	0	2	0
Aug. 7	1	0	1	1	0	1
ug. 11	0	1	0	0	1	0
g. 13	0	0	0	0	1	1

TABLE V

NUMBER OF LEAFHOPPERS OTHER THAN POTATO
AND SIX-SPOTTED LEAFHOPPERS
ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	6	2	6	4	5	3
June 30	0	1	1	2	0	0
July 3	0	0	0	0	0	0
July 7	0	0	0	0	0	0
July 10	1	0	0	0	0	0
July 14	0	0	0	1	1	2
July 17	0	0	0	0	0	0
July 21	1	0	1	0	0	0
July 24	0	0	0	0	0	0
July 28	1	0	0	0	1	1
July 31	0	1	0	0	0	1
ug. 4	1	0	0	0	0	0
g. 7	0	0	0	0	0	0
g. 11	0	0	0	0	0	0
. 13	0	1	0	1	1	0

TABLE VI

NUMBER OF APHIDS ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	1	0	2	2	2	1
June 30	1	3	0	2	2	3
July 3	5	5	6	1	2	5
July 7	4	12	8	5	11	7
July 10	4	16	12	15	10	9
July 14	8	21	6	4	11	3
July 17	7	9	6	7	8	5
July 21	6	6	7	9	6	6
July 24	6	10	5	3	8	4
July 28	5	8	9	10	10	7
July 31	6	6	18	13	18	15
Aug. 4	8	18	32	25	27	39
Aug. 7	29	92	149	181	96	114
Aug. 11	35	117	159	247	176	151
Aug. 13	148	286	191	304	354	204

TABLE VII

NUMBER OF TARNISHED PLANT BUGS ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	0	2	3	1	3	2
June 30	11	14	13	11	14	14
July 3	10	4	8	7	5	5
July 7	5	17	11	15	22	21
July 10	6	7	10	2	4	3
July 14	6	9	12	8	12	13
July 17	7	12	12	10	8	15
July 21	5	8	7	6	7	8
July 24	4	1	2	2	2	2
July 28	6	4	4	5	2	3
July 31	1	1	1	0	1	0
Aug. 4	2	1	2	0	2	0
Aug. 7	5	1	1	1	3	3
Aug. 11	3	2	2	2	1	0
Aug. 13	6	3	3	0	2	2

TABLE VIII

NUMBER OF PLANT BUGS OTHER THAN TARNISHED PLANT BUGS ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 30	1	2	3	1	0	1
July 3	1	0	1	0	1	0
July 7	5	1	2	1	3	2
July 10	1	0	0	1	0	1
July 14	3	1	2	1	3	3
July 17	7	3	5	3	5	2
July 21	4	5	2	5	3	6
July 24	1	0	0	1	1	3
July 28	2	1	2	1	2	1
July 31	0	0	0	0	0	0
Aug. 4	2	1	0	0	0	1
Aug. 7	1	0	1	0	0	1
Aug. 11	1	0	0	1	1	0
Aug. 13	1	0	0	0	0	1

TABLE IX

NUMBER OF FLEA BEETLES ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 3	1	0	0	0	0	0
July 7	0	0	0	0	0	0
July 10	0	0	0	0	0	0
July 14	1	0	0	0	0	0
July 17	7	1	3	3	3	2
July 21	14	30	24	21	25	53
July 24	3	1	0	0	0	1
July 28	18	4	3	3	4	5
July 31	2	0	0	0	0	0
Aug. 4	13	0	0	0	0	1
Aug. 7	10	2	0	1	0	0
Aug. 11	8	0	0	1	0	0
Aug. 13	8	2	0	0	1	1

TABLE X

NUMBER OF SPITTLE BUGS ON POTATOES

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
June 25	3	0	0	1	3	2
June 30	4	8	15	8	14	8
July 3	5	7	7	6	12	8
July 7	8	12	18	22	21	17
July 10	7	2	4	3	3	2
July 14	12	9	9	6	9	4
July 17	7	9	12	13	10	14
July 21	3	7	6	14	13	10
July 24	6	3	2	3	1	2
July 28	3	4	4	4	6	6
July 31	2	1	0	0	0	1
Aug. 4	2	2	1	2	1	2
Aug. 7	3	2	1	0	2	0
Aug. 11	2	4	0	2	1	4
Aug. 13	2	1	4	1	2	1

TABLE XI

POTATO YIELD IN BUSHELS PER ACRE

Based On One Bushel Equals Sixth Pounds

	PLOTS					
Replicate	Check	1333	Sher-Will	1334	Deenate	1335
			Grade - U.S. No. 1			
1	146	354	384	436	498	318
2	383	281	475	482	342	535
3	465	628	352	442	451	421
4	563	604	556	531	449	359
Average	389	467	442	473	435	408
			Grade - U.S. No. 2			
1	33.2	33.2	30.2	25.7	24.2	36.3
2	36.3	30.2	39.3	30.3	36.2	43.9
3	36.3	33.2	43.9	33.2	30.3	24.2
4	42.4	13.6	36.3	27.2	36.3	13.6
Average	37.0	27.6	37.4	29.1	31.8	29.5

TABLE XII

BEAN INSECTS

Days After Spraying	Total Number of Sweeps	Average Number Of Insects Per Sweep — PLOTS: Check	1333	Sher-Will	1334	Deenate	1335
		Potato Leafhoppers					
3	144	1.8	.1	.1	.1	.1	.1
7	144	2.4	.3	.4	.7	.3	.4
		Six-Spotted Leafhoppers					
3	144	.0	0	0	.1	0	0
7	144	.1	0	.1	0	0	0
		Other Leafhoppers					
3	144	.2	0	0	0	0	0
7	144	.5	.3	.2	.3	.2	.3
		Spittle Bugs					
3	144	.1	0	0	0	0	0
7	144	.1	0	0	0	0	0
		Tarnished Plant Bugs					
3	144	.1	0	0	0	0	0
7	144	.1	.1	.1	0	0	0
		Other Plant Bugs					
3	144	.4	0	.1	0	0	0
7	144	.3	.1	.1	0	.1	0

TABLE XII CONTINUED

Days After Spraying	Total Number of Sweeps	Average Number Of Insects Per Sweep — PLOTS: Check	1333	Sher-Will	1334	Deenate	1335
					Aphids		
3	144	.1	.1	.1	.1	0	0
7	144	.1	.1	.1	.1	.1	.1
					Flea Beetles		
3	144	.1	0	0	0	0	0
7	144	0	0	0	0	0	0
					Mexican Bean Beetles		
3	144	0	0	0	0	0	0
7	144	0	0	0	0	0	0

TABLE XIII

NUMBER OF POTATO LEAFHOPPERS ON BEANS

Average Number of Insects For Five Sweeps

				PLOTS		
Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	23	23	13	21	15	17
Aug. 1	44	54	42	24	40	44
Aug. 4	22	1	1	1	0	0
Aug. 8	45	5	4	8	4	5
Aug. 12	19	1	1	2	2	1
Aug. 15	17	4	6	11	5	5
Aug. 18	8	0	0	1	0	0
Aug. 22	5	1	2	0	0	1
Aug. 25	4	1	0	0	0	0
Aug. 29	3	1	0	1	0	0
Sept. 3	2	0	0	0	0	0
Sept. 5	1	0	0	0	0	1
Sept. 8	0	0	0	2	0	0
Sept. 12	2	0	0	0	0	0

TABLE XIV

NUMBER OF SIX SPOTTED LEAFHOPPERS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	13	1	2	11	3	3
Aug. 1	3	4	2	3	3	5
Aug. 4	1	0	0	0	1	0
Aug. 8	3	0	2	0	1	1
Aug. 12	0	0	1	1	0	1
Aug. 15	0	0	0	0	1	0
Aug. 18	0	0	0	1	0	0
Aug. 22	0	0	0	0	0	0
Aug. 25	0	0	0	0	0	0
Aug. 29	0	0	0	0	0	0
Sept. 3	0	0	0	0	0	0
Sept. 5	0	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	0	0	0	0	0	0

TABLE XV

NUMBER OF LEAFHOPPERS OTHER THAN POTATO AND SIX-SPOTTED LEAFHOPPERS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	3	1	1	2	1	1
Aug. 1	1	0	0	1	1	1
Aug. 4	0	0	0	0	0	0
Aug. 8	1	0	0	1	0	0
Aug. 12	1	0	0	0	0	0
Aug. 15	1	1	0	1	0	1
Aug. 18	1	0	0	0	0	0
Aug. 22	2	1	0	1	0	1
Aug. 25	4	1	1	1	0	1
Aug. 29	7	6	5	7	3	6
Sept. 3	1	0	0	0	0	0
Sept. 5	2	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	2	0	0	0	1	0

TABLE XVI

NUMBER OF APHIDS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	2	0	0	0	0	0
Aug. 1	3	1	1	1	2	0
Aug. 4	0	1	2	1	0	0
Aug. 8	0	1	0	1	0	0
Aug. 12	0	0	0	0	0	0
Aug. 15	0	0	0	0	1	0
Aug. 18	1	1	2	1	1	0
Aug. 22	1	1	1	0	1	0
Aug. 25	0	0	0	0	0	1
Aug. 29	0	1	2	2	1	2
Sept. 3	0	0	0	0	0	0
Sept. 5	0	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	0	0	0	0	0	0

TABLE XVII

NUMBER OF TARNISHED PLANT BUGS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	4	2	1	1	1	1
Aug. 1	0	1	1	1	2	0
Aug. 4	2	0	0	0	0	0
Aug. 8	1	1	1	0	0	0
Aug. 12	0	0	0	0	0	0
Aug. 15	1	0	0	1	0	0
Aug. 18	1	0	1	0	0	1
Aug. 22	1	0	0	0	0	0
Aug. 25	0	0	0	0	0	0
Aug. 29	0	0	1	0	0	0
Sept. 3	0	0	0	0	0	0
Sept. 5	0	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	1	0	0	0	0	0

TABLE XVIII

NUMBER OF OTHER PLANT BUGS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	8	7	3	3	3	5
Aug. 1	6	2	10	4	4	4
Aug. 4	2	0	0	0	0	0
Aug. 8	2	0	1	0	0	1
Aug. 12	5	0	0	0	0	0
Aug. 15	1	0	0	0	0	0
Aug. 18	2	0	1	0	0	0
Aug. 22	1	0	0	0	0	0
Aug. 25	2	0	0	1	0	0
Aug. 29	3	2	0	1	1	0
Sept. 3	1	0	0	0	0	0
Sept. 5	1	0	0	0	0	0
Sept. 8	1	0	0	0	0	0
Sept. 12	2	1	1	0	0	0

TABLE XIX

NUMBER OF FLEA BEETLES ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	1	0	0	0	0	1
Aug. 1	0	0	1	1	0	0
Aug. 4	0	0	0	0	0	0
Aug. 8	0	0	0	0	0	0
Aug. 12	1	0	0	0	0	0
Aug. 15	0	0	0	0	0	0
Aug. 18	1	0	0	0	0	0
Aug. 22	0	0	0	0	0	0
Aug. 25	0	0	0	0	0	0
Aug. 29	0	0	0	1	0	0
Sept. 3	0	0	0	0	0	0
Sept. 5	0	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	0	0	0	0	0	0

TABLE XX

NUMBER OF SPITTLE BUGS ON BEANS

Average Number of Insects For Five Sweeps

PLOTS

Date	Check	1333	Sher-Will	1334	Deenate	1335
July 17	3	1	1	1	1	1
Aug. 1	2	1	1	1	0	1
Aug. 4	2	0	0	0	0	0
Aug. 8	1	0	0	0	0	0
Aug. 12	0	0	0	0	0	0
Aug. 15	0	0	0	0	0	0
Aug. 18	0	0	0	0	0	0
Aug. 22	1	0	1	0	0	1
Aug. 25	0	0	0	0	0	0
Aug. 29	1	0	0	0	0	0
Sept. 3	0	0	0	0	0	0
Sept. 5	0	0	0	0	0	0
Sept. 8	0	0	0	0	0	0
Sept. 12	0	0	0	0	0	0

DISCUSSION

The five formulations of DDT that were used in this work were of three types, generally speaking. Michigan Chemical Corporation's 1334 and E. I. du Pont de Nemours and Company's Deenate were of the flocculating type; Michigan Chemical Corporation's 1333 and Sherwin Williams Company's formulation were of the intermediate suspension type; and Michigan Chemical Corporation's 1335 was of the high suspension type.

Sankeur (24), in his report in 1952, stated that Michigan Chemical Corporation's 1334 and E. I. du Pont de Nemours and Company's Deenate were similar in amounts initially deposited and retained but were inferior to the other three preparations. He further stated that Michigan Chemical Corporation's 1335 resembled in behavior the Sherwin-Williams Company's product but that the former product was generally superior to all of the others in amounts initially retained. He found that Michigan Chemical Corporation's 1333 and Sherwin-Williams Company's product were superior in lasting qualities with the former being superior to all others in lasting qualities and inferior to all others in amounts initially deposited. He also found from the analysis of samples from unsprayed plots that drift was an important factor.

This study was primarily concerned with three specific insects and members of five families of insects that were found on both potatoes and beans. These were the potato leafhopper, the six-spotted leafhopper, the tarnished plant bug, other members of the families Cicadellidae and Miridae, members of the family Aphididae, adults of the family Cercopidae, and flea beetle adults of the family Chrysomelidae.

POTATOES:

Very definite and good control was obtained for the potato leafhopper. In all cases populations of this insect on the sprayed plots remained below the populations on the check plot. Control of this insect varied little with the formulation used up to ten days after spraying (see Fig. 6). After ten days, variations appeared, but the data was insufficient to justify any comparisons. Drift apparently affected the populations of this insect on the check plot (see Fig. 14).

The populations of the six-spotted leafhopper showed that this insect was rather evenly dispersed throughout the field regardless of spraying (see Fig. 7). Spraying did affect the populations to varying degrees throughout the testing period (see Fig. 15). Based on the populations on the check plot DDT gave poor control of this insect (see Table IV). Drift may have obscured the true results in this case.

DDT gave some control of the other leafhoppers found on potatoes. The difference in populations on the sprayed plots and the check plot were slight (see Fig. 8).

In most instances the spittle bug populations were greater on the sprayed plots than the populations on the check plot (see Fig. 9). This can be explained most clearly by the habits of the adult spittle bugs. These insects move about and are easily disturbed. The disturbance caused by spraying may have caused many to move to the weeds bordering the field or the spray may have killed those that were on the potatoes at the time of spraying. In either case the insects would move into the field again after a period of time had elapsed and settle on the more succulent foliage of the sprayed plants (see Fig. 20).

The tarnished plant bug populations behaved in much the same way as did those of the spittle bugs (see Fig. 10). These insects are strong fliers and readily disturbed and may have flown to the weeds during spraying operations and returned later. These insects require meristematic tissue to oviposit in and would naturally collect on the more succulent foliage of the sprayed plants. Spraying either controlled the insects present at the time of spraying or caused them to leave the field and remain for a short time (see Fig. 17).

The other plant bugs found on potatoes appeared to be controlled to some extent by DDT (see Fig. 11). These insects may have behaved in nearly the same manner as the preceeding two, but in most instances populations on the sprayed plots were lower than those on the check plot (see Fig. 18).

Aphids appeared to benefit from spraying with DDT. The data show clearly that aphid populations were generally higher on the sprayed plots than on the check plot (see Figs. 12 & 16).

Aphid populations continued to increase on the sprayed plots at a much faster rate throughout the testing period than they did on the check plot. These facts verified previous findings that DDT wettable powders give little or no control of aphids. Apparently, at the rate applied, DDT kills the parasites and predators that prey on the aphids but not enough aphids to lower the reproductive potential markedly.

The flea beetles on potatoes were definitely controlled by DDT. Good control was obtained up to ten days after spraying (see Fig. 13). Populations then increased rapidly if no DDT was applied. Drift appeared to influence the numbers of these insects on the check plot to a large extent (see Fig. 19).

The various formulations did not seem to vary too much in the amount of control they gave. In all instances the sprayed plots gave higher average yields of U. S. No. 1 potatoes than did the check plot. The plot receiving Michigan Chemical Corporation's 1335 did not give an average yield much higher than the check plot, but both of these plots had one replicate which bordered on weedy margins of the field. These two plots received a greater amount of insect damage because the migration of insects from the weeds into the field would have come primarily through the replicates which bordered the weeds.

BEANS:

At the rate applied, DDT gave excellent control of potato leafhoppers on beans (see Fig. 21). Drift may have influenced the populations of this insect on the check plot, but not to the extent that it did on the potatoes (see Fig. 29).

The populations of the six-spotted leafhopper were small throughout the testing season. After spraying started, this insects' numbers were reduced to practically nothing and remained low during the rest of the testing period (see Table XIV). Apparently the heavy rate of application was the chief reason for such complete control.

DDT gave good control of the other leafhoppers found on the beans. In most cases the sprayed plots had populations below those of the check plot (see Table XV). There was a marked increase in these insects on August 29 although only seven days had elapsed since the last spray application (see Table XV). Good control was obtained up to seven days after spraying (see Fig. 23).

Good control of spittle bugs was obtained. The insect populations remained low for at least seven days after spraying (see Fig. 24). Migration into the plots after spraying did not seem to be a factor.

Fair control of the tarnished plant bug was obtained also. The numbers of insects on the sprayed plots remained below the numbers of this insect on the check plot although they built up faster than the spittle bugs did (see Fig. 25). Migration onto the plots was probably a larger factor in this case.

DDT gave very good control of the other plant bugs on

beans. Populations on sprayed plots remained low for at least seven days after spraying (see Fig. 26). After spraying had started, populations on the check plot were always higher than populations on the sprayed plots although in most cases the difference was small (see Table XVIII).

The aphid population was of low density throughout the test period (see Table XVI). Only winged forms were observed or collected. DDT had little or no apparent effect on the aphids unless it was to attract them to the sprayed plots because of the white powder which remained as a residue from spraying (see Fig. 27).

The populations of flea beetles were low on all plots. DDT apparently gave some control but the numbers of insects were quite low and it would be difficult to state the effects exactly (see Fig. 28).

CONCLUSIONS AND SUMMARY

1. The populations of insects were in general smaller on the beans and larger on the potatoes. This was most likely due to the great differences in the rates of application of the spray materials.

2. Drift had a greater effect on the potatoes than it did on the beans.

3. No apparent difference was great enough in the control obtained by any of the formulations used to allow the recommendation of any one of them over the rest collectively or any one singly.

4. Good control was obtained for the potato leafhopper on both the potatoes and beans.

5. Little if any control seemed to be obtained for the six-spotted leafhopper on potatoes while good control was obtained for this insect on beans.

6. Good control of other leafhoppers was obtained on both potatoes and beans.

7. Spittle bug control was questionable on the potatoes, migration being a possible factor. On beans, good control of spittle bugs was obtained.

8. Control of the tarnished plant bug followed the same pattern as the control of spittle bugs, being questionable on potatoes and good on beans.

9. Only fair control was obtained for other plant bugs on potatoes whereas good control was obtained for them on beans.

10. Aphids appeared to benefit by the spraying of DDT on potatoes. Aphid populations were higher on the sprayed plots than on the check plot. The populations of this insect were insufficient on the bean plots to allow a definite statement.

11. Definite and good control of flea beetles resulted from the application of DDT on potatoes. Not enough flea beetles were present on beans to warrant a definite statement, but DDT apparently gave some control of this insect on these plants.

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