BULLETIN No. 702 JUNE, 1942

New York State Agricultural Experiment Station

Geneva, N. Y.

SPRAYING AND DUSTING EXPERIMENTS WITH BUSH LIMA BEANS ON LONG ISLAND FOR CONTROL OF THE MEXICAN BEAN BEETLE

H. C. HUCKETT

PUBLISHED BY THE STATION
UNDER AUTHORITY OF CORNELL UNIVERSITY

ABSTRACT

A summarized report is presented of field experiments carried on during the seasons of 1936 to 1941, both inclusive, for the purpose of noting the comparative merits of sprays and dusts containing pyrethrum and rotenone-bearing powders for control of the Mexican bean beetle on lima beans. The study was extended to include tests of fungicidal-insecticidal mixtures containing copper sulfate and copper oxychloride.

Comparisons were drawn between sprays based on skimmilk powder, wettable sulfur, copper oxychloride, and bordeaux mixture, respectively, and between dusts based on clay or talc, sulfur, copper oxychloride, and monohydrated copper sulphate-hydrated lime, respectively. Rotenone sprays contained 4 pounds of rotenone-bearing powder in 100 gallons of water, the rotenone strength of which ranged from 0.019 to 0.0262 per cent according to yearly differences in analytical content of fresh samples of powder. Pyrethrum sprays contained 8 or 4 pounds of pyrethrum powder (0.9 per cent pyrethrins) in 100 gallons of water, the pyrethrin strengths of which were 0.009 and 0.0045 per cent, respectively. Rotenone dusts contained 10 pounds of rotenone-bearing powder in 100 pounds of dust, the rotenone strengths of which ranged from 0.475 to 0.59 per cent, being prepared from the same samples of powder as for sprays. Pyrethrum dusts contained 0.54 and 0.49 per cent pyrethrins, the powder being taken from the same samples as for sprays, except in 1941. Limited tests were made of impregnated dusts containing 0.2 per cent pyrethrin strength and 0.12 per cent rotenone strength, respectively.

Results from spraying showed that copper sprays on their own merits were superior to sulfur sprays for foliage protection. Yields from copper treatments were satisfactory in 1937 and 1938, but not so in 1936 and 1940, and only partly so in 1941. Pyrethrum or rotenone-bearing powder added to copper sprays served to increase their effectiveness in foliage protection slightly, but such improvement did not invariably result in higher yields than that obtained from copper treatments alone. Sulfur sprays were considerably improved by the addition of rotenone-bearing powder as expressed in terms of foliage protection and yield of pods. There was no instance of reduced yields from such treatments as with bordeaux mixture. Rotenone sprays were more effective than pyrethrum sprays when used with wettable sulfur or skimmilk powder.

Results from dusting as expressed in yield tended to be inferior to those from spraying, except that there were no notable yield decreases with copper-lime dusts during 1936 and 1940 as with bordeaux mixture. In general, dusts as applied were not as effective as sprays for foliage protection against the Mexican bean beetle. In 1940 and 1941, when foliage parasites were not a factor, the yield was less depressed on account of copper dusts as compared to copper sprays.

Bulletin No. 702

SPRAYING AND DUSTING EXPERIMENTS WITH BUSH LIMA BEANS ON LONG ISLAND FOR CONTROL OF THE MEXICAN BEAN BEETLE

H. C. HUCKETT

INTRODUCTION

DURING the past decade the successful production of lima beans on Long Island has become an arduous task owing to the increasing economic importance of the Mexican bean beetle (*Epilachna varivestis* Mulsant). Previous to this time the raising of beans had progressed with little thought as to the need or expense of spraying or dusting to control insects. Isolated instances are on record in which sulfur was used to combat red spider mite (*Tetranychus* spp.) and nicotine to control the bean aphid (*Aphis rumicis* L.), but no regular program of insect control had been contemplated comparable to that which had recently been proposed for diseases (1).[1] The arrival of the Mexican bean beetle made it expedient that attention be given to the possibility of extending such operations to include protective measures against the newly introduced pest.

The Mexican bean beetle was first noticed at Selden (6) in 1928 on snap beans and has since spread to nearly all places where beans are grown commercially on Long Island. Early attempts to control the insect were carried out successfully by means of sprays and dusts containing fluosilicate and arsenical compounds, applied with or without the addition of a fungicide (7). These insecticides have largely been dispensed with recently in favor of products manufactured from the roots of rotenone-bearing plants, commonly referred to as derris, cubé, or timbo powder (12, 13). The success of such a change in the use of insecticides came about largely thru a desire on the part of bean growers to avoid risks attached to the employment of materials that are capable in practice of leaving residues on the marketed product in excess of that permitted by law, especially in so far as such might jeopardize the orderly procedure of cooperative methods in marketing the crop.

For some years now insecticidal sprays and dusts containing

[1]Figures in parenthesis refer to Literature Cited, page 44.

rotenone-bearing powders have been employed successfully as a means of combatting the Mexican bean beetle (11). The active constituents of such powders, particularly rotenone, are regarded as chemically incompatible with spray or dust mixtures possessing an alkaline chemical reaction, such as bordeaux mixture or copper-lime dusts, hence the feasibility of using such insecticides and fungicides in a common program of insect and disease control seemed doubtful, to say the least. However, preliminary trials in the field had given no such adverse results as would signify the elimination of such a proposition from practical consideration (8). In view of the present importance attached to the use of rotenone-bearing products as an insecticide and of copper-lime sprays and dusts as a fungicide, it seemed highly desirable that information regarding the possibility of using such materials in the field should be based on the results from a more extensive series of experiments.

What was applicable to rotenone-containing products was also true of pyrethrin-containing products; and since the latter insecticide was also being used and recommended for Mexican bean beetle control, there seemed the additional need for fuller information regarding the comparative merits of the two insecticides under local conditions.

SEASONAL ACTIVITIES OF PESTS

The Mexican bean beetle normally emerges from hibernation during May and June in the vicinity of woodlands, hedge rows, waste land, and the debris accumulated around farm buildings. (See Fig. 1.) Adults migrate on mild days to fields of early planted beans to satisfy their hunger and to take advantage of conditions corducive to the requirements of successful propagation.

Egg laying occurs during May and June, its progress being more rapid in the western half of Long Island owing to the prevailing warmer temperatures during the day. From mid-June to early July it is not unusual for eggs to commence hatching in such numbers as to provide a larval population that seriously threatens the healthy condition of the foliage. (See Fig. 2.) The first generation of larvae become destructive as soon as most of the grubs become more than half grown, which is usually during the latter half of June or in early July. At such times a few of the more mature larvae may have commenced to pupate. This phenomenon becomes more in evidence during the following two or three weeks.

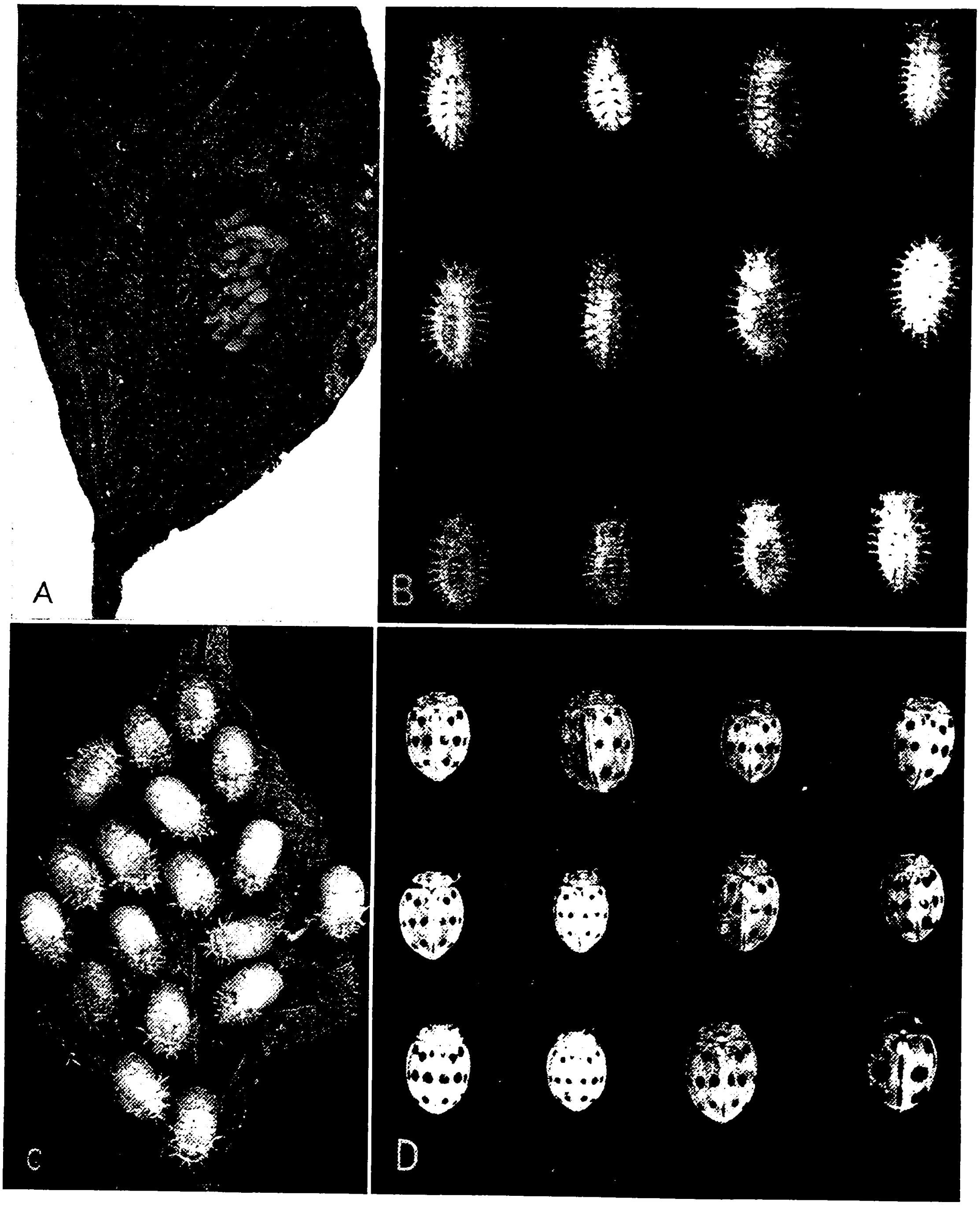

FIG. 1.—STAGES IN THE LIFE HISTORY OF THE MEXICAN BEAN BEETLE.
A, eggs; B, larvae; C, pupae; D, adults. The lower right adult is the common lady bird beetle shown by way of comparison with the adult Mexican bean beetle.

For a short period during July there is usually a lull in the injurious activities of the insect owing to the prevalence of pupation. During this interval the earlier individuals of the first generation of adults commence to emerge from pupal skins. In Nassau County and warmer sections of the Island this generation may have largely

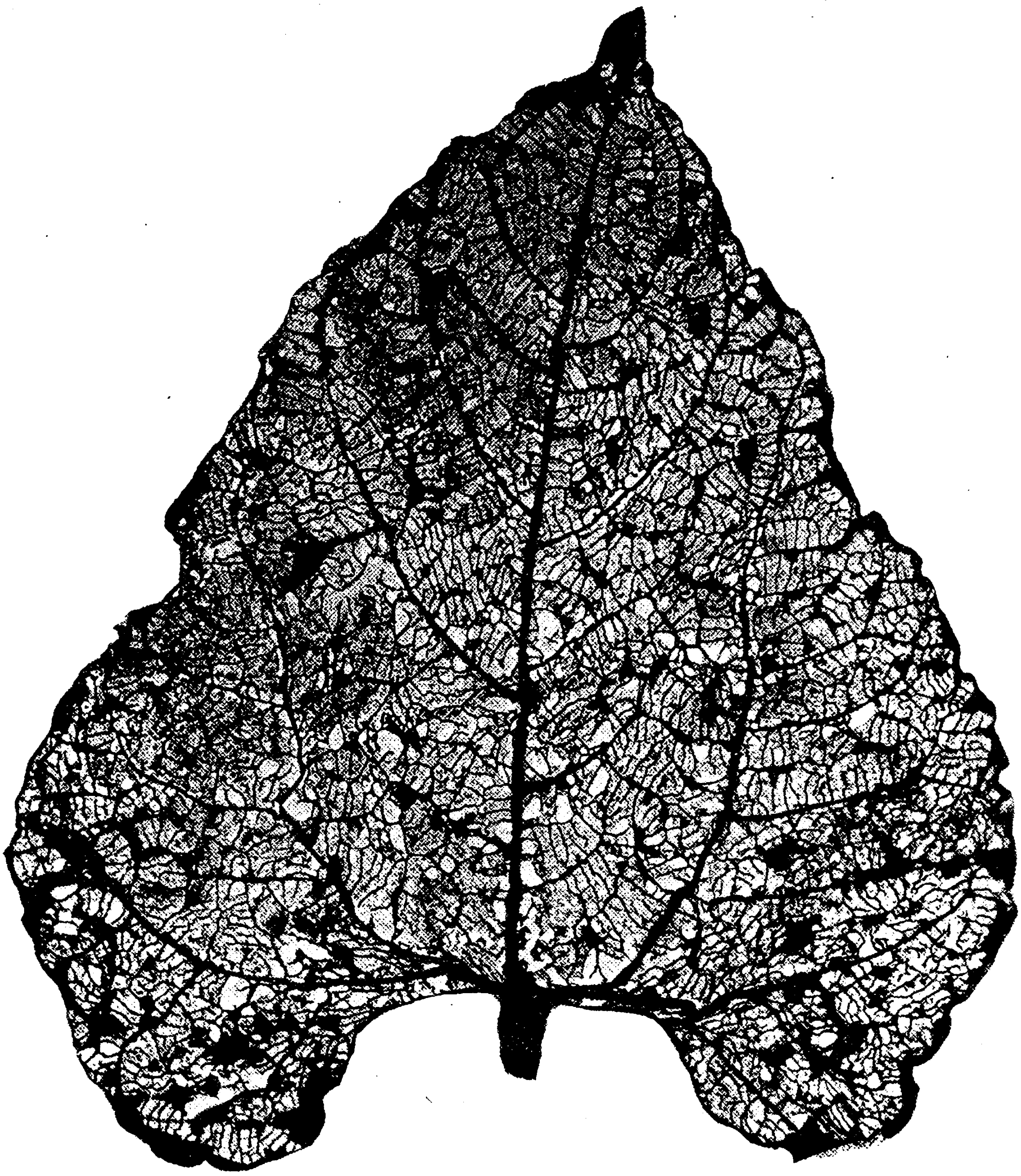

FIG. 2.—LEAF OF LIMA BEAN SHOWING CHARACTERISTIC PATTERN OF FEEDING INJURY BY THE MEXICAN BEAN BEETLE.

finished development before the end of July and a second generation of larvae have commenced to cause injury. In eastern Suffolk County infestation due to the second generation does not build up so rapidly owing to the slower and more protracted development of the life stages of the insect. In these circumstances it is not unusual to find that injury caused by larvae of the second generation increases in extent during the month of August. This is the generation that normally causes most injury to mid-season plantings of lima beans. Such fields may have largely escaped serious infestation by the overwintering brood of beetles owing to the belated appearance of the plants, but they none the less remain open to attack by succeeding broods of migrating beetles and their progeny.

In western Long Island a second and third generation of the pest may develop during August and September, respectively, in time to do much injury before frost closes the growing season. In eastern Long Island the succeeding generations develop at a slightly slower rate owing to the retarding influence of cooler and more temperate climatic conditions. During the latter half of September and during October, lima beans in such areas may serve to harbor a not inconsiderable population of the insect but still be capable of maintaining a natural growth that is sufficient for the needs of a satisfactory crop. Under conditions of prolonged dry weather during mid-summer, as experienced in 1939, it is not unusual for the second and third generations to be so seriously depleted in numbers due to the adverse influence of natural conditions that the pest subsides temporarily to a position of minor practical concern.

Besides the Mexican bean beetle there are other foliage pests that may be found to infest lima beans to a greater or less extent each season. When the weather becomes warm and dry, red spider mite (*Tetranychus* spp.), bean aphid (*Aphis rumicis* L.), and potato leafhopper (*Empoasca fabae* Harris) may develop in such numbers as to cause injury to plants and in a few instances thereby effect an appreciable reduction in yield of pods.

The red spider mite survives the winter in rubbish accumulated along woodland borders and in hedge rows. Plants grown adjacent to such sheltered situations are usually the first to be attacked by the mite. They thus provide an additional source of possible infection for the whole field. Usually, the spread and development of the pest will depend largely on subsequent weather conditions, being favored by warm dry periods and retarded by wet spells.

The bean aphid migrates from numerous secondary hosts growing in the neighborhood, such as dock and burdock, onto bean plants scattered in the field. It is not uncommon for plants near such points of initial infection to eventually become likewise contaminated with a colony of black aphids, but only rarely does the infestation become so severe as to involve the whole field. In the majority of cases the spread of aphid colonies is gradually arrested and subsequent infestation almost completely wiped out by natural causes.

The green clover worm (*Plathypena scabra* Fabr.) occurs periodically in certain seasons and on occasion does considerable foliage injury to lima beans. Its presence may usually be noted by the appearance of comparatively large ragged holes in the younger leaves caused by larval feeding. The worms superficially resemble the cabbage looper in that the body undergoes a looping motion when the insect is walking. When the larvae are disturbed they frequently hang from the foliage by a silken thread or if dropped to the ground may wriggle actively as in the case of larvae of the diamond-back moth. It is usually the summer brood of worms occurring during July and August that causes most of the injury.

DESCRIPTION OF SPRAYS AND DUSTS

In order to eliminate as far as possible any unnecessary repetition in the account of the experiments from year to year, some of the salient features regarding the composition and insecticidal strength of spray and dust mixtures are briefly reviewed below.

INSECTICIDES

Rotenone-bearing powders were applied as suspensions in spray mixtures at a strength equivalent to 4 pounds of powder to 100 gallons of spray. The rotenone strength of sprays differed slightly from year to year when based on such a formula owing to differences in the analytical content of new samples of powder. Approximately, the rotenone strength in such sprays ranged from 0.019 to 0.0262 per cent. The same samples of powder were diluted into dust mixtures in proportions equivalent to 10 pounds of powder in 100 pounds of dust. The rotenone strength of such mixtures ranged from approximately 0.475 to 0.59 per cent. In 1936 the insecticide consisted of timbo powder from Brazil having an analytical content of 5.9 per cent rotenone and 20.45 per cent total ether extractives. The powder was placed on trial as a standard and as a stabilized product. In 1937 and 1938 the insecticide consisted of cubé powder cited as containing 4.5 to 5 per cent rotenone and 12 per cent total ether extractives. In 1939 the insecticide consisted of two samples of derris powder, one a standard product analyzing 5 per cent rotenone content, the other a stabilized product reputed to contain 4.75 per cent rotenone. In 1940 two fresh samples of derris powder were employed, the standard product analyzing 5.2 per cent and the stabilized product 4.36 per cent rotenone strength. In 1941 the same samples were used as in 1940.

Pyrethrum insecticides were used as finely ground pyrethrum flowers standardized to contain 0.9 per cent pyrethrins, and as a proprietary powder containing a minimum of 2 per cent pyrethrins (2). Finely ground flowers were applied as suspensions in spray mixtures at a strength equivalent to 8 pounds of powder to 100 gallons of spray during the first three seasons and at half that strength for the remaining three. The pyrethrin strength of such sprays was approximately 0.009 and 0.0045 per cent, respectively. The same samples of powder were diluted into dust mixtures in proportions equivalent to 60 pounds of powder in 100 pounds of dust during 1936 and 1937, and to 55 pounds of powder in 1938, 1939, and 1940. These mixtures were considered as containing 0.54 and 0.495 per cent pyrethrin strength, respectively. Impregnated pyrethrin powder was applied only as a dust. The powder, containing a minimum of 2 per cent pyrethrins, was diluted for dusting purposes to form a mixture of 0.2 per cent pyrethrin strength.

TYPES OF DUSTS AND SPRAYS

The different series of treatments were referred to largely on the basis of differences in the types of spray and dust employed to distribute the insecticide during application, such as bordeaux mixture, copper oxychloride, wettable sulfur, and skimmilk powder among sprays, and copper-lime, copper oxychloride, sulfur, and clay or talc among dusts.

Bordeaux mixture was applied according to the ratio of 4–6–50 during the 1936 and 1937 seasons and 4–4–50 in subsequent years. In 1936 the mixture contained the equivalent of 1 quart of Penetrol per 100 gallons of spray for purposes of improving its wetting properties. From 1937 to 1940, 2 pounds of skimmilk powder were substituted for Penetrol and in 1941, 2 pounds of a proprietary soybean powder instead of skimmilk. Copper oxychloride sprays in 1938 contained the equivalent of 6 pounds of a proprietary powder having 24 per cent metallic copper content and 2 pounds of skimmilk powder to 100 gallons of water. In 1939 and 1940 the amount of copper oxychloride powder was reduced to 4 pounds. In 1941 the powder possessed a content of 58 per cent metallic copper and was employed at a dosage of 3 pounds in 100 gallons of spray.

Wettable sulfur sprays contained the equivalent of 20 pounds of a proprietary sulfur mixture in 100 gallons of water during the seasons 1936 and 1937 and 12 pounds in subsequent years. Skimmilk powder sprays were applied at a strength equivalent to 2 pounds of powder in 100 gallons of water.

So-called copper-lime dusts were prepared containing the equivalent of 15 pounds of monohydrated copper sulfate and 85 pounds of hydrated lime. In cases where a rotenone-bearing powder was included as an ingredient of a copper-lime dust, the powder displaced an equal weight of hydrated lime. In the case of pyrethrum mixtures the percentage content of copper-lime dust was reduced to permit the finished dust to retain its full quota of pyrethrum powder, as in other types of dust. Copper oxychloride dusts were applied during 1938 at a strength equivalent to 15 pounds of copper oxychloride powder (24 per cent metallic copper content) in 100 pounds of dust. In 1939 and 1940 the amount of copper oxychloride powder was reduced to 10 pounds. In 1941, 5 pounds of powder (58 per cent metallic copper content) were included in 100 pounds of dust. The diluent in fixed copper dusts consisted of 2 pounds of infusorial earth and the balance talc, except in the case of a mixture containing impregnated pyrethrin powder applied in 1938 when the infusorial earth content was raised to 5 pounds.

Sulfur dusts were prepared by the admixture of a finely ground grade of conditioned sulfur (325-mesh) as chief extender and diluent. During the first three seasons the diluent consisted largely of sulfur, and in subsequent years of sulfur and talc in equal proportions by weight, except in the case of pyrethrum mixtures when the sulfur content was retained in nondiluted form. Infusorial earth was incorporated with sulfur mixtures in amounts equivalent to 5 per cent by weight of the finished dust during the 1936 and 1938 seasons and to 2 per cent in 1937 and subsequent years.

Clay dusts were applied during the 1936 and 1937 seasons and talc dusts for the remaining years of the experiment. Infusorial earth was added to clay and talc dusts as a fluffing agency in amounts equivalent to 2 per cent by weight of the finished dust, except in the case of so-called impregnated dusts when the content of earth was raised to 5 per cent.

PROCEDURE AND METHODS

In general, plots were laid out in short sections of rows 20 to 40 feet in length which were further arranged in tiers across the field. Treatments were grouped according to whether dust or spray and further subdivided according to the type of dust or spray. Each treatment was replicated systematically two to five times thruout the field. Check rows were placed at intervals between subdivisions representing the different types of spray or dust, or were confined to two or three border rows.

Sprays and dusts were applied by hand machines going once along each side of the row. The average rate of application for sprays ranged from 90 to 160 gallons per acre increasing with size of plants. Similarly, the rate of dusting ranged from 25 to 55 pounds per acre, the amount being in some measure controlled by the type of dust employed, i.e., whether hydrated lime or one of greater density, such as talc or sulfur. Sprays were applied preferably in calm weather when leaves were dry, and dusts usually in the early morning when leaves were wet. No particular attention was paid to periods of blossoming in timing applications, altho some degree of care was exercised when spraying or dusting with copper mixtures to avoid blossoms for fear of causing copper injury.

The results of treatment were expressed in terms of yield and according to the comparative condition of foliage towards the close of the experiment. For the latter purpose plants were classified arbitrarily into four groups under captions denoting the extent of defoliation and leaf injury, such as trace, slight, moderate, or severe.

RESULTS

1936 EXPERIMENTS

Comparative tests were made of sprays containing bordeaux mixture, wettable sulfur, and skimmilk powder, and of dusts containing monohydrated copper sulfate-hydrated lime, dusting sulfur, and clay, respectively, as a basis for the application of treatments involving the use of timbo powder, pyrethrum powder, and impregnated pyrethrin powder as insecticides for control of the Mexican bean beetle and other foliage parasites of the lima bean. Two types of timbo powder were employed, one standard and the other stabilized, both regarded as containing approximately 5.9 per cent rotenone and 20.5 per cent total ether extractives. Pyrethrum powder was guaranteed as analyzing 0.9 per cent pyrethrins and impregnated pyrethrin powder 2 per cent pyrethrins.

In making copper and sulfur treatments the insecticides in the case of timbo and pyrethrum powder were applied as a component part of the mixture and again separately as a clay dust following the application of the fungicide. In the case of impregnated pyrethrin powder only separate applications of the insecticide were made as a part of each treatment. By making two separate applications for fungicide and insecticide it was hoped that in cases where the materials might be considered incompatible that the adverse effect of their interaction with one another might be partly mitigated.

Beans of the Fordhook bush lima variety were planted on June 17 in five series or tiers of 29 rows each. The tiers represented different types of sprays or dusts, namely, bordeaux mixture, copper-lime dust, wettable sulfur spray, sulfur dust, and clay dust or skimmilk powder spray. Different individual treatments consisted of single row units replicated two or three times systematically in each tier. Check or untreated rows comprised three outside rows on each side of the experimental plot.

Plants commenced to emerge above ground on June 28 and first came into blossom on August 4. The crop largely escaped injury by the first larval brood of the Mexican bean beetle during July owing to the proximity of a planting of snap beans on which overwintering adults had earlier collected. Later, during August, the lima bean crop was subjected to a temporary infestation of leafhoppers migrating from potato fields. During this period the first generation of adults of Mexican bean beetle commenced to emerge from the pupal stage and to migrate onto plants, but egg hatching and larval feeding did not begin to assume serious proportions until after mid-August. It was undoubtedly injury from the second and third generations of the Mexican bean beetle that was the chief factor in destroying the foliage. Such other parasites as red spider mite, bacterial leaf spot, and downy mildew were largely absent, and hence were considered unimportant features of the situation.

Treatments were applied on three occasions, namely, during August 5 and 7; August 14, 18, and 19; and during September 2 and 3, at average intervals of 10 to 14 days apart. Pods were picked on August 31 and September 1 and again on September 16, 17, and 22. The condition of the plants in the various plots as indicated by foliage injury was arbitrarily scored on September 27 and 28 for comparative purposes. At this date plants in untreated rows were practically devoid of foliage as a result of larval feeding. The summarized data concerning foliage condition and yield of pods on sprayed and dusted plots are presented in Tables 1 and 2.

FOLIAGE PROTECTION IN SPRAYED PLOTS

It was apparent during the course of the 1936 experiments that plants sprayed with bordeaux mixture were protected to a surprisingly high standard of efficiency even when no insecticide was included in the treatment. Protection was slightly improved by addition of timbo or pyrethrum powder, whether they were applied as a suspension in bordeaux mixture or separately in a clay dust. Both methods of applying the insecticide seemed to result in equally effective control. The significance of such promising results from the application of bordeaux mixture and insecticide in one operation may be readily appreciated owing to its practical implications.

It will be noted in Table 1 that the condition of foliage in checks is represented as being decidedly inferior to that of treated plants, and yet check rows of the bordeaux mixture series were able to

TABLE 1.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON SPRAYED PLOTS.

Insecticide treatments and percentage strength of rotenone or pyrethrins in spray or dust	Percentage of plants having foliage injury			Yield per 100 plants, ounces	Increase or decrease from checks, ounces
	Slight	Moderate	Severe		
Bordeaux Mixture Series					
None	71	25	4	355.3	-18.0
Standard timbo powder, 0.0295	87	12	1	344.9	-28.4
Stabilized timbo powder, 0.0295	90	10	0	351.5	-21.8
Pyrethrum powder, 0.009	81	17	2	363.3	-10.0
Standard timbo dust, 0.59	91	8	1	387.3	14.0
Stabilized timbo dust, 0.59	86	13	1	336.1	-37.2
Pyrethrum dust, 0.54	84	16	0	383.7	10.4
Impregnated pyrethrin dust, 0.20	77	21	2	391.7	18.4
Check	1	11	88	373.3	——
Wettable Sulfur Series					
None	20	47	33	417.3	47.3
Standard timbo powder, 0.0295	87	13	0	487.4	117.4
Stabilized timbo powder, 0.0295	80	20	0	405.9	35.9
Pyrethrum powder, 0.009	37	41	22	448.0	78.0
Standard timbo dust, 0.59	85	14	1	461.2	91.2
Stabilized timbo dust, 0.59	37	54	9	471.5	101.5
Pyrethrum dust, 0.54	30	42	28	416.1	46.1
Impregnated pyrethrin dust, 0.20	26	30	44	379.3	9.3
Check	0	4	96	370.0	——
Skimmilk Powder Series					
None	4	27	69	371.1	16.0
Standard timbo powder, 0.0295	95	5	0	467.5	112.4
Stabilized timbo powder, 0.0295	92	8	0	400.5	45.4
Pyrethrum powder, 0.009	70	27	3	448.0	92.9
Check	1	10	89	355.1	——

yield as heavily as most of the treated rows. The significance of the data obtained in these comparisons is not properly understood and seemed further to be obscured owing to the conflicting evidence obtained in other series of the same experiment. Tests carried on in 1940 in the absence of injury by the Mexican bean beetle tended to show that applications of bordeaux mixture might not sometimes be beneficial to crop development. However, it might be pertinent to mention in connection with these findings that it was not unusual in many later experiments to discover that there seemed little or no logical relationship between foliage condition as presented and yield

TABLE 2.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON DUSTED PLOTS.

INSECTICIDE TREATMENTS AND PERCENTAGE STRENGTH OF ROTENONE OR PYRETHRINS IN DUST	PERCENTAGE OF PLANTS WITH FOLIAGE INJURY			YIELD PER 100 PLANTS, OUNCES	INCREASE OVER CHECK, OUNCES
	Slight	Moderate	Severe		
Copper—Lime Series					
None	41	41	18	454.1	69.2
Standard timbo powder,* 0.59	65	32	3	481.9	97.0
Stabilized timbo powder,* 0.59	67	28	5	415.0	30.1
Pyrethrum powder,* 0.54	46	41	13	418.3	33.4
Impregnated pyrethrin powder,* 0.20	51	34	15	450.8	65.9
Standard timbo dust,† 0.59	74	26	0	427.8	42.9
Stabilized timbo dust,† 0.59	74	26	0	462.8	77.9
Pyrethrum dust,† 0.54	58	32	10	499.5	114.6
Impregnated pyrethrin dust,† 0.20	44	46	10	429.8	44.9
Check	0	4	96	384.9	——
Sulfur Series					
None	42	27	31	342.0	56.0
Standard timbo powder,* 0.59	95	5	0	350.7	64.7
Stabilized timbo powder,* 0.59	96	4	0	317.1	31.1
Pyrethrum powder,* 0.54	62	38	0	330.8	44.8
Impregnated pyrethrin powder,* 0.20	53	46	1	376.6	90.6
Standard timbo dust,† 0.59	95	5	0	348.0	62.0
Stabilized timbo dust,† 0.59	74	24	2	369.2	83.2
Pyrethrum dust,† 0.54	60	28	12	345.4	59.4
Impregnated pyrethrin dust,† 0.20	49	15	36	355.3	69.3
Check	0	5	95	286.0	——
Clay Series					
None	4	27	69	371.1	16.1
Standard timbo powder,* 0.59	91	9	0	427.1	72.1
Stabilized timbo powder,* 0.59	53	33	14	380.7	25.7
Pyrethrum powder,* 0.54	51	31	18	330.2	-24.8
Impregnated pyrethrin powder,* 0.20	34	26	40	400.8	45.8
Check	1	10	89	355.0	——

*Dust ingredients applied together.
†Insecticidal dust applied separately.

of pods. This may be due to the fact that detailed information concerning the comparative condition of the foliage was not recorded until near the close of the experiment and that such data gave no indication as to how long such differences between treated and untreated rows may have existed or been approximated. In this regard it may be stated that in most seasons check rows were seriously injured by the end of August as a result of feeding by the second generation of the Mexican bean beetle, and that at that time the different treated rows began to give some indication relative to the comparative effectiveness of different treatments in foliage protection. It is felt, however, that even were such information available it would not suffice to explain fully the reasons for such apparent disparity in the relationship between foliage condition and yield of pods in the case of lima beans.

Because of the frequent occurrence of the seeming lack of correlation between condition of foliage and resultant yield of pods, it has been thought advisable to discuss the data relating to foliage protection and yield of pods separately in an attempt to define more clearly the comparative merits of different treatments for insect control.

In the wettable sulfur series the foliage was not as effectively protected as in the bordeaux mixture series, except with treatments containing timbo powder. Sulfur spray in itself was not as effective as bordeaux mixture, and it was evident that sulfur spray mixtures containing pyrethrum powder in suspension or where supplemented by the additional application of pyrethrum powder as a dust were not as effective as comparable treatments in the bordeaux mixture series. Both methods of applying the insecticide seemed to give comparable results in foliage protection, altho it may be noted that in the case of sulfur mixtures this point did not have the same practical significance as in the case of bordeaux mixture where the procedure was evolved as a result of dealing with materials that were chemically incompatible.

In the skimmilk powder series the applications were confined to single operations entailing the use of timbo and pyrethrum powders as suspensions in the spray. The insecticidal treatments were about as effective as those of the bordeaux mixture series, timbo sprays being slightly superior to that of pyrethrum.

It may be noted from the data in these series of tests that there was no clear indication of differences in the comparative effectiveness of standard and stabilized grades of timbo powder for purposes of plant protection. Treatments of pyrethrum dust were slightly more effective than those of impregnated pyrethrin dust.

YIELD OF PODS IN SPRAYED PLOTS

Despite the superior condition of foliage in treated rows belonging to the bordeaux mixture series, there was no indication that the yield of pods was significantly higher than that from untreated rows. In 1940 similar unsatisfactory results were obtained in plots sprayed with bordeaux mixture during a season when injury by the Mexican bean beetle was considered of little, if any, practical significance. It may be suggested by way of explanation that applications of bordeaux mixture have been known to affect adversely the set of vegetable fruits by injuring the blossoms (3, 15), and that more recent observations have indicated that they may not always be beneficial to plant growth in the case of lima beans (16).

The yields of all treated plots in the wettable sulfur and skimmilk powder series, with one notable exception, were decidedly superior to that of the check. The highest yields were invariably obtained in rows treated with standard timbo powder and with spray suspensions of pyrethrum powder. Stabilized timbo powder applied as a dust resulted in equally satisfactory yields, but where applied as a suspension the increase in yield was considerably limited.

The data provided no indication that treatments containing stabilized timbo powder were more effective than those containing standard timbo powder nor that a dust impregnated by an admixture of pyrethrin powder was superior to one containing pyrethrum powder.

FOLIAGE PROTECTION IN DUSTED PLOTS

Copper-lime dust, as applied, was not considered as dependable as bordeaux mixture for purposes of foliage protection. However, it was apparent in the course of the experiment that applications of this type of dust had had some influence in determining the results of many of the treatments in the series, much in the same manner as occurred in the bordeaux mixture series. Dusts were slightly more effective when timbo powder was included in the treatment as compared to those containing pyrethrum or impregnated pyrethrin powder. Little was gained in applying the insecticidal and fungicidal elements separately instead of together in the same dust in an effort to improve the effectiveness of treatment, provided the insecticidal ingredients were comparable.

Dusts in the sulfur series of tests were slightly more effective than those in the copper-lime series. This improvement was particularly significant in treatments where sulfur and insecticidal ingredients of the dust were applied together in one operation. Treatments containing timbo powder were more effective than those containing pyrethrum powder or impregnated pyrethrin powder, thus corroborating the results obtained in the wettable sulfur series with regard to foliage protection. It seems probable that the superior results obtained in the sulfur series were in a greater measure due to the insecticidal qualities of various mixtures than to sulfur in itself. In the copper-lime series the fungicidal ingredient of various dusts seemed to have exerted a more marked influence than the insecticidal ingredients, particularly where both were applied in the same dust.

In the clay series of tests treatments were confined to single operations entailing the use of timbo, pyrethrum, and impregnated pyrethrin powders as dusts. A mixture containing standard timbo powder was considerably more effective than other mixtures. The inferior results with impregnated pyrethrin dusts in both spray and dust series of tests may be partly explained on the grounds that clay has a tendency to adsorb the pyrethrin solution in such dusts and thus prevent them from exercising their fullest efficiency (9).

There were no indications that treatments containing stabilized timbo powder were more effective than those containing standard timbo powder, as applied, provided other factors were equal.

YIELD OF PODS IN DUSTED PLOTS

The yield of pods in the copper-lime series averaged slightly higher than in other series. Unlike the results in the bordeaux mixture series, there were substantial gains from treatment in the copper-lime series even where no insecticide had been included. Other than this, the yields in this series gave no clear indication concerning the comparative effectiveness of different insecticidal treatments or of separate versus single operations in treatment. The apparent discrepancy in the relation of yield to foliage condition, particularly as it may concern the checks, has been discussed in connection with data pertaining to foliage protection by means of sprays. It was suggested that the information conveyed by the data relative to foliage injury and yield of pods might be misleading owing to the fact that there was no indication as to how long such differences between treated and untreated rows had existed or been approximated.

The yield of pods in the sulfur series averaged lower than in copper-lime or clay series. When the various treated plots were compared to their respective checks, it became evident that increases in yield in the sulfur series were in many instances as substantial as in other series. The yields, however, did not provide any clear evidence as to the occurrence of notable differences in the merits of various insecticidal treatments.

The yields of pods in the clay series were extremely variable among plots treated with an insecticide. However, in all but one case there were moderate to large increases in yield from treatment, the greatest being recorded in rows treated with timbo powder.

SUMMARY

In summarizing the results for the 1936 season in which the Mexican bean beetle was considered the most injurious pest of the foliage of lima beans, it may be said from the evidence provided by the comparative condition of the foliage in the respective plots at the close of the experiment that

1. Treatments involving the use of timbo powder were more effective than those involving pyrethrum powder, and that those involving pyrethrum powder were more effective than treatments with impregnated pyrethrin powder.
2. Treatments of the bordeaux mixture series were more effective than those of the copper-lime series.
3. Treatments of the sulfur dust series were slightly more effective than those of the copper-lime dust series or of the wettable sulfur spray series.
4. Insecticidal sprays containing skimmilk powder as a spreader averaged as high a degree of effectiveness, under the circumstances, as any comparable group of insecticidal treatments in any other series, being superior in this regard to the insecticidal treatments of the clay series.
5. Treatments involving the application of insecticide and copper-lime mixtures in one operation were practically as effective as those in which the insecticide and fungicide were applied in separate operations.

The results in terms of yield may be summarized as follows:

1. There was little if any direct correlation between the results as expressed in terms of foliage protection and yield of pods.
2. Treatment with insecticides generally and invariably resulted in substantial increases in yield over untreated plots, except in the case of the bordeaux mixture series.
3. There were no clear indications among the various treatments concerning the superiority of one kind of insecticide over another as was evident from the results in foliage protection. Exclusive of the bordeaux mixture and copper-lime series, the results tended to indicate that higher yields were usually obtained in rows treated with standard timbo powder.

1937 EXPERIMENTS

Plans and procedure for experiments during the 1937 season were essentially the same as those of the previous year. Sprays of bordeaux mixture and wettable sulfur and dusts of copper-lime and finely ground sulfur were employed as a basis for insecticidal treatments with cubé powder and pyrethrum powder. In the series of treatments with bordeaux mixture insecticidal powders were either applied as a suspension in bordeaux mixture or as an ingredient of a clay dust in a separate operation following the fungicidal treatment. In the copper-lime series insecticides were applied separately. In the wettable sulfur and sulfur series the insecticidal powders formed an integral part of each mixture.

The insecticides were a standard grade of cubé powder reputed to contain 4.5 to 5 per cent rotenone and 12 per cent total ether extractives, and a commercial grade of pyrethrum powder standardized to contain 0.9 per cent pyrethrins.

The various treatments were arranged in systematic series of single row units spread over two adjacent tiers and involving three replications per treatment. Check or untreated rows were placed at uniform intervals among treated rows and consisted of two-row units replicated six times.

Planting was made on June 7, shoots commenced to emerge above ground during mid-June, and the first period of blooming occurred during the latter half of July. Plots were not seriously infested with the Mexican bean beetle until mid-July when adults of the first generation commenced to migrate from adjoining sources of infestation. From then until the close of the experiment in mid-September plants were exposed to a period of considerable activity on the part of the second and third generations of the Mexican bean beetle. By late August the foliage of untreated plants was nearly completely devoured by this insect. Pest injury from other causes was considered of little significance under the circumstances, altho it may be noted that during early August there occurred a severe but temporary infestation by adults of the potato leafhopper which were migrating from potato fields. Pods were picked on August 24 and September 7 and 17.

The crop was much lighter than that raised in 1936 largely owing to the poor set of pods during the season. Temperatures in July and August had averaged considerably above normal for these months and precipitation was seriously deficient for most of this period. These conditions were believed to be partly responsible for the light yield. Applications of spray and dust were made on July 17 to 19, July 27, August 6 to 7, August 18 to 20, and September 1 to 3, or at average intervals of 10 to 12 days apart.

On September 14 data were recorded pertaining to the comparative effectiveness of different treatments in foliage protection, with particular reference to injury caused by feeding of the Mexican bean beetle. Thruout September it had been observed that rows sprayed with bordeaux mixture were distinctly superior in foliage appearance to those receiving other treatments. Data relative to yield and the comparative extent of foliage injury in the respective plots at the close of the experiment are summarized in Table 3.

TABLE 3.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON SPRAYED AND DUSTED PLOTS.

INSECTICIDE TREATMENTS AND PERCENTAGE STRENGTH OF ROTENONE OR PYRETHRINS IN SPRAY OR DUST	PERCENTAGE OF PLANTS WITH FOLIAGE INJURY				YIELD PER 100 PLANTS, OUNCES	INCREASE OVER CHECK, OUNCES
	Trace	Slight	Moderate	Severe		
Bordeaux Mixture Series						
None	12	76	12	0	175.9	103.1
Cubé powder, 0.0237	50	49	1	0	199.2	126.4
Pyrethrum powder, 0.009	40	57	3	0	200.7	127.9
Cubé dust, 0.475*	29	67	4	0	181.4	108.6
Pyrethrum dust, 0.54*	27	67	6	0	169.6	96.8
Check	0	6	27	67	72.8	——
Wettable Sulfur Series						
Cubé powder, 0.0237	7	80	13	0	178.1	100.7
Pyrethrum powder, 0.009	0	34	43	23	175.3	97.9
Check	0	7	25	68	77.4	——
Copper—Lime Series						
None	0	8	46	46	148.3	76.6
Cubé dust, 0.475*	0	23	56	21	154.4	82.7
Pyrethrum dust, 0.54*	0	14	50	36	158.9	87.2
Check	0	5	31	64	71.7	——
Sulfur Series						
Cubé powder, 0.475	8	60	26	6	222.3	144.9
Pyrethrum powder, 0.54	0	27	38	35	165.9	88.5
Check	0	7	25	68	77.4	——

*Insecticidal dust applied separately.

FOLIAGE PROTECTION

It was early apparent that applications of bordeaux mixture were having a marked effect in protecting the foliage from feeding by the Mexican bean beetle. This superiority was well maintained thruout the experiment, even where no insecticide had been included in the treatment. The addition of cubé or pyrethrum powder, either as a component part of the spray or in the form of an insecticidal dust applied separately, slightly increased the effectiveness of treatment. Improvement was more noticeable where the insecticidal powders were applied as suspensions in the spray mixture than where the insecticides were applied as a dust in a separate operation.

By comparison, the protection secured in the wettable sulfur, copper-lime, and sulfur series was markedly inferior. It may be noted, however, that in the wettable sulfur and sulfur series there was a perceptible difference in the condition of the foliage in rows treated with cubé powder as compared with those treated with pyrethrum powder in favor of the former treatment, whereas in the bordeaux mixture and copper-lime series the comparative differences in foliage condition between rows receiving cubé and pyrethrum treatments were much less marked. Such results are in a large measure supported by data gathered from similar experiments in 1936.

YIELD OF PODS

The yield of pods, altho considerably lower than that secured in previous years, was at least doubled where treatments had been applied. In the bordeaux mixture series the yield was considerably improved even where no insecticide had been included in the treatment. The yield in rows sprayed with a mixture containing cubé or pyrethrum powder in suspension was superior to that of rows receiving the fungicidal and insecticidal elements of the treatment in separate operations.

In the copper-lime series the yields did not equal those of other series. It may be observed, however, that here as well as in the bordeaux mixture series there were considerable increases in yield in rows that had received no insecticidal treatment; in this respect being little, if at all, inferior to rows treated with an insecticidal dust.

The comparative yields of rows treated with cubé and pyrethrum powders showed little differences except in the sulfur series where rows treated with cubé powder greatly outyielded those dusted with pyrethrum powder.

SUMMARY

In summarizing the results for the 1937 season, which was characterized by warm, dry weather and light yields as well as by extensive injury by the Mexican bean beetle, it may be said from the evidence provided by the data concerning the comparative condition of foliage in various plots at the close of the experiment that,

1. Treatments of the bordeaux mixture series were more effective than those of the copper-lime, wettable sulfur, and sulfur series, particularly when insecticidal powders had been applied as suspensions in the spray.
2. Where cubé powder was included in treatments of the copper-lime, wettable sulfur, and sulfur series, the foliage, tho inferior, was perceptibly in better condition than where pyrethrum powder was used. In the bordeaux mixture series, where treatments were productive of superior results, such differences between cubé and pyrethrum treatments were not apparent.

The results in terms of yield of pods may be summarized as follows:

1. There was little if any correlation between data representing the degree of effectiveness obtained by different treatments in foliage protection and the yield of pods.
2. All treatments resulted in large increases in yield over untreated rows, particularly in the bordeaux mixture, wettable sulfur, and sulfur series.
3. The yield of pods from plots treated with cubé and pyrethrum powder averaged small differences between the respective treatments except in the case of the sulfur series where the yield from cubé treatment was considerably higher than that from pyrethrum.
4. Treatment in the form of bordeaux mixture or copper-lime alone resulted in comparatively satisfactory yields.

1938 EXPERIMENTS

The scope of the 1938 experiment was enlarged over the 1937 experiment to include comparative tests of an insoluble copper compound as a basis for insecticidal sprays and dusts. The reason for the addition of such tests was largely due to the results of recent experiments in Ohio and western New York which indicated that applications of bordeaux mixture had had a deleterious effect on young growth and set of blossoms of such plants as tomato, beans, and cucumbers (3, 4, 5, 17). In comparison, treatments with insoluble copper compounds, where applied, had had a less harmful influence on plant development. A more immediate reason for such tests was the fact that many commercial products containing insoluble copper compounds were neutral in their chemical reaction and hence might be considered compatible with pyrethrum or rotenone-bearing powders in spray or dust mixtures. It also became urgent in view of the promising results obtained with bordeaux mixture and copper-lime dusts in control of the Mexican bean beetle, that some reasonable explanation be advanced for their success and a proper interpretation placed on the part that pyrethrum and rotenone-bearing powders may or may not play in these results (14).

The brand of insoluble copper compound chosen for such tests contained not less than 40 per cent copper oxychloride, representing a minimum metallic copper content of 24 per cent. The only other notable change in procedure from that of previous years was that a pyrophyllite talc was substituted for clay as a diluent in dusts.

The experimental planting consisted of four tiers of 36 rows each. Each treatment appeared once in each tier at staggered intervals across the field. Different treatments were represented by single rows arranged in systematic series along each tier. Check rows were distributed at regular intervals among treated rows, appearing three times in each tier as two-row units.

Beans were planted on June 15 and shoots began to appear above ground by June 25. The first crop of blossoms commenced to develop about July 26 to 27. The most injurious insects during the season were the second and third generations of the Mexican bean beetle and an infestation of the green clover worm during August. The presence of red spider mite or potato leafhopper was not apparent. The season, in contrast to those of former years, was characterized by the occurrence of frequent rainfall. Under the circumstances bacterial leaf spot and diaporthe leaf spot were prevalent but were considered of minor significance in their effect on plant development. Downy mildew did not develop.

Applications of spray and dust were made on July 26 to 27, August 8, August 22, and September 6 to 7. During this period it was apparent that copper sprays were more effective than other treatments in protecting the foliage from parasitic injuries. Dust treatments appeared to be at a serious disadvantage owing to the prevalence of rainfall, a factor which is known to cause a sharp reduction in effectiveness of applications shortly after they have been applied. By September 1 foliage in most of the check rows was severely injured by insect feeding.

Pods were picked on August 29 to 30, September 12 to 13, and September 27 to 29. Data relating to foliage injury and yield of pods in the various plots are summarized in Tables 4 and 5.

TABLE 4.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON SPRAYED PLOTS.

INSECTICIDE TREATMENTS AND PERCENTAGE STRENGTH OF ROTENONE OR PYRETHRINS IN SPRAY OR DUST	PERCENTAGE OF PLANTS WITH FOLIAGE INJURY				YIELD PER 100 PLANTS		INCREASE OVER CHECK, OUNCES
	Trace	Slight	Moderate	Severe	Number	Ounces	
	Bordeaux Mixture Series						
None	47	36	17	0	1,184	328	255
Cubé powder, 0.0237	59	31	10	0	1,256	355	282
Pyrethrum powder, 0.009	77	19	4	0	1,348	372	299
Cubé dust, 0.475	55	43	2	0	1,319	348	275
Pyrethrum dust, 0.495	59	28	13	0	1,347	354	281
Check	0	2	9	89	341	73	—
	Copper Oxychloride Series						
None	40	48	11	1	1,283	341	278
Cubé powder, 0.0237	38	38	19	5	1,225	322	259
Pyrethrum powder, 0.009	37	47	14	2	1,232	329	266
Check	0	1	8	91	285	63	—
	Wettable Sulfur Series						
None	1	5	22	72	285	66	13
Cubé powder, 0.0237	41	45	14	0	927	235	182
Pyrethrum powder, 0.009	2	7	16	75	677	147	94
Check	1	2	13	84	225	53	—
	Skimmilk Powder Series						
Cubé powder, 0.0237	42	31	21	6	1,039	254	201
Pyrethrum powder, 0.009	8	19	26	47	669	162	109
Check	0	0	8	92	216	53	—

FOLIAGE PROTECTION ON SPRAYED PLOTS

Treatments in the spray series were invariably more effective than treatments in the dust series, and this fact was particularly pronounced in plots sprayed with bordeaux mixture or copper oxychloride. The reason for these results is believed to be due chiefly to the superior adhering qualities of spray mixtures as compared to dust mixtures under

TABLE 5.—COMPARATIVE EXTENT OF FOLIAGE PROTECTION AND YIELD OF PODS ON DUSTED PLOTS.

Insecticide treatments and percentage strength of rotenone or pyrethrins in dust	Percentage of plants with foliage injury				Yield per 100 plants		Increase over check, ounces
	Trace	Slight	Moderate	Severe	Number	Ounces	
Copper—Lime Series							
None	11	32	41	16	736	207	148
Cubé dust, 0.475*	23	36	32	9	870	219	160
Pyrethrum dust, 0.495*	21	38	33	8	971	255	196
Check	1	2	13	84	241	59	—
Copper Oxychloride Series							
None	5	15	49	31	790	190	127
Cubé powder, 0.475	7	14	34	45	657	162	99
Pyrethrum powder, 0.495	3	13	28	56	588	144	81
Impregnated pyrethrin powder, 0.20	1	7	28	64	499	116	53
Check	0	1	8	91	285	63	—
Sulfur Series							
None	0	1	5	94	370	83	23
Cubé powder, 0.475	23	32	38	7	747	173	113
Pyrethrum powder, 0.495	0	20	38	42	712	168	108
Impregnated pyrethrin powder, 0.20	6	23	28	43	627	156	96
Check	1	2	13	84	253	60	—
Talc Series							
Cubé powder, 0.475	27	46	18	9	626	152	104
Pyrethrum powder, 0.495	4	8	32	56	303	72	24
Impregnated pyrethrin powder, 0.20	3	8	17	72	340	84	36
Check	0	0	8	92	207	48	—

*Insecticidal dust applied separately.

circumstances that were distinctly trying on account of frequent showers. A high measure of protection was obtained in cases where bordeaux mixture and copper oxychloride were applied alone as the treatment. In the bordeaux mixture series there was a slight increase in effectiveness when an insecticide was added to the treatment, but this was not apparent in the copper oxychloride series. Both methods of applying the insecticide, whether as a spray or as a dust, seemed to give equally good protection in the bordeaux mixture series.

In the wettable sulfur and skimmilk powder series cubé powder treatment again showed up to good advantage, being superior to that containing pyrethrum powder. No such marked differences were recorded between these insecticidal treatments in the bordeaux mixture or copper oxychloride series, altho it should be observed that results obtained in foliage protection were generally more satisfactory in the bordeaux mixture series than in the wettable sulfur and skimmilk powder series. These data serve to support the findings of two previous years' work with reference to foliage protection.

YIELD OF PODS ON SPRAYED PLOTS

The yield of pods in treated rows was two to four times greater than that in the respective checks. Highest yields were obtained in the bordeaux mixture and copper oxychloride series, with little or no comparative significance to be attached as to specific treatments. In the wettable sulfur and skimmilk powder series only cubé treatments were represented by satisfactory yields. It is to be noted that in treatments containing bordeaux mixture and copper oxychloride alone yield of pods approximated that of other treated plots, whereas where sulfur was applied alone the yield barely exceeded that of the checks.

A record was also taken of the number of pods gathered from the various rows in an attempt to ascertain more clearly whether treatments with bordeaux mixture applied under field conditions were more likely to interfere with the set of pods than other treatments or than other causes. The data gave no clear indication that treatments with bordeaux mixture were likely to be significantly harmful in this manner under such conditions. The most noteworthy fact determining the comparative number of pods at harvest was the degree of success attained by individual treatments in Mexican bean beetle control.

FOLIAGE PROTECTION ON DUSTED PLOTS

The condition of the foliage on most of the dusted plots was inferior to that on most of the sprayed plots. It was thought that this was chiefly due to the wet season which was considered more unfavorable for dusts than for sprays. Under the circumstances, treatments in the copper-lime series and those containing cubé powder in the sulfur and talc series were indicative of more promising results than other treatments.

As in the spray series, cubé treatments showed up to best advantage when incorporated in a sulfur or non-copper mixture, and in such cases were distinctly more effective than pyrethrum or impregnated pyrethrin treatments. In both copper series no such marked differences were observed between any of the treatments within each series.

YIELD OF PODS ON DUSTED PLOTS

The yield of pods on most of the dusted plots was likewise inferior to that on most of the sprayed plots, altho in nearly every case the yields were considerably superior to those of the checks. Under the circumstances, yields in the copper-lime series were superior to those of other series. In both copper series there was a notable increase in yield over checks with treatments containing no insecticide. In the sulfur series the yield was notably increased by treatments containing an insecticide as compared to treatment with sulfur alone or the check. In the talc series cubé powder was the only insecticidal treatment that contributed to a marked increase in yield.

In comparing the results between the sulfur, talc, and both copper series it seems evident that in the latter case the results tended to emphasize the merits of the copper content in treatments as compared to the insecticidal content, whereas in the sulfur series the insecticidal content seemed to be of paramount importance. These conclusions were supported by the results obtained in the spray series of the experiment, both with regard to foliage protection as well as yield of pods.

SUMMARY

In summing up the results for the 1938 season, it is apparent that the data presented relative to the comparative condition of the foliage on the various plots at the close of the experiment and the yield of pods provide comparisons that lead to very similar conclusions. On account of this the more significant features of such comparisons are stated together. The season was characterized by the occurrence of frequent showers, which seemed to have a more unfavorable effect on dust treatments than on spray treatments. It was also a season when copper applications on account of their fungicidal properties were likely to be a more appropriate measure of crop insurance than sulfur applications. The Mexican bean beetle was again considered the most injurious pest of the foliage and its control had a marked influence on the development of the crop.

The results in terms of foliage protection and yield of pods may be summarized as follows:

1. Sprayed rows averaged higher yields than dusted rows, particularly in the case of bordeaux mixture or copper oxychloride sprays.
2. Sulfur treatments were invariably less effective than copper treatments for purposes of foliage protection except in cases where cubé powder was included in the treatment. The beneficial influence of cubé powder in sulfur and other non-copper mixtures was also reflected in the frequent occurrence of a marked increase in yield where such treatments had been applied.
3. Cubé treatments in the wettable sulfur, skimmilk powder, sulfur, and talc series were invariably superior to pyrethrum treatments. On the other hand, in the bordeaux mixture, copper-lime, and copper oxychloride spray and dust series the addition of an insecticide, whether cubé or pyrethrum powder, to the treatment rarely proved of material value.
4. The presence of copper in spray or dust applications appeared to have a significant influence in determining in a large measure the effectiveness of the treatment, a value that was not evident in the case of sulfur *per se*.

1939 EXPERIMENTS

Not much change was attempted in planning or carrying out tests during the 1939 season. Since there had been no significant improvement in control by treatments in which insecticides and fungicides had been applied separately as compared to one single operation, it was decided to confine their application to the latter method. Thus, insecticidal powders were incorporated as suspensions of the spray in the bordeaux mixture series and as a component part of the dust in the copper-lime series. Two types of derris powder were placed on trial for comparative purposes, one a standard grade reputed to contain 5 per cent rotenone, the other a stabilized form analyzing 4.75 per cent rotenone. Pyrethrum powder was of a standard grade analyzing 0.9 per cent pyrethrins. Owing to its increased cost the dosage of pyrethrum powder in sprays was reduced by half to 4 pounds of powder per 100 gallons of spray. Talc was substituted for one half of the weight of the sulfur in treatments belonging to the sulfur series, except in the case of pyrethrum mixture where the original sulfur content was maintained.

The experimental plot consisted of eight tiers of 14 rows each. Different treatments, including the checks, consisted of single-row units arranged in a continuous systematic series from tier to tier. Rows representing spray treatments were replicated 4 times, those of dust treatments 3 times, and checks 10 times.

Seed was sown on June 13 to 14 and shoots began to appear above ground on June 26. The first crop of blossoms commenced to form by the last week of July. The season proved to be unusually warm and dry, a combination of conditions that had a marked adverse effect on the development of the second generation of Mexican bean beetle. Due to this temporary relief from insect damage, foliage in all plots remained healthier during August and early September than in previous seasons. There was a light crop, however, owing to the unfavorable influence of weather conditions. During September foliage in check rows rapidly declined as a result of continued feeding by the insect population that had been built up there during the course of the experiment.

Treatments were made on July 27, August 14 to 15, and September 8 and 13. Pods were picked on September 6 and 26 and October 17. On October 4 a comparison was made of the appearance of foliage in different rows as denoted by extent of insect injury and defoliation. These data are summarized in Tables 6 and 7.

FOLIAGE PROTECTION ON SPRAYED PLOTS

There was as usual considerable differences in the condition of foliage of treated and untreated plots at the close of the season, altho the extent of feeding injury in untreated rows had not reached such severe proportions as in previous years. Copper sprays in the bordeaux mixture and copper oxychloride series seem to have been again slightly more effective than wettable sulfur or skimmilk powder sprays. This superiority was particularly evident in comparisons between bordeaux mixture, copper oxychloride, and wettable sulfur treatments that contained no insecticidal ingredients. Treatments containing derris powder were more effective than those containing pyrethrum powder. Differences in the comparative condition of foliage in rows treated with stabilized and standard derris powder seemed too small to be significant.

TABLE 6.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON SPRAYED PLOTS.

INSECTICIDE TREATMENTS AND PERCENTAGE STRENGTH OF ROTENONE OR PYRETHRINS IN SPRAY	PERCENTAGE OF PLANTS WITH FOLIAGE INJURY				YIELD PER 100 PLANTS, OUNCES	INCREASE OVER CHECK, OUNCES
	Trace	Slight	Moderate	Severe		
Bordeaux Mixture Series						
None	40	53	7	0	157	71
Standard derris powder, 0.025	75	25	0	0	155	69
Stabilized derris powder, 0.023	82	18	0	0	142	56
Pyrethrum powder, 0.0045	68	31	1	0	129	43
Check	2	58	35	5	86	—
Copper Oxychloride Series						
None	40	58	2	0	165	82
Standard derris powder, 0.025	84	15	1	0	151	68
Stabilized derris powder, 0.023	84	15	1	0	162	79
Pyrethrum powder, 0.0045	54	39	7	0	157	74
Check	0	23	55	22	83	—
Wettable Sulfur Series						
None	10	30	43	17	127	37
Standard derris powder, 0.025	58	32	8	2	175	85
Stabilized derris powder, 0.023	65	26	8	1	198	108
Pyrethrum powder, 0.0045	22	55	21	2	171	81
Check	1	33	48	18	90	—
Skimmilk Powder Series						
Standard derris powder, 0.025	73	25	2	0	151	68
Stabilized derris powder, 0.023	79	21	0	0	188	105
Pyrethrum powder, 0.0045	37	59	4	0	107	24
Check	1	43	49	7	83	—

YIELD OF PODS ON SPRAYED PLOTS

The yield of pods in most of the sprayed and dusted plots was greatly increased by treatment despite the lightness of the crop. The greatest gains were recorded in rows treated with stabilized derris powder in combination with wettable sulfur or skimmilk powder. It will be noted that in the wettable sulfur series sulfur treatment alone was inferior to bordeaux mixture and copper oxychloride spray treatments alone, and that the sulfur content of sulfur mixtures, as such, had a less influential part in determining the effectiveness of treatment than the insecticidal content. In contrast, in the bordeaux mixture and copper oxychloride series, the copper content of the mixture seems to have played a more active role than the insecticidal content, there being no added increases

TABLE 7.—COMPARATIVE EXTENT OF FOLIAGE INJURY AND YIELD OF PODS ON DUSTED PLOTS.

Insecticide treatments and percentage strength of rotenone or pyrethrins in dust	Percentage of plants with foliage injury				Yield per 100 plants, ounces	Increase over check, ounces
	Trace	Slight	Moderate	Severe		
Copper-Lime Series						
None	15	67	18	0	155	71
Standard derris powder, 0.50	30	59	11	0	141	57
Stabilized derris powder, 0.475	33	63	4	0	135	51
Pyrethrum powder, 0.495	26	45	24	5	138	54
Check	2	46	38	14	84	—
Copper Oxychloride Series						
None	13	72	14	1	119	35
Standard derris powder, 0.50	28	54	15	3	132	48
Stabilized derris powder, 0.475	15	60	23	2	161	77
Pyrethrum powder, 0.495	5	41	33	21	136	52
Check	2	33	48	17	84	—
Sulfur Series						
None	11	25	43	21	152	61
Standard derris powder, 0.50	16	55	24	5	173	82
Stabilized derris powder, 0.475	30	32	24	14	175	84
Pyrethrum powder, 0.495	19	42	21	18	156	65
Check	1	37	44	18	91	—
Talc Series						
Standard derris powder, 0.50	51	46	3	0	145	47
Stabilized derris powder, 0.475	55	39	6	0	130	32
Pyrethrum powder, 0.495	19	32	41	8	98	0
Check	1	47	48	4	98	—

in yield where insecticides were included in such treatments. Yields in the copper oxychloride series averaged slightly superior to those of the bordeaux mixture series. Yields of plots treated with derris powder averaged slightly higher than those treated with pyrethrum powder, and in nearly all such instances plots treated with stabilized derris powder outyielded those treated with standard derris powder.

FOLIAGE PROTECTION ON DUSTED PLOTS

In comparing data obtained in sprayed and dusted series of the experiment with reference to foliage protection as presented in Tables 6 and 7, it will be seen that dusts were not as effective as sprays, as applied. In discussing the results of the previous season it was suggested that the inferiority of dusts in this connection was probably due to inferior adhering qualities in a season characterized by frequent rainfall. In the present case inferiority cannot be based on such grounds since rainfall was meagre. However, it does seem probable that owing to the extended intervals between applications, namely, 19 and 29 days, respectively, much of the dust deposit had become dislodged from foliage long before the close of such periods as a result of weathering. A truer comparison between dusts and sprays might have been possible for practical purposes if four applications of dust had been made instead of three.

It was evident that treatments containing derris powder were consistently more effective than those containing pyrethrum. This was particularly noticeable in the talc series of tests, in which case derris dusts attained their highest degree of effectiveness. Data from the copper-lime, copper oxychloride, and sulfur series provided no notable feature arising from the comparisons, except that there were again indications that copper dusts when used alone were slightly more effective than the sulfur dust.

YIELD OF PODS ON DUSTED PLOTS

Yield of pods from dusted plots, as applied, averaged less than from sprayed plots. The highest yields from dusted plots were obtained in the sulfur series, as in the case of sprayed plots. Plants treated with derris powder outyielded those treated with pyrethrum powder in the sulfur and talc series, but this was not invariably the case in copper-lime and copper oxychloride series. The yields gave no clear indication as to the comparative merits of copper and sulfur treatments when applied alone, nor of the comparative values of stabilized and standard grades of derris powder.

SUMMARY

In summing up the results of tests during the 1939 season which was characterized by abnormally dry conditions, light yields, and less intensive injury by the Mexican bean beetle than in previous years, it may be concluded from the evidence provided by the comparative condition of foliage in the respective plots at the close of the experiment that,

1. Spray treatments were more effective than dust treatments, as applied.
2. Treatments containing copper averaged superior results to those containing sulfur.

3. Treatments containing derris powder were more effective than those containing pyrethrum powder.
4. There were no significant differences in the results obtained from treatments containing standard and stabilized grades of derris powder, nor from treatments containing monohydrated copper sulfate with hydrated lime and those of copper oxychloride.

The results in terms of yield may be summarized as follows:

1. Yields from sprayed plots invariably averaged higher than those from dusted plots.
2. Treatments containing sulfur and an insecticide averaged superior yields to those containing copper and an insecticide.
3. Plots treated with derris powder as the insecticide averaged higher yields than plots treated with pyrethrum powder, and plots receiving a treatment of stabilized derris powder invariably outyielded in each series those treated with standard derris powder.
4. The effectiveness of mixtures in both copper series was apparently due in no little measure to their copper content, whereas the effectiveness of mixtures in the wettable sulfur series seemed to be due largely to their insecticide content, particularly of derris powder.

In order to make closer observations concerning the behavior of larvae and adults of the Mexican bean beetle when subjected to treatments containing bordeaux mixture and derris powder, a series of complimentary tests was carried out under greenhouse conditions during 1938, 1939, and 1940. It was hoped that results from these tests might provide some clue as to the function of such treatments, which chemically were held invalid, in foliage protection. The conclusions drawn from the results of these experiments have been reported in greater detail elsewhere (10).

Insofar as they may have a bearing on the results of tests carried out under field conditions, it may be noted that it was evident under caged conditions that the effectiveness of bordeaux mixture was largely due to its deterrent properties in rendering the surface of the foliage obnoxious for feeding purposes. (See Fig. 3.) When derris powder was included in bordeaux mixture, the effectiveness of the spray in this regard was considerably enhanced. It was also evident that bordeaux mixture containing derris powder was toxic to larvae and adults when applied as a contact spray, tho not as toxic as one containing derris and skimmilk powders. These results seemed to provide in some degree an explanation for the compara-

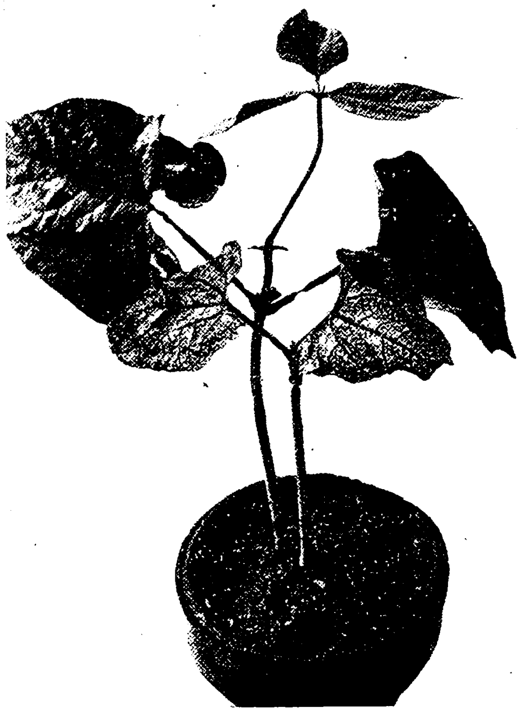

FIG. 3.—PLANTS CAGED FOR A WEEK WITH LARVAE OF THE MEXICAN BEAN BEETLE, ONE SPRAYED WITH DERRIS SUSPENSION AND THE OTHER UNTREATED, SHOWING REPELLENT EFFECT OF DERRIS SPRAY SUSPENSIONS.

tive success attained in the field in the use of copper sprays and dusts, with or without the addition of a rotenone-bearing powder, in protecting the foliage of beans from injury by the Mexican bean beetle.

1940 AND 1941 EXPERIMENTS

The chief purpose in presenting the results of tests carried out during the seasons of 1940 and 1941 is to provide information concerning the comparative merits of the different types of sprays and dusts in seasons when pests, including the Mexican bean beetle, may be considered of minor practical concern in crop development. Such data may serve indirectly as a useful check to the formulation of spray and dust schedules for control of the Mexican bean beetle. It may be remembered that during the summer of 1939 infestation by the second and subsequent generations of the Mexican bean beetle subsided to insignificant proportions owing to the serious setback suffered by the pest during mid-summer as a result of prolonged periods of excessively hot weather conditions. During the following seasons the Mexican bean beetle did not develop in sufficient numbers on the experimental plots to warrant serious consideration. An attempt to infest the rows (½ acre) artificially during 1941 by the introduction and dispersal of some 8,000 adults of the second generation failed of its purpose.

During these seasons the procedure accorded with that of previous years. In both series of experiments the same samples of derris powder were employed in formulating mixtures the initial analyses of which were used for computing the extent of dilutions. Thus, the standard grade of derris powder contained 5.2 per cent rotenone, the stabilized grade of derris powder 4.36 per cent rotenone, and a brand of impregnated rotenone powder 0.6 per cent rotenone and 2.1 per cent total ether extractives. In the latter case fresh samples were employed each season. Sprays containing suspensions of standard or stabilized grades of derris powder were formulated to give the same rotenone strength, namely, 0.026 per cent. Dusts containing these powders were similarly prepared to contain the same rotenone strength, namely, 0.52 per cent. Sprays containing impregnated rotenone powder were diluted to a strength of 0.003 per cent rotenone (4 pounds of impregnated powder in 100 gallons of water) and dusts of this type to 0.12 per cent rotenone (20 pounds of impregnated powder in 100 pounds of dust). Pyrethrum sprays contained samples of pyrethrum powder analyzing 0.9 per cent pyrethrins. Pyrethrum dusts in 1940 contained pyrethrum powder from the same samples as used for sprays; however, in 1941, they were formulated to carry the same pyrethrin strength as in 1940 by the introduction of a grade of freshly ground powder analyzing 0.6 per cent pyrethrins. Copper sprays were conditioned by the addition of a proprietary product containing soybean flour instead of by the usual skimmilk powder. Dusts were diluted by the admixture of a form of pyrophyllite talc known as Pyrax ABB.

Four applications of spray and dust mixtures, respectively, were made each season, the first on or about July 24 and the last by mid-September. Plots consisted of eight tiers of rows which were divided into alternate series of spray and dust treatments. Each treatment exclusive of checks appeared once in every other tier at staggered intervals in the field, being replicated four times. The seed was sown on June 21 in 1940 and June 20 in 1941 and plants commenced to develop their first set of blossoms during early August. Feeding by the green clover worm was prevalent in both seasons during late July and early August, and it was observed that plots receiving copper treatments, particularly as sprays, and those treated with pyrethrum mixtures were considerably less injured in this manner than plots receiving other treatments. In 1940 it was noticed that the first application of bordeaux mixture which had been prepared according to the ratio of 4–2–50 had a decided deleterious effect on plant growth, a condition which was not completely overcome during the remainder of the season. No such adverse effect was noted in the case of plots dusted with copper-lime mixtures. In 1941 the weather during September was abnormally dry and undoubtedly caused a reduction in yield. Pods were picked twice in 1940 and once in 1941. The data are summarized in Table 8.

TABLE 8.—COMPARATIVE YIELD OF PODS IN 1940 AND 1941.

TYPE OF INSECTICIDAL TREATMENT	1940 SEASON				1941 SEASON			
	Sprayed plots		Dusted plots		Sprayed plots		Dusted plots	
	Yield of 100 plants, ounces	Difference from check, ounces	Yield of 100 plants, ounces	Difference from check, ounces	Yield of 100 plants, ounces	Difference from check, ounces	Yield of 100 plants, ounces	Difference from check, ounces
Bordeaux Mixture and Copper-lime Series								
None	256.6	−13.3	272.6	−7.2	177.7	20.4	164.6	9.0
Standard derris	267.2	−2.7	295.8	16.0	186.2	28.9	180.1	24.5
Stabilized derris	247.2	−22.7	271.0	−8.8	189.7	32.4	217.3	61.7
Impregnated rotenone*	245.7	−24.2	299.8	20.0	228.5	71.2	225.4	69.8
Pyrethrum	261.3	−8.6	289.4	9.6	222.0	64.7	317.4	161.8
Check	269.9	——	279.8	——	157.3	——	155.6	——
Copper Oxychloride Series								
None	300.6	17.7	258.7	−28.3	168.9	−3.9	159.8	30.1
Standard derris	278.9	−4.0	295.5	8.5	169.1	−3.7	165.7	36.0
Stabilized derris	275.7	−7.2	299.4	12.4	206.9	34.1	176.1	46.4
Impregnated rotenone	277.9	−4.9	289.3	2.3	185.7	12.9	192.1	62.4
Pyrethrum	301.7	18.9	321.6	34.6	179.3	6.5	260.3	130.6
Check	282.9	——	287.0	——	172.8	——	129.7	——
Wettable Sulfur and Sulfur Series								
None	292.3	18.4	311.0	11.8	294.5	116.0	270.1	66.3
Standard derris	290.1	16.2	328.8	29.6	314.9	136.4	366.1	162.3
Stabilized derris	316.2	42.2	318.1	18.9	396.9	218.4	359.2	155.4
Impregnated rotenone	337.1	63.2	332.1	32.9	326.7	148.2	419.8	216.0
Pyrethrum	349.1	75.2	374.9	75.7	336.6	158.1	356.9	153.1
Check	273.9	——	299.2	——	178.5	——	203.8	——
Spray Spreader and Talc Series								
Standard derris	281.1	−8.2	288.5	15.7	145.4	−8.8	168.6	1.2
Stabilized derris	262.1	−27.2	313.4	40.6	142.2	−12.0	202.9	35.5
Impregnated rotenone	316.6	27.4	327.4	54.9	163.2	9.0	169.1	1.7
Pyrethrum	305.3	16.0	344.6	71.8	187.7	33.5	233.3	65.9
Check	289.3	——	272.8	——	154.2	——	167.4	——

*Agicide powder.

It will be seen from the data presented in Table 8 that there was evidence of considerable differences in results as expressed in yield of pods in plots sprayed and dusted with fungicides and insecticides during seasons characterized by an absence of injury from plant parasites of the foliage.

The most noteworthy features were the re-occurrence of losses in plots sprayed with copper compounds and of gains in plots treated with sulfur mixtures. It should be noted, however, that the effect of copper treatments as indicated by the resultant yield was not always seemingly adverse, since in 1941 many of the plots thus treated showed slight gains. It should also be noted that under the circumstances copper dusts seemed to be less harmful in this respect than copper sprays, as applied.

The extent of the beneficial effects of sulfur treatments as indicated by gains in yield likewise seemed to vary from season to season, being decidedly favorable in 1941 in all plots and only considered slightly significant in a few of the plots in 1940.

The data obtained in the spreader-talc series of tests, where insecticides were applied without the admixture of fungicides, were too variable to be significant. Here apparently dusted plots also averaged better gains than sprayed plots. It should be noted that in this as well as in other series the greatest gains were invariably recorded from plots treated with pyrethrum.

It may be concluded from these results that regular applications of sulfur mixtures for control of the Mexican bean beetle may be of benefit to the crop in some degree even should parasites of the foliage fail to develop to injurious proportions. The regular application of copper treatments or of those containing an insecticide only, such as derris powder, may be of doubtful value under such circumstances, especially when applied as sprays.

SUMMARY OF ALL RESULTS

During the 1936 and 1938 seasons, the yield of pods averaged much higher than in 1937, 1939, and 1941, owing chiefly to the occurrence of more favorable temperatures and moisture conditions during the period of growth. In the 1937, 1939, and 1941 seasons the crop was much lighter as a result largely of poor distribution of rainfall and the occurrence of excessively high temperatures during July and August. In 1940 the season was notably cooler than in previous years.

The Mexican bean beetle was the chief pest in the experimental plots during the 1936 to 1939 seasons, particularly during the first three years, causing injury to foliage, blossoms, and pods. During 1939 the degree of injury caused by the pest was much less than in previous years owing to the reduction of the population under drought conditions. In 1940 and 1941 injury by the Mexican bean beetle was of little, if any, importance. The potato leafhopper, red spider mite, leaf spots, and downy mildew were comparatively much less injurious than the Mexican bean beetle during seasons when that insect was abundant. In other years these parasites were not conspicuously evident.

The results of experiments carried on from 1936 to 1939 will be summarized apart from those made in 1940 and 1941, since during the former period the crop was subject to serious injury by the Mexican bean beetle while during the two latter seasons the pest was not an important factor in the experiment. It is felt that despite such conditions during the later years, the results from treatment are worth recording on account of the significance of one or two features that they reveal.

EXPERIMENTS FROM 1936 TO 1939

During these seasons results from spraying were more satisfactory than those from dusting, with the single exception of treatments in the bordeaux mixture series during 1936 when yields were seriously curtailed apparently owing to treatment. (Reduced yields were again in evidence in the bordeaux mixture series during 1941 when the Mexican bean beetle was non-injurious.) A notable feature of the 1936–39 results has been the comparatively high average degree of foliage protection secured by applications of spray in the copper series, especially in the case of bordeaux mixture. The addition of rotenone-bearing powder or pyrethrum powder to bordeaux mixture or copper oxychloride sprays, as prepared, increased the effectiveness of treatment to a limited degree and to approximately an equivalent extent. The benefits in foliage protection from such sprays were more marked than the resultant increases in yield, in fact in many instances the yield from treatments containing copper alone was as satisfactory as where insecticides had been included in the treatment.

The greatest increases in yield from specific treatments were obtained in most seasons from plots sprayed with a mixture containing rotenone-bearing powder and wettable sulfur or skimmilk powder despite the fact that such treatments were not as effective as copper treatments in the matter of foliage protection. Sprays containing wettable sulfur without an insecticide were consistently less effective than those of bordeaux mixture or copper oxychloride without an insecticide. Tests of pyrethrum in the wettable sulfur and skimmilk powder series gave inferior results to those of rotenone-bearing powder.

There were no indications that the effectiveness of insecticidal treatments in the bordeaux mixture series might be improved by applying the fungicide and insecticide in separate operations.

There was no reliable evidence to indicate that under field conditions stabilized rotenone-bearing powder might be more effective than standard rotenone-bearing powder, other things being equal. Both materials were capable of being applied with equal success.

Results from comparisons between spray applications of bordeaux mixture and copper oxychloride revealed little or no differences relative to their comparative merits in Mexican bean beetle control. Both materials were effective in foliage protection. However, the response of the plant to treatments of copper oxychloride in terms of yield varied from gains recorded in 1938 and 1939 when the Mexican bean beetle was injurious to little or no increases in many of the plots in 1940 and 1941 when parasites of the foliage were of little practical concern.

Dusts were less effective than sprays in most instances, and results from year to year were less consistent than in the case of sprays. The more satisfactory results from treatments in the different series were obtained in plots dusted with a mixture containing rotenone-bearing powder. In comparison, plots treated with a pyrethrum dust were decidedly inferior. Treatments in the copper-lime series averaged slightly superior results to those in the sulfur series. It was evident that the yield from plots dusted with a copper-lime mixture without an insecticide was about equal to those of plots treated with a copper-lime dust and an insecticide. In terms of foliage protection, however, results tended to indicate that applications of copper-lime dust without an insecticide were less effective than those containing an insecticide in the form of rotenone-bearing powder.

EXPERIMENTS DURING 1940 AND 1941

During these seasons, characterized by the absence of injury by the Mexican bean beetle, results as indicated by the response of the plant to treatment in terms of yield showed that treatments in the sulfur series were consistently more beneficial than treatments in other series and, as in 1941, were capable of considerably improving the yield under such circumstances. Plots in the copper sulfate and copper oxychloride series showed little benefit from treatment, except in a few instances during 1941. The most notable feature of such treatments and also those in the spreader-talc series was the actual losses recorded from spraying during these seasons. It was evident that dusting was less harmful than spraying in these series.

In many of the tests there was a tendency for the yield from plots treated with pyrethrum to be superior to those of plots treated with rotenone-bearing powder.

RECOMMENDATIONS

In order to combat such pests as the Mexican bean beetle or red spider mite on lima beans it is recommended that sprays or dusts be applied containing a rotenone-bearing powder, such as derris, cubé, or timbo.

SPRAY MATERIALS

For those who prefer to spray, it is recommended that 4 or 5 pounds of rotenone-bearing powder of approximately 5 per cent rotenone content be included in every 100 gallons of spray, the actual amount varying approximately in inverse proportion according to the rotenone content of the powder. Sprays containing wettable sulfur, skimmilk powder, copper oxychloride, and, on occasion, bordeaux mixture, provide a satisfactory basis for insecticidal applications. The choice as to which to use will depend largely on the circumstances. Under conditions where it has been customary to take into account the possibility of infestation by red spider mite or potato leafhopper, wettable sulfur sprays are recommended. Where or when it is advisable to adopt measures that will protect the crop against infection by downy mildew or certain foliage diseases, bordeaux mixture or a fixed copper compound is recommended. In the case of bordeaux mixture, it seems necessary for best results that the rotenone-bearing powder should not be added to the tank until it is nearly full and ready for application. In all cases rotenone-bearing powders should be reduced to paste form before being added to the bulk of the spray.

The formulae for sprays are as follows, amounts representing the minimum requirements per acre:

Wettable sulfur spray:	
Derris, cubé, or timbo powder*	4 lbs.
Wettable sulfur	12 lbs.
Water	100 gals.
Simple suspension spray:	
Derris, cubé, or timbo powder	4 lbs.
Skimmilk powder	2 lbs.
Water	100 gals.
Fixed copper spray:	
Derris, cubé, or timbo powder	4 lbs.
Fixed copper compounds and spreader according to manufacturer's directions	
Water	100 gals.
Bordeaux mixture spray:	
Derris, cubé, or timbo powder	4 lbs.
Skimmilk powder	2 lbs.
Bordeaux mixture, 4-4-50	100 gals.

*Dosage computed on the basis of a powder containing 5 per cent rotenone.

Despite the fact that thoro applications of bordeaux mixture or copper oxychloride sprays without an insecticide have given a certain degree of protection against attack by the Mexican bean beetle and have resulted in comparatively satisfactory yields on many occasions, it is not recommended that such sprays should be preferred to those containing wettable sulfur for Mexican bean beetle control in view of the fact that under certain conditions common to Long Island copper sprays as now known may exert a deleterious effect on plant development and thus may cancel any benefit that might accrue due to insect control.

DUST MATERIALS

For those who prefer to dust it is recommended that 10 to 15 pounds of rotenone-bearing powder, such as derris, cubé, or timbo powder, analyzing 4 or 5 per cent rotenone content, be included in each 100 pounds of dust, the actual amount varying approximately in inverse proportion according to the rotenone content of the powder.

Talc or clay and sulfur, either in part or by themselves, make satisfactory diluents for rotenone-containing dusts, provided care is taken to ensure that their pH reaction does not exceed the neutral point. The proportion of sulfur contained in the mixture will in many cases be largely determined by the rôle that red spider mite or potato leafhopper has played in the production of beans under local conditions. Where these pests are known to be a not infrequent cause of injury to the crop, the diluent may largely consist of sulfur. In cases where it seems advisable to apply a dust for control of certain plant diseases as well as the Mexican bean beetle, it is safer on grounds of chemical compatibility among ingredients to select a formula in which the rotenone-bearing powder is added to a talc or clay mixture (with or without sulfur) containing one of the recommended so-called fixed or insoluble copper compounds rather than resort to the expedient of preparing a mixture containing hydrated lime, monohydrated copper sulfate, and rotenone-bearing powder.

However, in cases necessitating the use of a copper-lime dust to control a plant disease, such as downy mildew, and where it is also desired to apply an insecticide such as derris powder for control of the Mexican bean beetle, it is suggested that on account of practical considerations pertaining to its application, it may be feasible to include rotenone-bearing powder in a monohydrated copper sulfate-hydrated lime mixture provided the dust is freshly prepared for each day's operation and is immediately applied.

Formulae for dust mixtures are as follows, the amount applied per acre averaging about 30 to 40 pounds or more per application, depending largely on the size of plants and atmospheric conditions while dusting:

Talc, clay, or sulfur dust:	
Derris, cubé, or timbo powder*	10 lbs.
Infusorial earth†	2 lbs.
Talc, clay, or sulfur	88 lbs.
Sulfur-talc or clay dust:	
Derris, cubé, or timbo powder	10 lbs.
Infusorial earth	2 lbs.
Sulfur	44 lbs.
Talc or clay	44 lbs.

*Dosage computed on the basis of a powder containing 5 per cent rotenone.

†"Celite", manufactured by Johns-Manville, New York; "Dicalite" manufactured by the Dicalite Co., New York.

Fixed copper dust:

Derris, cubé, or timbo powder	10 lbs.
Infusorial earth	2 lbs.

Fixed copper compound according to manufacturer's directions

Talc, clay or sulfur to make 100 lbs. of dust.

Copper-lime dust:

Derris, cubé, or timbo powder	10 lbs.
Monohydrated copper sulfate	15 lbs.
Hydrated lime	75 lbs.

TIMING APPLICATIONS

Altho the crop is subject to injury at any time from June to September owing to infestation by the Mexican bean beetle, there are definite periods during the season when adults are likely to be most numerous and egg laying most prolific. Such peaks are likely to occur roughly at monthly intervals during the warmer months of the season commencing during the latter part of June or early July on eastern Long Island, and recurring as late as October. Their arrival may usually be detected superficially by a notable increase in the prevalence and extent of newly made foliage injury, caused by the feeding of recently hatched batches of larvae. In western Long Island these periods may occur a week to 10 days earlier than in eastern districts.

It is recommended that the timing of control operations for Mexican bean beetle be based largely on the occurrence of such peaks in the life history of the insect. In this respect it is advisable to note conditions in neighboring fields as well as in one's own planting. It is recommended that one or two applications of spray or dust be made at such periods to check larval feeding and adult egg laying, and that one or more applications be made during the intervals between peaks to meet conditions that may arise owing to subsequent reinfestation. Such a schedule of applications is not inconsistent with the timing of fungicidal applications that are recommended for best results in disease control.

LITERATURE CITED

1 Clayton, E. E. Spraying experiments with bush lima beans. *New York State Agr. Exp. Sta. Bul. No. 558. 1928.*

2 Gnadinger, C. B. Pyrethrum Flowers. *Minneapolis: McLaughlin Gormley King and Co. Ed. 2. 1936.* (Page 247.)

3 Horsfall, J. G., Magie, R. O., and Suit, R. F. Bordeaux injury to tomatoes and its effect on ripening. *New York State Agr. Exp. Sta. Tech. Bul. No. 251. 1938.*

4 ————, and Harrison, A. L. Effect of bordeaux mixture and its various elements on transpiration. *Jour. Agr. Res.,* **58,** *423–443. 1939.*

5 ————, Hervey, G. E. R., and Suit, R. F. Dwarfing of cucurbits sprayed with bordeaux mixture. *Jour. Agr. Res.,* **58,** *911–927. 1939.*

6 Huckett, H. C. The Mexican bean beetle. *New York State Agr. Exp. Sta. Circ. No. 125. 1932.*

7 ————. The tolerance of beans to sprays and dusts for the Mexican bean beetle. *Jour. Econ. Ent.,* **24,** *200–204. 1931.*

8 ————. Recent problems on Long Island in the control of bean insects. *Jour. Econ. Ent.,* **31,** *266–270. 1938.*

9 ————. Further tests with pyrethrum as an insecticide for cabbage worms. *Jour. Econ. Ent.,* **30,** *323–328. 1937.*

10 ————. Derris and the control of the Mexican bean beetle. *Jour. Econ. Ent.,* **34,** *566–571. 1941.*

11 ————. The Mexican bean beetle. *New York State Agr. Exp. Sta. Circ. No. 160. 1935.*

12 Roark, R. C. A digest of the literature of derris *(Deguelia)* species used as insecticides, 1747–1931. *United States Dept. Agr. Misc. Pub. No. 120. 1932.*

13 ————. *Lonchocarpus* species (Barbasco, Cubé, Haiari, Nekoe, and Timbo) used as insecticides. *United States Dept. Agr. Mimeo. Ser. E-367. 1936.*

14 ————. An insect that breathes through its nose. *Jour. Econ. Ent.,* **30,** *526. 1937.*

15 Suit, R. F., and Horsfall, J. G. The copper factor in bordeaux injury. *Phytopath.,* **28,** *20. 1938.*

16 Wilson, J. D. Certain injurious effects of spraying vegetables with the fixed coppers. *Ohio Agr. Exp. Sta. Bimonth. Bul. 25, No. 203, 39–40. 1940.*

17 ———— and Runnels, H. A. Transpirational response of various plants to bordeaux mixture. *Ohio Agr. Exp. Sta. Bimonth. Bul. 19, No. 171, 198–202. 1934.*