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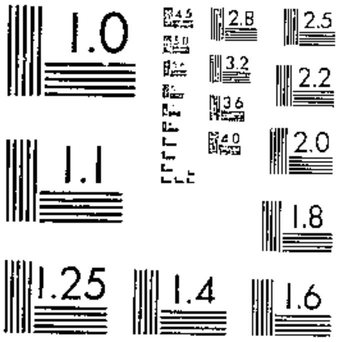

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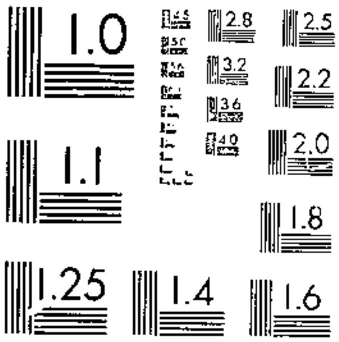

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HABITS, LIFE HISTORY, AND CONTROL OF THE MEXICAN BEAN BEETLE IN NEW MEXICO

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CONTENTS

INTRODUCTION

The Mexican bean beetle[2] is the most serious insect enemy of beans in the infested districts of New Mexico. Although beans have been grown by farmers in the foothills of the Estancia Valley for years, it was not until 1914 that the first commercial plantings were made, at which time four carloads were produced. During the World War demands for increased production and the introduction of modern farm machinery permitted the plantings to be increased to about 85,000 acres. The bean beetle increased with the increase of commercial acreage, and large acreages of beans were defoliated along the foothills. As the industry was threatened, an appeal to the Federal Government was made for a study of the bean beetle in the valley, and the writer was sent to Estancia, N.Mex., in the summer of 1923

[1] Acknowledgments are due Harry and Cecil Glover, of Tajique, and Rea Brown, of Estancia, who placed their entire bean plantings at the disposal of the writer without compensation and cooperated by furnishing teams, tractors, and labor in applying insecticides and securing data on yields; L. O. Bachmann, who operated thermographs in the foothills west of Tajique and prepared, planted, and cultivated fields from which infestation records were obtained; Frank Moore, who kindly threshed the 1930 foothill plats without compensation; the U.S. Forest Service, especially the Manzano National Forest force, for permission to utilize certain areas for hibernation studies and for help in various ways; the Santa Fe office of the U.S. Weather Bureau for meterological data; E. B. Wiggins, field assistant, who rendered valuable assistance in securing field data for 4 seasons; and farmers and bean-warehouse owners, who willingly placed at the writer's service every possible means to facilitate the investigations.

[2] *Epilachna corrupta* Muls.; order Coleoptera, family Coccinellidae.

to establish a field laboratory. This bulletin reports studies conducted up to December 1931. The information is intended to acquaint the agriculturists of the Southwest with the habits, life history, and control of the Mexican bean beetle.

This insect, presumably a native of Mexico, was first described in 1850 from specimens collected there. The first authentic account in agricultural literature of its presence in the United States was from the Southwest in 1864 (*1*).[3] Evidently this beetle was a pest in the

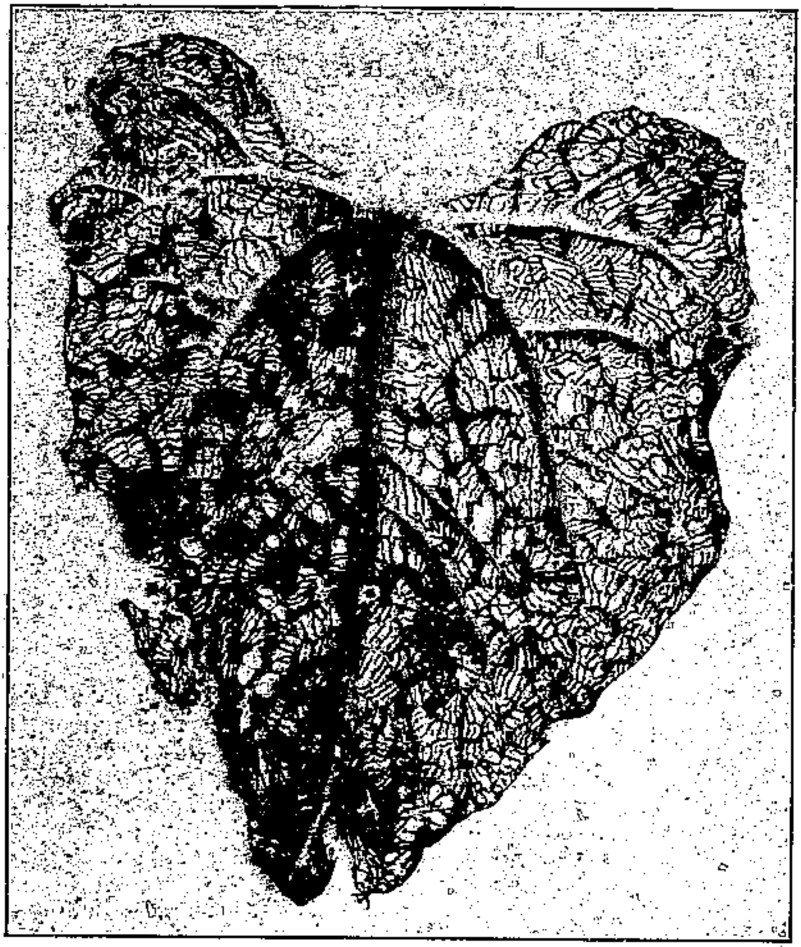

FIGURE 1.—Injury to bean leaf caused by the feeding of larvae of the Mexican bean beetle. Slightly enlarged (N. F. Howard).

Southwest years before, as beans were a staple food of the Indians during the earlier days, and later of the Spanish Conquistadors. In the ruins of prehistoric agricultural tribes are to be found varieties of beans which have survived the race under whose husbandry they originated. Through centuries of natural selection this insect has produced a type eminently adapted to remain in hibernation through the dry, hot period of spring and to emerge with the coming of the

[3] Italic numbers in parentheses refer to Literature Cited, p. 45.

summer rains. Its reproductive capacity makes this beetle a pest of primary economic importance.

The Pinto bean (*Phaseolus vulgaris*) is the only variety of bean grown commercially in the Estancia Valley and therefore is the only variety worked with in the field.

CHARACTER OF INJURY

Injury to the leaves of beans both by the adults and by larvae of the Mexican bean beetle is characteristic and distinct from that produced by other bean insects. They feed on the undersurface of the leaves, and their feeding can be distinguished as follows: The beetles eat ragged holes through the leaf, but often do not cut through the upper surface, leaving the larger veins and portions of the upper

FIGURE 2.—Feeding marks of the Mexican bean beetle on young green bean pods. Such feeding causes deformity and dropping of the pods.

epidermis and giving the leaves a lacelike appearance. The larvae cut away the lower surface of the leaf in narrow parallel strips about the length of their bodies, leaving intact the upper surface, the larger veins, and narrow linear strips of the lower surface. This results in a peculiar network (fig. 1). At first the larvae feed in groups near the egg mass but later become scattered as they crawl to other leaves in search of more food. The more injured leaves dry up and drop from the plant, while others, not completely skeletonized, hang dead on the plant.

Although the insects feed chiefly on the leaves, all parts of the plant above the ground are subject to attack. After destroying the leaves, they will attack the green pods (fig. 2) and even the stems. When the insects are numerous, an injured plant presents the appearance of being completely dried out.

The primary causes of reduction in yield are the destruction of the leaves and the injury caused through the eating of the blossoms and the feeding on the young pods, which results in deformity and dropping. The pods that have been injured by being fed on become water-soaked during rainy weather, and consequently the beans become discolored and are therefore of a lower grade. This deterioration often takes place after the beans have been harvested and piled in small shocks to cure before being threshed.

The extent of injury depends upon the number of insects per acre, the time of their appearance in the field, the condition of the plants, and seasonal variations. Under a heavy infestation complete defoliation will result early in the season so that only a few pods will be produced per plant, provided nothing is done to prevent destruction

FIGURE 3.—Field of beans near Tajique, N.Mex., destroyed by the Mexican bean beetle.

(fig. 3). Defoliated fields are not harvested, as they will not pay the cost of harvesting and threshing. One farmer who harvested a devastated field got less than 18 pounds of beans per acre.

RELATION OF DEFOLIATION TO REDUCTION IN YIELD

Experiments were undertaken to determine the relation of foliage injury to decrease in yield. Areas were selected where the soil was of uniform character and where the spacing of the plants was as regular as occurs under mechanical planting. Each experimental plat contained 13 rows, including 3 check or untreated rows, and each row contained 20 plants. The plants in rows in the first series were defoliated by hand on August 1, when the beans started blooming; those in the second series were similarly defoliated on August 11; and those in the third on August 21. The leaves of each plant were counted and the desired number removed to give 10 percent defoliation or a multiple thereof. Thus 10 percent of the leaves were removed on the first row, 20 percent on the second, and so on until 100 percent defoliation was reached, as shown in figure 4. Care was used to remove a fair sample of the different stages of leaf growth at each defoliation.

Figure 4 gives the percentages of foliage destroyed and the combined yields of the three series. In general, the results show that there is a direct relation between defoliation and yield. The yield of beans from the August 1 defoliation was 99.3 ounces, as compared to 131.4 ounces for the August 11 defoliation and 326.8 ounces for the August 21 defoliation. When considered separately, these and similar experiments also showed that the earlier the defoliation, after the plants start blooming and bearing, the greater the decrease in yield.

HIBERNATION

The Mexican bean beetle passes the winter in only the adult or beetle stage. In the Estancia Valley the beetles begin their fall migration in search of suitable hibernation quarters in early September and reach the maximum flight during the latter part of September and the

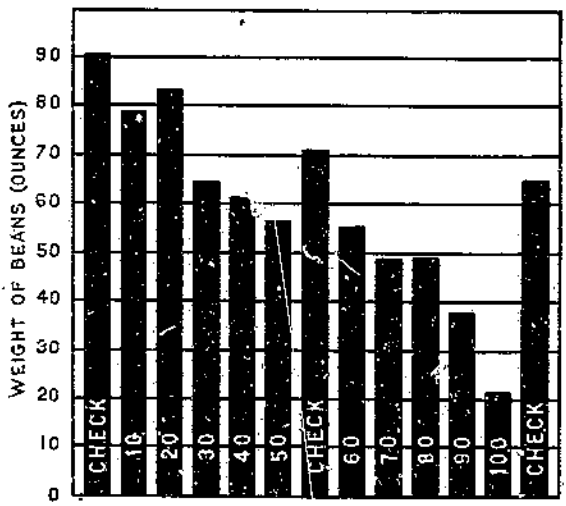

FIGURE 4.—Reduction in yield of dry shelled beans from 13 rows, resulting from various degrees of hand defoliation after blooming had begun. The figures in the bars indicate the percentage of leaves removed.

first part of October, depending upon seasonal variation, harvest of bean plants, and killing frost. The findings here presented are the results of a comprehensive study of the overwintering of the insect in the Estancia Valley from 1923 to 1930, during which time 286,327 beetles were used in field-hibernation studies.

The hibernation cages used during these investigations were constructed of 2 by 4 inch lumber, and measured from 3 to 6 feet in width, from 4 to 6 feet in length, and from 2 to 4 feet in height. They were covered with 14-mesh screen wire, and had removable tops (fig. 5). After the beetles had become dormant, the 14-mesh screen wire tops were exchanged for 1-inch mesh wire tops which permitted snow to enter the cage and at the same time excluded intruders. These tops were again exchanged before activity was manifested in the spring. In this manner conditions approximating, as nearly as possible, those prevailing under natural hibernation were obtained.

Three cages were located in the fir-spruce zone, 5 in the yellow pine zone, 1 in the pinyon or nut pine forest zone, and 3 in the grama-grass association.

These studies show that the character of the hibernation material has an important effect on the successful overwintering of this insect. Suitable material is one that permits beetles to enter and emerge readily, and at the same time protects them from rapid changes and low temperature. The material must also retain moisture and prohibit too rapid drying out. Oak leaves and pine needles, alone or in combination, when lying in well-protected places under good drainage conditions, are the most favorable materials. Compact materials such as fir, cedar, and pinyon needles are unsuitable, as beetles are unable to enter them. Weeds are the most unsatisfactory material found, as they permit rapid changes in temperature and moisture. Russian thistle (*Salsola pestifer*) is the most abundant and widely distributed

FIGURE 5.—Type of hibernation cage used in studies of the Mexican bean beetle. The self-recording weather instrument is in the white box above the cage and the rain-gage stand is just back of the lock on the door.

weed in the Estancia Valley. When mature, it breaks off at the surface of the ground and rolls before the wind. These weeds finally lodge and pile up along fences where they break the force of the wind, which deposits a large quantity of sand and dust on the leeward side of the fence. This accumulation continues until the fence is covered with wind-blown sand. This condition alone prevents the successful hibernation of the beetles along fence rows in the valley.

Figure 6 shows that on February 10, 1929, the air temperature decreased to −27° F. at Estancia, as compared with a temperature of 25°, under a 6-inch blanket of snow in the hibernation material of oak leaves and pine needles in a near-by cage, as registered by a distance thermograph. At the same time temperature in the hibernation material in an adjacent cage, where Russian thistles were used, decreased to $-1°$. This demonstrates that weeds hold the blanket of snow off the ground, permitting the temperature to fall below the killing point.

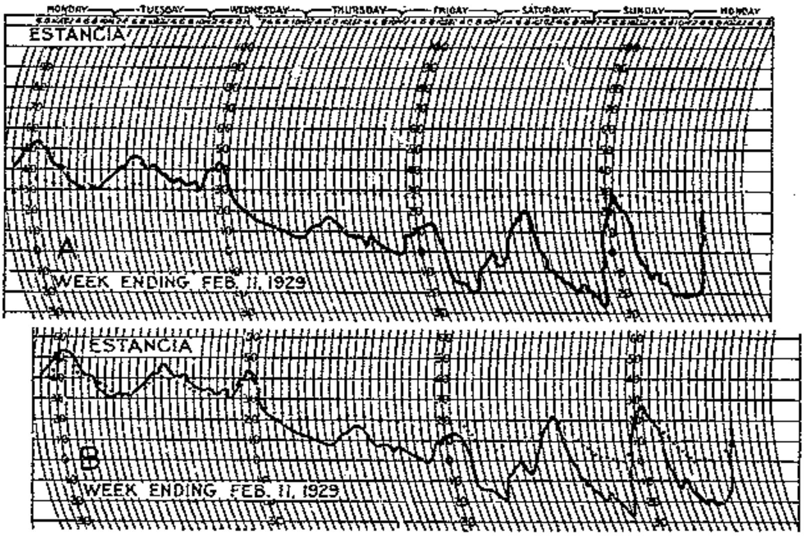

FIGURE 6.—Temperature records for the week ended February 11, 1929, at Estancia, N.Mex., showing the comparison between air temperature and the temperature of the hibernation material used by the Mexican bean beetle. Oak leaves and pine needles were the hibernation material in the upper record (A) and Russian thistles in the lower (B). The solid line indicates the air temperature and the dotted line that of the hibernation material.

FIGURE 7.—Mexican bean beetles hibernating in oak leaves and pine needles (N. F. Howard).

The evidence secured in these investigations shows that the overwintering of the beetles is confined primarily to the yellow pine forest zone and that conditions become more favorable where oak trees are found in the association, as shown in figure 7.

The sketch map of the valley (fig. 8) shows that the yellow pine forest zone occurs only along the western edge of the valley, and that therefore the valley has a 1-way invasion of overwintered beetles. A study of the arrival in the fields early in the season confirms this statement, as the first overwintered beetles are found in the foothill-canyon fields, from which they later migrate down the canyons into the valley. This point has been checked by the use of marked beetles that were liberated in the heads of the canyons and later recovered in fields lower down. Also, the beetles are more numerous and the damage greater along the western foothills, east of the Manzano Mountains, than out in the valley. The Mexican bean beetle is not a serious major pest in areas remote from suitable hibernation quarters, as in the eastern part of New Mexico. There are a number of areas in New Mexico that have a 1-way infestation.

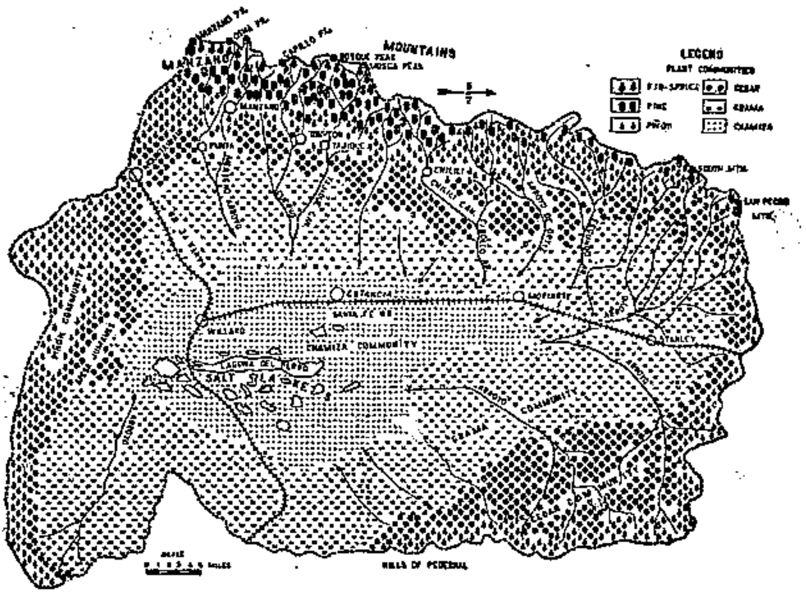

FIGURE 8.—Sketch map of the Estancia Valley showing plant communities.

Stacks of bean hulls (fig. 9) do not furnish ideal hibernation quarters for the bean beetle, as only the top layer receives moisture, which is essential for overwintering. Long periods of drying out are fatal. These stacks are usually consumed by livestock during the winter, although a few are not utilized for several years. No initial infestation has been traced to these stacks. What few beetles remain in the shocks at threshing time are usually separated out with the dirt, and very few, if any, are blown into the stack of hulls.

The effect of climate on the overwintering of this insect has been studied for 7 years, with a view to determine the relation of weather to winter mortality. Mild or severe winter temperatures seem to have no correlation with winter survival. Some of the severe winters have been favorable for the overwintering of the insect. The primary reason for this is that the beetles overwinter in the yellow pine forest zone which covers the higher rolling hills and the lower and drier slopes of the mountains, and during periods of below-zero weather the ground is usually covered with snow, which protects the beetles from a fatal temperature by its insulating qualities. The preferred hibernation material also acts as an insulator. The indications are that precipitation is the major factor affecting survival from hibernation and that as the temperature decreases so do the moisture requirements of the beetles. Apparently the seasonal distribution of moisture is more important than the quantity. According to the available evidence, the spring is the critical period during hibernation when periods of excessive rain and heavy, wet snowfalls followed by cloudy conditions occur or prevail. Damp or rainy weather, however, is favorable

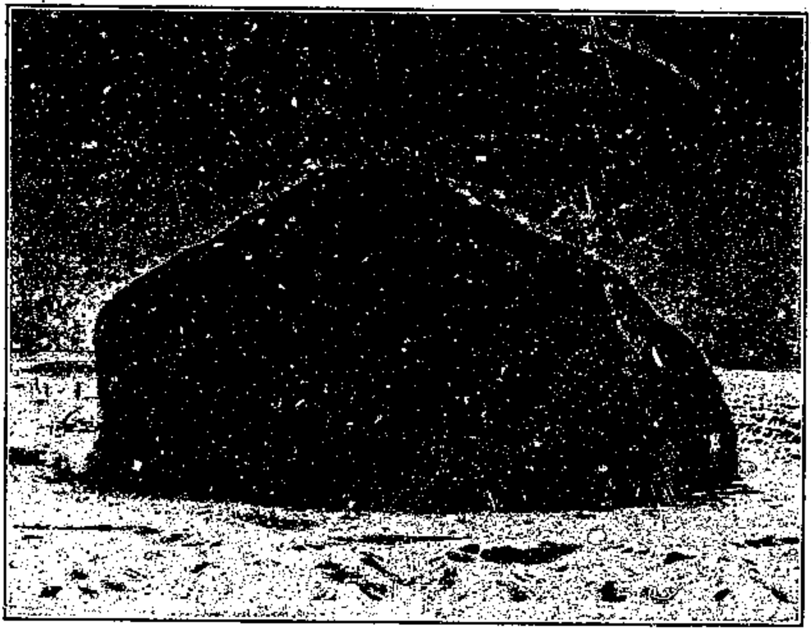

FIGURE 9.—Stack of bean hulls, worth about one half the value of alfalfa as feed for cattle.

to the parasite fungus *Sporotrichum globuliferum*, which may cause a high death rate among the overwintering beetles.

EMERGENCE FROM HIBERNATION

The emergence of the beetles from the hibernation cages was studied at the same time, and some of the data obtained are given herewith. The experiments were carried on in the foothills west of Tajique.

The cages utilized in the emergence studies were located in the yellow pine (*Pinus ponderosa*) forest zone that covers the higher rolling hills and the lower and drier slopes of the Manzano Mountains. The locations of these cages represented a typical cross section of the natural hibernation quarters.

In the fall of 1925, 5,000 beetles were placed in cages 5 and 7. Into cage 6, 1,500 beetles were introduced. In the fall of 1926, 10,000 beetles were placed in cage 5, 15,000 in cage 7, and 5,000 in cage 8.

All the beetles were collected in the irrigated area near Hoehne, Colo., and in the Rio Grande Valley, north of Albuquerque, N.Mex.

The temperature records used in this connection have been compiled from the meteorological records of a cooperative observer of the United States Weather Bureau at a station located near Tajique, 3 miles northeast of the location of the foothill experiments. The locations of the weather station and of the Tajique Canyon cages are very similar in regard to exposure, topography, drainage, and environment. The precipitation data were obtained from rain gages close to the different cages in order to insure accuracy (fig. 5).

Examinations of the cages were made as often as time and other conditions would allow; usually daily, or at least every other day, during the emerging season. After emergence became general the active beetles were removed from the cages when examinations were made, and the numbers thus removed were used in computing the percentages given in the accompanying tables.

During the season of 1926 the first emergence in the foothills was on April 8, when 5 adults were found on the screen in cage 8. These beetles later reentered the hibernation material. Emergence occurred again on May 2 and continued irregularly until July 30. This emergence period extended over 89 days and was very general and intensive for several weeks in the yellow pine forest zone. The greatest number emerged in cage 7, at an elevation of 7,000 feet. During the period of 12 days, from June 27 to July 8, inclusive, 1,171 out of 1,812 beetles, or 64.62 percent, emerged in this cage. During the same period 645 beetles out of 1,112, or 58 percent, emerged in cage 5, at an elevation of 7,050 feet. In table 1 it will be noted that during the period from June 24 to July 7, inclusive, the total emergence was 1,913 beetles out of 3,263, or 58.63 percent. Table 1 also shows that the periods and peaks of emergence from cage 6, within one half mile in the same canyon, vary from the other two, owing to differences in local conditions.

Table 1.—*Emergence of the Mexican bean beetle from hibernation in cages 5 and 6, at an elevation of 7,050 feet and from cage 7 at an elevation 7,000 feet, during 1926, Tajique, N.Mex.*

Week ended	Average mean temperature for period	Precipitation	Beetles emerging from—			Total emergence
			Cage 5	Cage 6	Cage 7	
	° F.	*Inches*	*Number*	*Number*	*Number*	*Number*
May 5	48.8	0.48	0	1	1	2
May 12	42.8	.04	0	0	0	0
May 19	52.7	.01	1	0	5	6
May 26	56.8	.55	12	8	41	61
June 2	55.1	.71	17	0	30	47
June 9	50.1	.29	80	12	57	149
June 16	50.0	.41	205	86	186	477
June 23	59.9	.25	95	32	150	277
June 30	63.9	.22	391	46	548	985
July 7	62.3	.20	254	77	597	928
July 14	60.4	.30	47	43	166	256
July 21	63.7	[1] T.	1	4	17	22
July 28	60.6	1.70	9	30	14	53
Aug. 4	63.6	.06	0	0	0	0
Total			1,112	339	1,812	3,263

[1] Trace.

In 1927 the first beetles emerged in the foothills on April 2, when two adults were noted crawling over the hibernation material in cage 7. These beetles later reentered hibernation. This appearance and disappearance continued at intervals until May 3, after which the active beetles were removed from the cages as they emerged. Starting on May 3 and continuing until August 6, this emergence extended over 95 days, with two short periods of intensive emergence.

The first intensive emergence occurred from June 14 to 17, inclusive, and the second from June 29 to July 1, inclusive. During the first period of 4 days 1,938, or 33.54 percent, emerged, and during the second period of 3 days 932 beetles, or 16.13 percent, emerged. On June 16, 1,126 beetles, or 19.49 percent, were removed from the cages. This represents the emergence for June 15 and 16, as no removal was made on the 15th, as shown in figure 11. During the week ended June 18, 2,228 insects, or 38.56 percent, emerged, as shown in table 2.

Table 2.—*Emergence of the Mexican bean beetle from hibernation in cage 5, at an elevation of 7,050 feet, cage 7, at an elevation of 7,000 feet, and cage 8, at an elevation of 6,975 feet, during 1927, Tajique, N.Mex.*

Week ended	Average mean temperature for period	Precipitation	Beetles emerging from—			Total emergence
			Cage 5	Cage 7	Cage 8	
	° *F.*	*Inches*	*Number*	*Number*	*Number*	*Number*
May 7	53.8	0	21	26	1	48
May 14	48.8	.21	18	5	0	23
May 21	60.8	.12	39	37	3	79
May 28	54.2	0	12	20	0	32
June 4	57.1	0	4	14	0	18
June 11	59.7	.18	52	39	9	100
June 18	53.6	1.63	1,305	656	267	2,228
June 25	61.6	.09	255	322	66	643
July 2	60.9	.18	426	609	77	1,112
July 9	62.9	.03	366	253	23	642
July 16	65.4	.20	194	255	33	482
July 23	65.6	.02	24	42	13	79
July 30	63.5	1.78	113	163	24	290
Aug. 6	64.0	1.41	0	2	0	2
Total			2,829	2,433	516	5,778

Collections from the hibernation cages during 1926 and 1927 are shown in figures 10 and 11. The emergence from the cages is summarized in tables 1 and 2. The rates of emergence from the cages are very similar and in general the beetles respond to the precipitation stimulus (*3*).

Table 3 shows by comparison that rainfall is the greater of the two stimuli influencing the emergence of the bean beetle from hibernation, especially after the mean temperature has reached 50° F. Emergence occurs at much lower temperatures during periods of rainfall, but the beetles resume hibernation after the rain ceases. Local showers during the heat of the day bring more beetles out of hibernation than would the same rainfall at a lower temperature. Local rainfall over one canyon area has no effect on the insects about to emerge in adjacent canyons. It has been noted that whenever heavy rains are preceded by hot, dry weather, the majority of the beetles emerge within a period of a very few days.

Figures 10 and 11 show that in general the greatest numbers of beetles emerge on days when precipitation occurs and that the numbers decrease as the hibernation material dries out. The effect of the combined factors of temperature and precipitation is best illus-

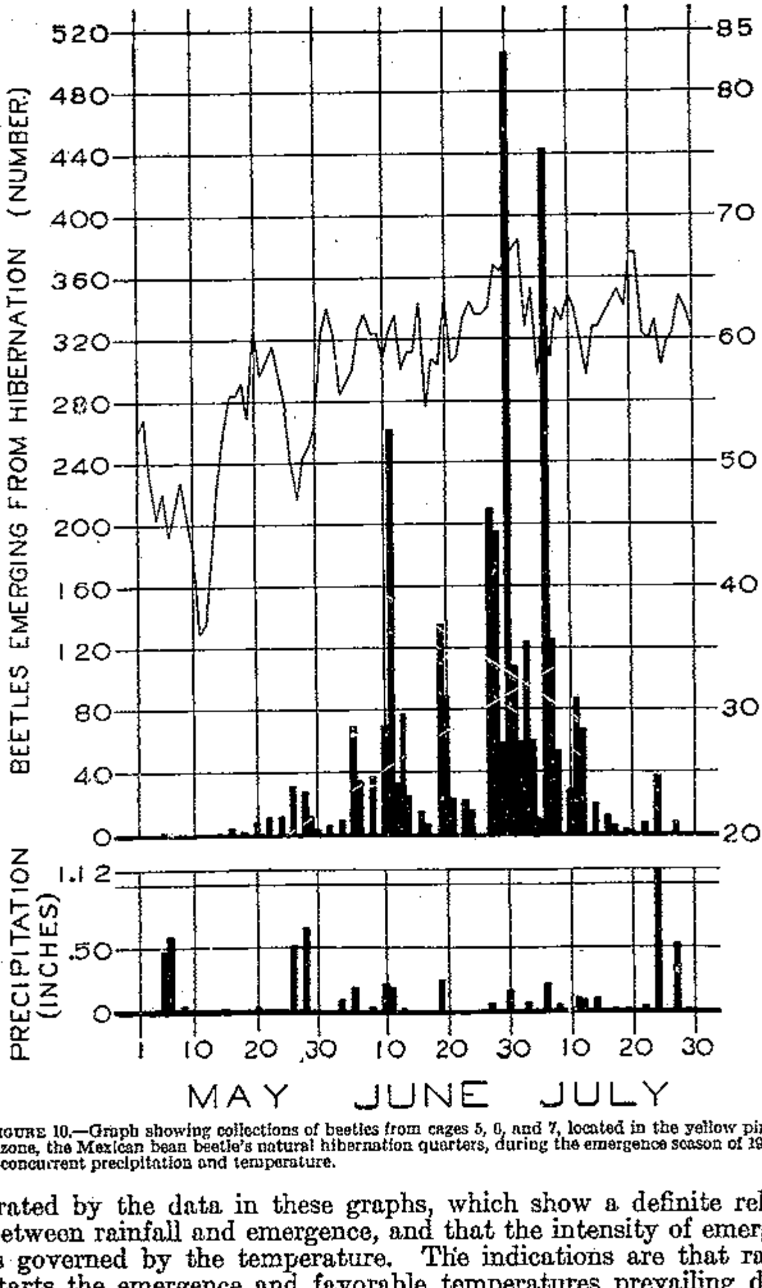

FIGURE 10.—Graph showing collections of beetles from cages 5, 6, and 7, located in the yellow pine forest zone, the Mexican bean beetle's natural hibernation quarters, during the emergence season of 1926, with concurrent precipitation and temperature.

trated by the data in these graphs, which show a definite relation between rainfall and emergence, and that the intensity of emergence is governed by the temperature. The indications are that rainfall starts the emergence and favorable temperatures prevailing during the period of precipitation or subsequent thereto act as an accelerator.

As further evidence (table 3), in cage 5, at an elevation of 7,050 feet, the greatest number of beetles emerged in 1925 on June 10, when, within a period of 5 hours during an experiment in which water approximating 1¼ inches of precipitation was sprayed into the

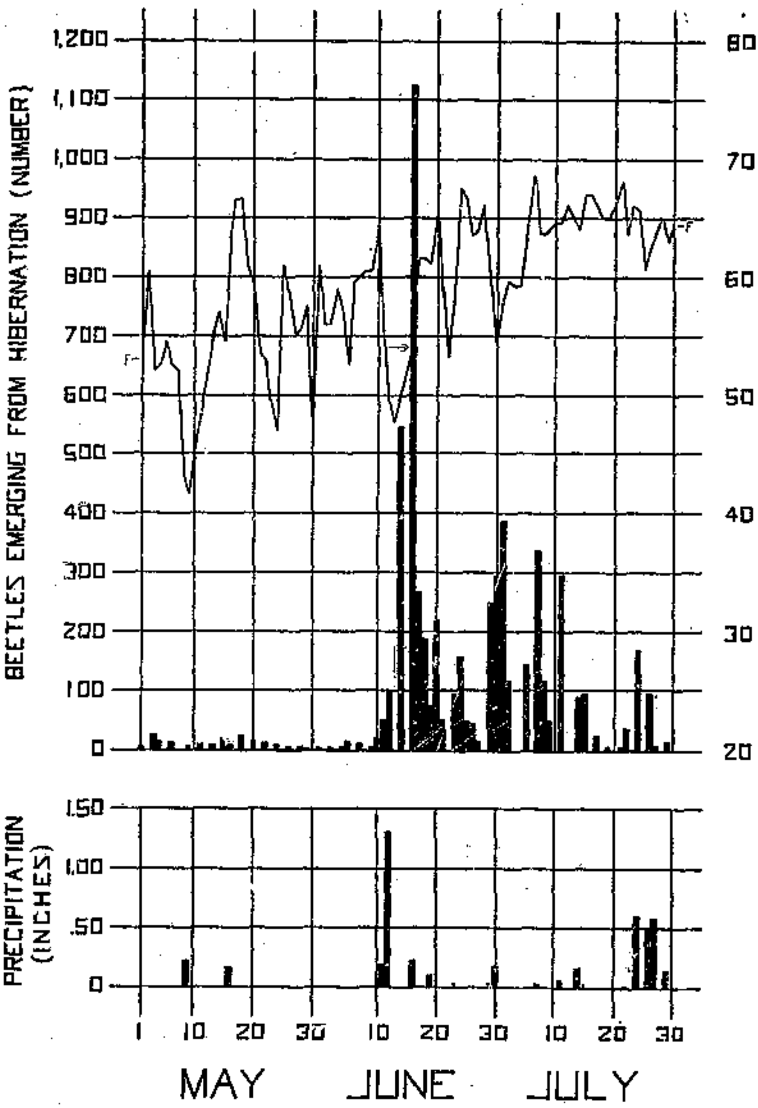

FIGURE 11.—Graph showing collections of beetles from cages 5, 7, and 8, located in the yellow pine forest zone, the Mexican bean beetle's natural hibernation quarters, during the emergence season of 1927. The exceptionally high bar represents the emergence of 2 days. Concurrent precipitation and temperature records are also shown.

cage, 64 beetles, or 49.23 percent, emerged. On May 10, 1928, a roof was placed over cage 6 and the sides screened with muslin to keep out all precipitation during the emerging season. On July 31, 1 inch of water was sprayed into the cage, and within 2 hours 72 beetles, or 58.53 percent, responded to the stimulating effect of contact moisture.

Figures 10 and 11 and tables 1 and 3 all show that there is a definite relation between precipitation and emergence of the bean beetle from hibernation and that the percentage emerging is directly influenced by the temperature during the period of rainfall.

TABLE 3.—*Emergence of the Mexican bean beetle from hibernation on some of the hottest and wettest days, Tajique, N.Mex., 1924–30*

Cage no.	Date	Temperature			Precipitation	Beetles emerging	
		Maximum	Minimum	Mean			
	1924	*°F.*	*°F.*	*°F.*	*Inches*	*Number*	*Percent*
7	June 17	86	48	67	0	3	0.23
	June 24	85	50	67.5	0	8	.61
	July 1	76	44	60	1.10	428	32.82
	July 2	67	50	58.5	.18	199	15.26
	1925						
7	June 14	79	55	67	0	0	0
	June 27	79	52	65.5	0	1	.27
5	June 10	73	44	58.5	[1] 1.25	64	49.23
7	July 5	74	50	62	.31	92	25.34
	July 6	78	48	63	.06	42	11.57
	1926						
7	June 30	83	50	66.5	.16	297	16.39
	July 2	84	52	68	0	36	1.99
	July 6	74	47	60.5	.21	283	15.62
	1927						
5	June 10	80	48	64	0	4	.01
	June 16	69	39	54	.22	608	21.47
	June 27	79	49	64	0	5	.02
	1928						
5	July 3	84	60	72	0	0	0
	July 7	81	61	71	0	0	0
	July 10	80	47	63.5	.11	33	44.00
6	July 31	76	48	62	[1] 1.00	72	58.53
	1930						
9	June 29	86	55	70.5	0	28	.64
	July 2	85	56	70.5	0	49	1.13
	July 4	81	50	65.5	.24	511	11.70
	July 11	75	52	63.5	[2] .28	569	13.10

[1] Artificial precipitation. [2] Rained late the preceding afternoon.

APPEARANCE IN THE FIELD

Merrill (*6, p. 6*) states: "Adult individuals of the bean beetle that have passed the winter successfully appear on the bean plants rather late. In the Mesilla Valley one finds them in small numbers after the first week in June." Chittenden (*2, p. 7*) makes the following statement: "It is somewhat remarkable that the beetles remain in hibernation during the last days of May and the first half of June when high temperatures, from 90° to 95° F., often prevail." List (*5, p. 14*) says:

> They begin to disappear for hibernation in the fall as soon as frost injures their food plants and no more activity is shown until in June when they suddenly appear. It is rather unusual that they remain in hibernation until so late as many days of high temperature are experienced and early beans are often in bloom before they are seen.

The mystery of the late appearance of the beetles has been explained by studies on emergence which showed that rainfall is the stimulus to emergence, especially after the mean temperature has risen to 50° F. Summer rains do not generally occur until late in the season, and therefore the beetles do not enter the fields until rather late.

Data upon the emergence of the beetles from natural hibernation were obtained in 1930 by recording the increase of beetles in fields located in canyons nearest the mountains where the natural hibernation quarters were located. Field 1 (one third acre) was located in Tajique Canyon, and field 2 (1,200 feet of row) was located in the fork of Canyon de la Mula and Afuera Canyon, both fields being near the lower edge of the yellow pine forest zone. The weather instruments were located about 1 mile above the former field, whereas the set-up was about one half mile down the canyon from the latter, and does not give a true picture of the rainfall occurring over the hibernation area of that field.

Figure 12 shows that the first beetles of the season were recorded in field 1 on June 2, 1930. A rain of 0.29 inch had fallen over the Tajique Canyon locality on May 31, which stimulated these few beetles to emerge. There were general increases in the number of beetles from June 2 to 11, when 34 insects were noted in the field. On the latter date 0.01 inch of rain fell, and the number of beetles increased from 34 to 56 by June 13. On June 16, 0.07 inch of rain fell over the drainage area of this canyon and stimulated emergence, with the result that the number of overwintered beetles increased from 56 on June 13 to 135 on June 16, and from 249 on June 18 to 390 on June 20. From June 20 to July 3 there was only a gradual increase in the infestation. At times the number of beetles migrating out of the field on down the canyon was greater than the number of beetles entering the field. The 0.24 inch of rain on July 4 stimulated a large number of beetles to leave their winter quarters for the fields. The number of overwintered beetles increased from 612 on July 3 to 3,840 on July 5, when the peak was reached. This number taxed the small plants to their capacity, and there was a rapid decrease in the number of beetles.

Figure 13 shows that the initial infestation of overwintered beetles in field 2 increased from 7 on June 16, 1930, to 144 on June 18, and from 280 on June 27 to 796 on July 1. Showers fell in the canyons from July 2 to 5, inclusive, and were followed by a rapid increase in the number of beetles that entered the field. The number of beetles increased from 763 on July 3 to 1,604 on July 5 and to 3,627 on July 8. From July 8 to 12, inclusive, there was little change in the infestation. On July 15 heavy rains fell over the foothills, with the result that an increase in infestation was noted. The peak was reached on July 16, when 4,381 beetles were recorded. This large number soon depleted the bean foliage and a comparatively rapid decrease in the number of overwintered beetles followed.

An examination of figures 12 and 13 will show that very few beetles entered the fields during the last 10 days of June, when the highest temperatures occurred, and that the excessive population of overwintered beetles lasted for only a short time. In field 1 the intensive infestation covered 4 days only, from July 5 to 8, inclusive, whereas in field 2 a 12-day period of heavy infestation occurred from July 8 to 19, inclusive, as illustrated in figure 13. Thus the beginning and the intensity of infestation of overwintered beetles vary slightly in different locations.

Figure 14 shows the maximum number of overwintered beetles on a ⅓-acre field in the foothills during the seasons from 1924 to 1930, inclusive. There were very few beetles during the period from 1924 to 1927, inclusive, and following this period there was a great increase each year in the number of overwintered beetles in the field. This

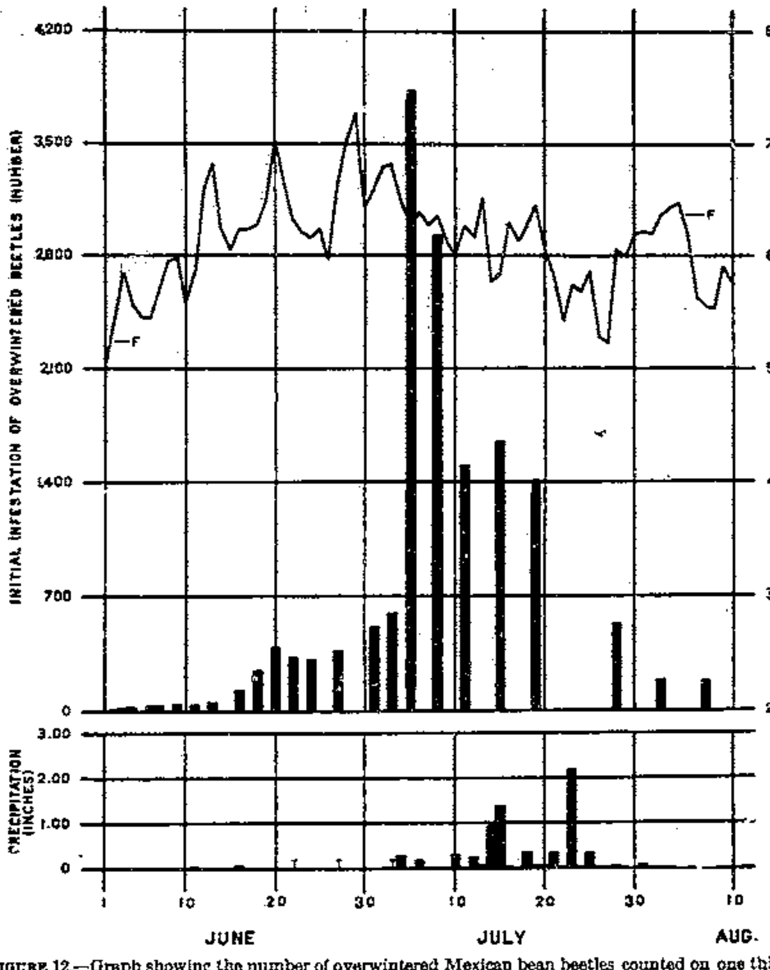

FIGURE 12.—Graph showing the number of overwintered Mexican bean beetles counted on one third acre in field 1 during 1930, with temperature and precipitation for the period.

shows the rapidity with which this insect can multiply when conditions permit, even after several seasons of adverse weather conditions.

Flight tests conducted with marked beetles over a period of several years showed that the insects fly either up or down the canyons with the prevailing winds and that they use the canyons as migration paths, both in entering and emerging from hibernation. In general, during the dissemination of the beetles from hibernation, the air currents are flowing down the canyons and arroyos out into the valley, owing to the greater density of the cool air of the mountains which is replacing the warmer air of the valleys. The heaviest infestation is found

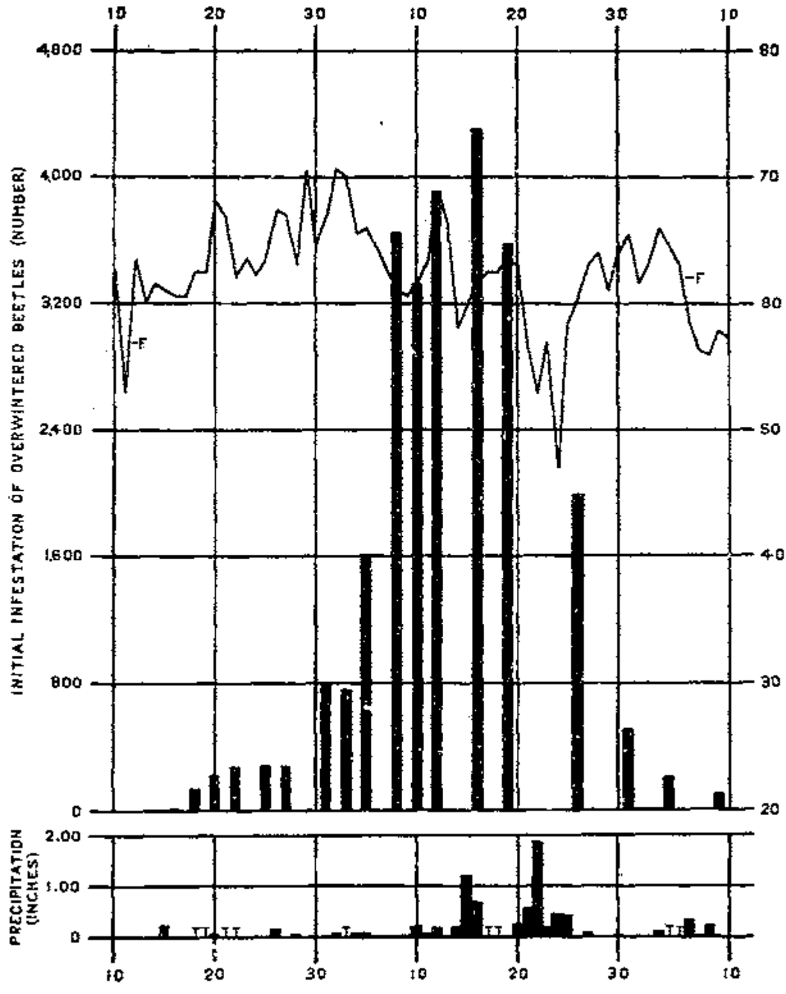

FIGURE 13.—Graph showing the number of Mexican bean beetles on 1,200 feet of row in field 2 during 1930, with temperature and precipitation for the period.

in fields located in canyons and arroyos, and the infestation decreases as the distance from the hibernation quarters increases.

The number of beetles varies from field to field, depending upon a number of physical factors, such as location, slope, air currents, type of soil, size of field, and condition of plants during the spring migration period. It has been noted for a number of years that beetles are more numerous, and therefore more destructive, on plantings on sandy soil than on those on heavier soils, even though the plantings were made at the same time and in the same community. The sandy soils warm up earlier in the spring and maintain a higher temperature

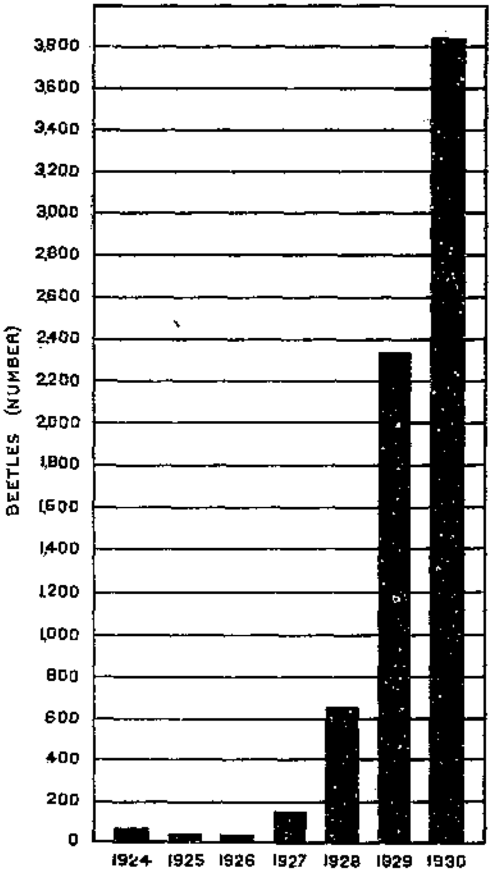

FIGURE 14.—Graph showing the maximum numbers of overwintered beetles on a ½-acre field in the foothills from 1924 to 1930, inclusive.

than heavy soils. Therefore the seed germinates faster, and the plants make a quicker growth early in the season and are larger and more attractive at the time the spring migration occurs than are the plants grown on heavier types of soil. This insect prefers vigorous and rapid-growing plants on which to feed and lay its eggs and will avoid dwarf and stunted plants, as they afford very little protection.

PERIOD BETWEEN EMERGENCE FROM HIBERNATION AND OVIPOSITION

The period between emergence from hibernation and oviposition is greater in the case of females which emerge early than in the case of those which issue later in the season. Figure 15, illustrating the rate of egg-mass deposition of 18 females that emerged on July 1, shows that 7 days was the minimum and 13 days was the maximum period, the average being 10 (9.9) days.

OVIPOSITION

Figure 15 shows that the shortest oviposition period, as ascertained from observation of 18 females, was 18 days and that the longest period was 76 days, the average being 51 days. This figure shows that very few egg masses were deposited after August 28. The interval between deposition of egg masses ranged from 1 to 12 days, with an average of 3.2 days between masses, while the average for each individual female ranged from 2.34 to 4.25 days. The number of egg masses deposited per female ranged from 5 to 26, the average being 16.9. As it has been found that the average number of eggs per mass is 53, the average number of eggs deposited per female is about 900.

DEVELOPMENTAL PERIOD

INCUBATION PERIOD

Temperature greatly influences the duration of the incubation period of the Mexican bean beetle, as is shown in figure 16. The incubation period in Estancia Valley ranged from 7 to 20 days, with the temperature averaging from 56° to 76° F. The greater number of eggs hatch in from 8 to 10 days in summer, and as cool weather approaches the period is prolonged.

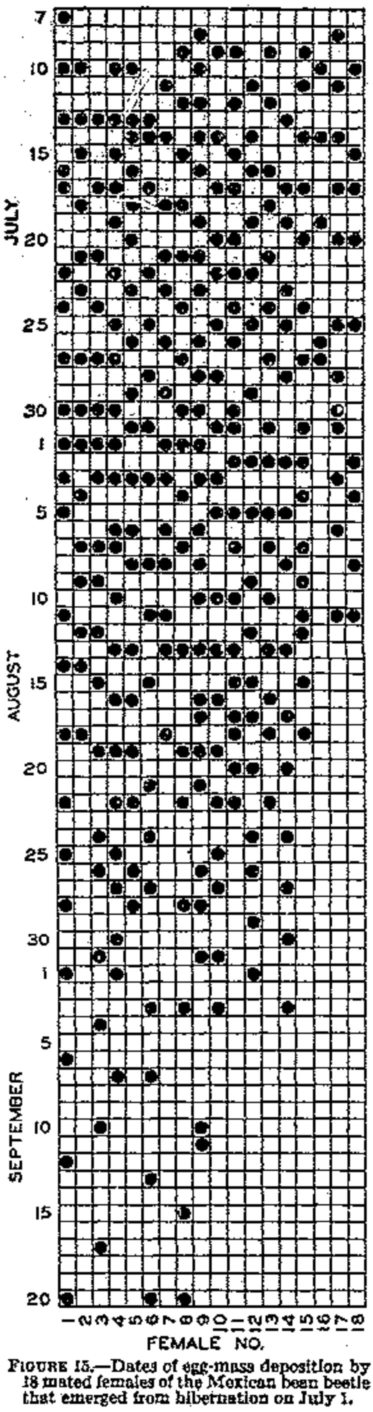

FIGURE 15.—Dates of egg-mass deposition by 18 mated females of the Mexican bean beetle that emerged from hibernation on July 1.

LARVAL PERIOD

During the summer the larval period ranges in length from 21 to 27 days, depending upon the temperature and the abundance of

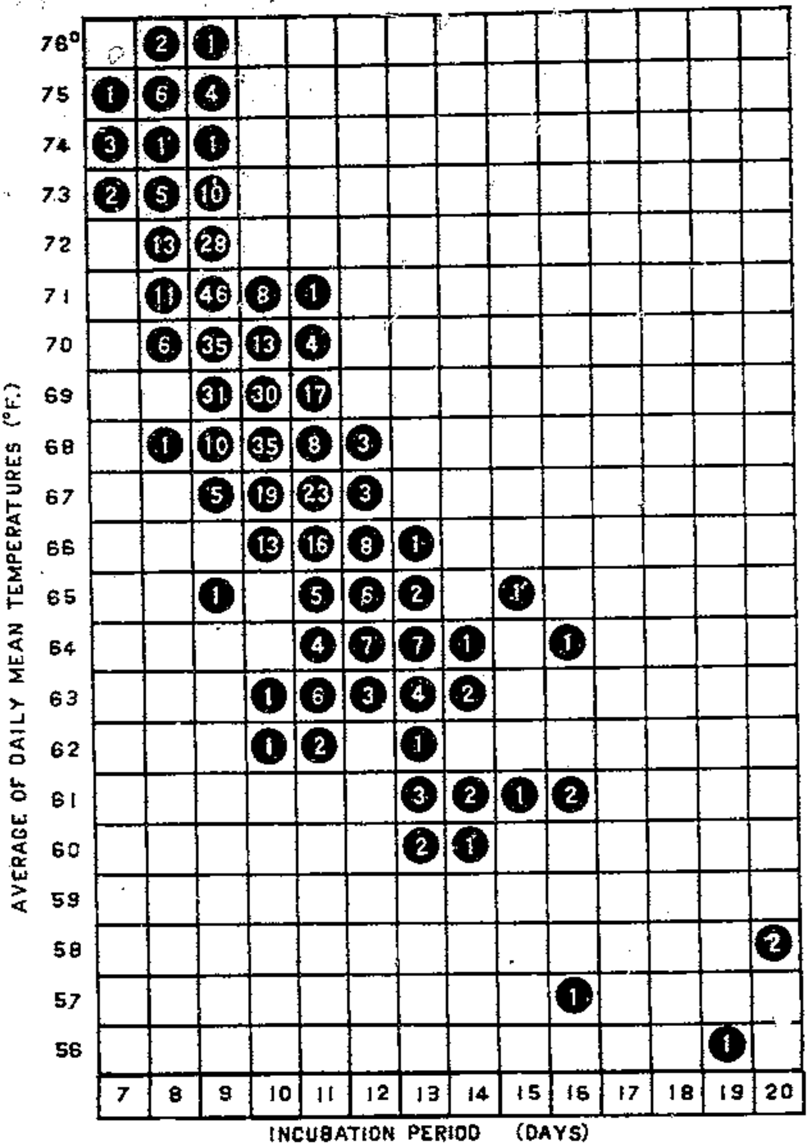

FIGURE 16.—Relation of length of incubation period of the Mexican bean beetle to temperature, Estancia, N.Mex. The figures in the circles represent the number of cases.

favorable food, as shown in table 4. Either a deficient food supply or low temperatures, as experienced during the latter part of the growing season, will prolong the developmental period of the larva.

TABLE 4.—*Developmental period of the Mexican bean beetle in Estancia, N. Mex.*

Experiment no.	Date eggs were deposited	Incubation period	Duration of larval instars				Pupation period	Date of emergence	Developmental period	Mean temperature
			First	Second	Third	Fourth				
		Days	*Days*	*Days*	*Days*	*Days*	*Days*		*Days*	°*F.*
1	June 29	9	5	3	5	8	10	Aug. 8	40	71.2
2	July 1	9	6	3	5	9	10	Aug. 12	42	71.0
3	July 2	8	7	3	5	10	9	Aug. 13	42	70.9
4	July 12	9	5	4	7	9	8	Aug. 23	42	70.1
5	July 14	8	7	4	7	8	9	Aug. 26	43	68.0
6	July 24	10	7	4	4	9	10	Sept. 6	44	66.9
7	July 27	11	6	4	5	9	10	Sept. 10	45	66.1
8	Aug. 8	10	6	5	5	10	10	Sept. 23	46	65.4
9	Aug. 10	10	6	5	6	10	10	Sept. 26	47	64.5
10	Aug. 14	10	6	4	6	10	12	Oct. 1	48	63.8

PUPAL PERIOD

The length of the pupal period ranges from 8 to 10 days during the summer and increases as the temperature decreases in the fall, as shown in table 4.

ENTIRE PERIOD

The influence of temperature on the entire development period from egg to adult is shown in figure 17.

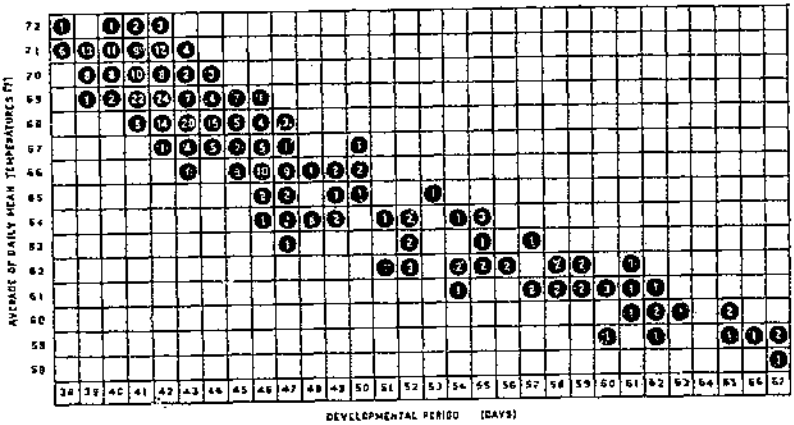

FIGURE 17.—Influence of temperature on the developmental period of the Mexican bean beetle. The figures in the circles show the number of egg masses that were reared from egg to adult in the number of days given and at the mean temperature given.

SEASONAL HISTORY

The seasonal history of the bean beetle for 1930, as illustrated in figure 18, was determined from records on emergence from hibernation, appearance in the fields, and the life history throughout the season. The seasonal history varies from season to season, depending on the time and intensity of emergence from hibernation and the appearance of the beetles in the field, as well as on other factors. The time and intensity of the early summer rains are governing factors in the seasonal history. A season that is favorable for the growth and production of beans is also favorable for the development of this insect. A good example was the season of 1929. Conversely, unfavorable seasons for the production of beans are unfavorable for the development of the insect. An example of this type of season was that of 1930, when literally millions of larvae died from lack of food during the latter part of the season. Plants made good growth during July, and development was accelerated; but the drought of August and September checked the growth and permitted the larvae to consume the foliage before a large number of them had matured, with the result that they starved and those that had pupated were exposed to excessive detrimental temperatures.

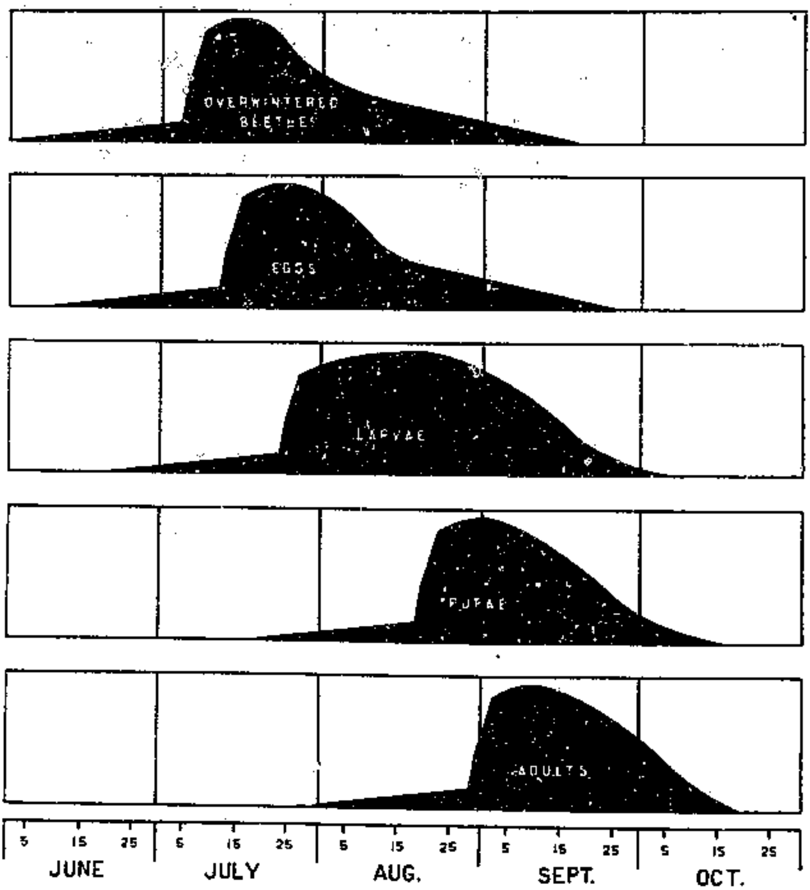

FIGURE 18.—Seasonal history of the Mexican bean beetle in Estancia Valley, N.Mex., in 1930, as determined by field observations and infestation counts.

The number of beetles entering hibernation in the fall, the number that successfully overwinter, and the time and percentage of emergence from hibernation are important factors in commercial production of beans in areas where this insect is an important economic factor. There are eight possible combinations which may be encountered: (1) A large number of beetles entering hibernation and successfully overwintering, with early emergence from hibernation; (2) duplication of the first case, but with late emergence from hibernation; (3) a large number of beetles entering hibernation, and early emergence, but with a high mortality in hibernation; (4) duplication of the third case, but with late emergence from hibernation; (5) a small number of beetles entering hibernation and successfully overwintering and emerging early from hibernation; (6) duplication of the fifth case, but with a high mortality in hibernation; (7) duplication of the fifth case, except for late emergence from hibernation; (8) duplication of the fifth case, except for high mortality in hibernation and late emergence from hibernation. Obviously the first case is the most threatening and the eighth is the least.

NATURAL CONTROL

NATURAL ENEMIES

It is a well-known fact that the bean beetle has no native parasite of importance to hold it in check. Its habit of remaining in hibernation until late in the season may aid in protecting it from parasites in New Mexico. A tachinid fly, *Nemorilla maculosa* Meig.,[4] was reared from parasitized bean-beetle larvae collected in the Rio Grande Valley near Albuquerque, N.Mex. A beetle, *Collops bipunctatus* Say,[5] of the family Melyridae, has been noted feeding on eggs of the bean beetle in the fields. Laboratory tests confirm the field observations.

Turkeys have been observed feeding on beetles in the field.

EFFECT OF METEOROLOGICAL FACTORS IN SUMMER

Drought periods accompanied by dry winds often occur in June, decreasing the soil moisture and desiccating the plants, with the result that the bean leaves are turned up vertically to the sun, exposing the eggs and young larvae to high temperatures. Such periods are noticeably detrimental to the eggs and cause them to dry and collapse. Only during such periods are the common thrips, *Frankliniella tritici* Fitch, very numerous, and they are found primarily on the leaf in and about the egg masses. Their feeding on the leaf around the base of the egg mass results in the drying of the leaf in that area. This portion turns whitish, and the injury to the leaf is no doubt a factor in causing the egg masses to fall off. During the season of 1928 the first egg mass was noted in the fields on June 15, and the first larva hatched on July 12, or 27 days later. All of the egg masses up to approximately this time had either collapsed or fallen to the ground, as no rain fell during this period until July 10. The Tajique weather station registered one of the driest Junes of record, as only a trace of precipitation was recorded for the month. During that period thrips were very numerous. The specific effect the thrips has on eggs is not known, and future investigations will have to ascertain their role in the collapsing and falling of eggs.

It has been noted that hard rains will knock beetles off the plants and that they will become stuck in the mud on their backs. During July 1930, 122 beetles were found stuck in the mud. Some of these are preyed upon by ground beetles (Carabidae), and many others are killed by exposure to high temperatures. In several instances the writer has noted mud-imprisoned females laying eggs.

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[4] Determined by J. M. Aldrich.

[5] Determined by E. H. Chapin.

ARTIFICIAL CONTROL

CONTROL EXPERIMENTS IN 1929

GENERAL CONDITIONS

Experimental work in 1929 was carried out on the Glover ranch, located about 4 miles northwest of Tajique in the foothill region of the Estancia Valley at an elevation of 7,200 feet. The ranch is situated near the lower border of the yellow pine forest zone, where the yellow pine and pinyon forest zones dovetail into each other on account of topography and slope exposure, and lies just east of the Manzano National Forest.

The location of the ranch is ideal for heavy infestation, as excellent hibernation quarters for bean beetles are found in the forest adjoining the ranch. The Canyon de los Migos runs through the ranch and affords the emerging beetles a migration path, since this insect follows the wind currents down the canyons to the bean fields.

The peak of overwintered-beetle infestation was reached on July 14, when 1,114 adults were noted on 1,200 feet of row. Following a rather heavy initial infestation, the weather conditions in 1929 proved to be favorable for both beetles and beans.

PROCEDURE

Plots were laid out and staked off some time before the first treatments would be due. Check, or untreated, plots consisted of 12 rows and the treated plots of 32 rows. The arsenicals were applied undiluted, that is, without a carrier. Sodium fluosilicate was diluted with hydrated lime and with superfine dusting sulphur, 1 to 2 by weight, a few days before the first application was made. The materials were weighed out and then mixed in a baker's sifter and mixer for 20 minutes at 60 revolutions per minute. After the materials had been mixed they were stored in tins with tight-fitting tops until used.

TABLE 5.—*Temperature and precipitation recorded at Tajique, N.Mex., elevation 7,100 feet, during the control-experiment period of 1929*

Date	Temperature: Maximum	Temperature: Minimum	Temperature: Mean	Temperature: Range	Precipitation	Date	Temperature: Maximum	Temperature: Minimum	Temperature: Mean	Temperature: Range	Precipitation
	° F.	° F.	° F.	° F.	Inches		° F.	° F.	° F.	° F.	Inches
July 15	75	58	66.5	17	-------	Aug. 7	61	55	58	6	0.80
16	78	58	68	20	-------	8	63	50	56.5	13	.70
17	80	53	66.5	27	-------	9	63	52	57.5	11	.90
18	77	55	66	22	-------	10	62	52	57	10	.39
19	70	52	61	18	0.34	11	62	52	57	10	.92
20	76	56	66	20	.05	12	63	52	57.5	11	.11
21	75	53	64	22	.52	13	70	47	58.5	23	-------
22	73	51	62	22	-------	14	71	47	59	24	-------
23	77	51	64	26	.05	15	72	48	60	24	-------
24	76	54	65	22	1.20	16	72	48	60	24	.14
25	69	53	61	16	.02	17	73	47	60	26	-------
26	73	57	65	16	-------	18	73	49	61	24	-------
27	75	52	63.5	23	-------	19	74	49	61.5	25	[1] T
28	64	52	58	12	.40	20	72	42	57	30	.09
29	57	51	54	6	.57	21	70	44	57	26	[1] T
30	64	52	58	12	.51	22	73	47	60	26	-------
31	69	50	59.5	19	-------	23	70	53	61.5	17	.05
Aug. 1	72	53	62.5	19	[1] T	24	74	54	64	20	-------
2	76	51	63.5	25	.63	25	73	53	63	20	.29
3	68	52	60	16	.13	26	71	52	61.5	19	.21
4	69	51	60	18	-------	27	73	47	60	26	.02
5	73	55	64	18		28	74	50	62	24	.03
6	73	53	63	20							

[1] Trace.

The applications were made with a 4-row, 8-nozzle, heavy-duty traction duster, equipped with bean-beetle attachments.

The weather data for the control period were recorded by Mr. Glover, a cooperative Weather Bureau observer (table 5). The atmometer readings were those recorded from set-ups located on the edge of the field (table 6).

TABLE 6.—*Evaporation (cubic centimeters) registered at Tajique, N.Mex., elevation 7,200 feet, during the control period of 1929*

For week ended—	Evaporation			For week ended—	Evaporation		
	Black sphere	White sphere	Difference		Black sphere	White sphere	Difference
July 15	274.7	170.3	104.4	Aug. 12	128.0	69.0	59.0
July 22	374.4	243.3	131.1	Aug. 19	328.0	199.2	128.8
July 29	217.9	124.4	93.5	Aug. 26	278.7	167.7	111.0
Aug. 5	195.8	109.9	85.9				

The yields given in the 1929 data are those of the cured vines and not of dried shelled beans. A pile row consisting of six rows of beans through each plot was weighed. This gave the weight of one half of the check, or untreated, plots, and three sixteenths of the treated plots. In the Estancia Valley the general practice is to figure the ratio of beans to vines as 40 percent beans to 60 percent vines. This estimate was determined by farmers who sold by weight their entire bean hulls to cattlemen. To be conservative, the yield of dry beans has been figured at one third. By this method, of course, the vines and culled beans were weighed, but the proportion of commercial beans was not obtained.

CONTROL EXPERIMENTS IN 1930

GENERAL CONDITIONS

The experimental work in 1930 was carried out in four different localities, two in the foothills and two in the valley. Experiments G1 to G7, inclusive, were conducted on the Glover ranch, the location of which has been discussed. Experiment T9 was conducted in a field in Tajique Canyon at an elevation of 6,850 feet, near the lower border of the yellow pine forest zone. The locations of these experimental fields were ideal for heavy infestation, as excellent hibernation quarters for the bean beetle are found in the yellow pine forest zone adjoining the fields.

The peak of the overwintered-beetle infestation at the Glover ranch was reached on July 16, when 4,381 beetles were recorded on 1,200 feet of row. In the Tajique Canyon field the peak was reached on July 5, when approximately 1,000 beetles were noted on 1,200 feet of row.

The field on which experiment L8 was conducted was located in Estancia, and the field on which experiments B10 to B12, inclusive, were conducted was situated on the south slope of Arroyo Mesteno, 10 miles southwest of Estancia. Both fields were irrigated, and the latter field was planted on June 21, which is rather late in the season for valley plantings. This was no doubt a factor in the crop.

PROCEDURE

The procedure of laying out and staking off the plots and the mixing of the materials was the same as during the preceding season, except that the arsenicals were also tested with the addition of lime, and sodium fluosilicate was used undiluted.

The applications of dust to experiments G1 to G7 were made with a 5-row, 10-nozzle, power duster, mounted on a tractor. Materials for experiments L and T were applied with a hand duster. Experiments B10 to B12 were dusted with a 4-row, 8-nozzle, heavy-duty traction crop duster.

The weather data given in table 7 for the control period are those recorded near Tajique by Mr. Glover and at the laboratory at Estancia. The atmometer readings given in table 8 are those recorded from two series of set-ups near the two weather stations.

Table 7.—*Temperature and precipitation recorded at Tajique and Estancia, N.Mex., at elevations of 7,100 and 6,100 feet, respectively, during the control period of 1930*

Date	Tajique					Estancia				
	Temperature				Precipitation	Temperature				Precipitation
	Maximum	Minimum	Mean	Range		Maximum	Minimum	Mean	Range	
	° F.	° F.	° F.	° F.	Inches	° F.	° F.	° F.	° F.	Inches
July 9	74	47	60.5	27	0.02	85	54	69.5	31	0
10	76	47	61.5	29	.20	83	48	65.5	35	.05
11	75	52	63.5	23	.04	84	58	71	26	0
12	79	59	69	20	.19	87	56	71.5	31	.19
13	76	57	66.5	19	0	92	56	74	36	.21
14	66	50	58	16	.18	84	55	69.5	29	1.48
15	68	52	60	16	1.20	77	58	67.5	19	.15
16	75	48	61.5	27	.67	79	54	66.5	25	0
17	76	49	62.5	27	T.[1]	87	56	71.5	31	0
18	76	49	62.5	27	T.	89	59	74	30	0
19	76	51	63.5	25	0	89	54	71.5	35	0
20	73	53	63	20	.23	89	54	71.5	35	.05
21	65	52	58.5	13	.55	85	57	71	28	.28
22	57	49	53	8	1.80	71	55	63	16	.73
23	64	50	57	14	.15	61	56	58.5	5	.39
24	79	46	62.5	33	.45	77	55	66	22	1.07
25	66	51	58.5	15	.41	78	58	68	20	.10
26	71	50	60.5	21	0	75	57	66	18	T.
27	73	53	63	20	.09	82	54	68	28	.02
28	72	56	64	16	0	87	54	70.5	33	0
29	70	52	61	18	0	83	56	69.5	27	0
30	72	54	63	18	.02	81	59	70	22	T.
31	72	59	65.5	13	0	84	58	71	26	0
Aug. 1	74	49	61.5	25	0	82	57	69.5	25	0
2	76	50	63	26	0	86	52	69	34	0
3	78	54	66	24	.10	87	57	72	30	0
4	79	50	64.5	29	T.	89	51	70	38	0
5	76	50	63	26	T.	91	55	73	36	T.
6	69	48	58.5	21	.31	86	52	69	34	.03
7	66	47	56.5	19	0	79	50	64.5	29	.03
8	63	49	56	14	.20	75	56	65.5	19	0
9	68	48	58	20	0	70	57	63.5	13	.70
10	68	47	57.5	21	.30	77	57	67	20	0
11	67	51	59	16	.06	79	50	64.5	29	0
12	70	45	57.5	25	T.	82	49	65.5	33	0
13	71	46	58.5	25	.03	81	50	65.5	31	0
14	73	45	59	28	0	80	51	65.5	29	0
15	73	43	58	30	0	81	47	64	34	0
16	76	44	60	32	0	85	45	65	40	0
17	77	45	61	32	T.	86	47	66.5	39	0
18	78	46	62	32	0	88	49	68.5	39	0
19	80	48	64	32	0	89	46	67.5	43	0
20	82	47	64.5	36	0	89	44	66.5	45	0
21	82	47	64.5	35	T.	95	50	72.5	45	0
22	82	54	68	28	0	95	57	76	38	T.
23	77	47	62	30	0	90	56	73	34	0
24	79	46	62.5	33	.30	87	51	69	36	0

[1] Trace.

TABLE 8.—*Evaporation (cubic centimeters) registered at Tajique and Estancia, N.Mex., at elevations of 7,200 and 6,100 feet, respectively, during the control period of 1930*

For week ended—	Tajique			Estancia		
	Evaporation			Evaporation		
	Black sphere	White sphere	Difference	Black sphere	White sphere	Difference
July 7	523.9	409.8	114.1	605.6	479.7	125.9
July 14	426.0	321.7	104.3	539.1	399.9	139.2
July 21	252.3	165.1	87.2	375.8	260.1	115.7
July 28	166.3	99.5	66.8	203.4	117.6	85.8
Aug. 4	327.1	226.6	100.5	423.1	321.0	102.1
Aug. 11	237.6	152.8	84.8	271.0	185.4	85.6
Aug. 18	369.3	253.9	115.4	434.1	324.6	109.5
Aug. 25	468.1	349.3	118.8	524.1	414.6	109.5

DISCUSSION OF RESULTS

The insecticide used, date of application, size of plot, quantity of materials applied, per-acre application, cost per application, and the cost per acre are given in tables 9 and 11 for 1929 and 1930, respectively.

TABLE 9.—*Insecticides used and costs of application in Mexican bean beetle control in the Estancia Valley, N.Mex., 1929*

Experiment no.	Insecticide used	Size of plot	Date of application	Quantity applied	Quantity applied per acre	Cost per application			Cost per acre		
						Material	Labor	Total	Material	Labor	Total
		Acres		*Lbs.*	*Lbs.*						
G1	Calcium arsenate, undiluted.	1.65	July 15	15.75	9.55	$1.58	$0.25	$1.83	$0.96	$0.15	$1.11
			Aug. 5	14.75	8.94	1.48	.25	1.73	.89	.15	1.04
			Aug. 16	11.75	7.12	1.18	.25	1.43	.71	.15	.86
G2	Lead arsenate, undiluted	1.65	July 15	15.25	9.24	2.59	.25	2.84	1.57	.15	1.72
			Aug. 5	12.50	7.58	2.13	.25	2.38	1.29	.15	1.44
			Aug. 16	10.25	6.21	1.74	.25	1.99	1.06	.15	1.21
G3	Magnesium arsenate, undiluted.	1.65	July 15	13.50	8.18	2.77	.25	3.02	1.68	.15	1.83
			Aug. 5	10.25	9.85	3.33	.25	3.58	2.02	.15	2.17
			Aug. 16	9.25	5.61	1.90	.25	2.15	1.15	.15	1.30
G4	Zinc arsenite, undiluted	1.65	July 15	11.25	6.82	2.03	.25	2.28	1.23	.15	1.38
			Aug. 5	13.75	8.33	2.47	.25	2.72	1.50	.15	1.65
			Aug. 16	11.25	6.82	2.03	.25	2.28	1.23	.15	1.38
G5	Calcium arsenate, undiluted.	1.60	July 16	14.50	9.06	1.45	.24	1.69	.91	.15	1.06
			Aug. 6	15.25	9.53	1.53	.24	1.77	.95	.15	1.10
			Aug. 17	12.25	7.66	1.23	.24	1.47	.77	.15	.92
G6	Sodium fluosilicate, 1 part to 2 parts of lime.	1.60	July 16	20.75	12.97	1.11	.24	1.35	.69	.15	.84
			Aug. 6	19.00	11.88	1.01	.24	1.25	.63	.15	.78
			Aug. 17	19.50	12.19	1.04	.24	1.28	.65	.15	.80
G7	Sodium fluosilicate, 1 part to 2 parts of sulphur.	1.60	July 16	30.50	19.06	2.44	.24	2.68	1.52	.15	1.67
			Aug. 6	29.50	18.44	2.36	.24	2.60	1.48	.15	1.63
			Aug. 17	34.50	21.56	2.76	.24	3.00	1.72	.15	1.87

TABLE 10.—*Summary of financial returns from the use of various insecticides on beans infested with the Mexican bean beetle in the Estancia Valley, N.Mex., 1929*

Experiment no.	Insecticide used	Area of plot	Yield per plot	Yield per acre	Difference per acre between untreated and treated plots [1]	Crop increase	Value of increased yield per acre [2]	Cost of treatment per acre	Net increased return per acre
		Acres	*Pounds*	*Pounds*	*Pounds*	*Per-cent*	*Dollars*	*Dollars*	*Dollars*
	Control or untreated	0.02	1,947	3,140					
G1	Calcium arsenate, undiluted	1.65	6,202	3,769	848	29.13	15.55	3.01	12.54
	Control or untreated	.62	1,603	2,682					
G2	Lead arsenate, undiluted	1.65	5,275	3,107	578	22.07	10.60	4.37	6.23
	Control or untreated	.62	1,585	2,556					
G3	Magnesium arsenate, undiluted.	1.65	4,500	2,704	337	13.89	6.18	5.30	.85
	Control or untreated	.62	1,425	2,298					
G4	Zinc arsenite, undiluted	1.65	4,447	2,695	541	25.12	9.92	4.41	5.51
	Control or untreated	.60	1,206	2,010					
G5	Calcium arsenate, undiluted	1.60	4,885	3,053	1,006	49.17	18.43	3.08	15.35
	Control or untreated	.60	1,250	2,083					
G6	Sodium fluosilicate, 1 part to 2 parts lime.	1.60	2,305	1,478	[3] 570	62.78	10.45	2.42	8.03
G7	Sodium fluosilicate, 1 part to 2 parts sulphur.	1.60	2,423	1,514	[3] 606	66.74	11.11	5.17	5.94
	Control or untreated	.60	545	908					

[1] From average of checks on both sides.
[2] Beans at 5 cents per pound and hulls at $5 per ton. One third of yield was figured as dry beans.
[3] Difference in yield per acre between the 2 treated plots and the lowest yielding untreated plot, as they received 1 less cultivation than the other plots on account of rains.

TABLE 11.—*Insecticides used and costs of application in Mexican bean beetle control, 1930*

Experiment no.	Insecticide used	Size of plot	Date of application	Quantity applied	Quantity applied per acre	Cost per application: Material	Cost per application: Labor	Cost per application: Total	Cost per acre: Material	Cost per acre: Labor	Cost per acre: Total
		Acres		*Lbs.*	*Lbs.*						
G1	Calcium arsenate, undiluted	5.22	July 9	22.0	4.2	$2.20	$0.63	$2.83	$0.42	$0.12	$0.54
			July 20	30.0	5.7	3.00	.63	3.63	.57	.12	.69
			Aug. 13	29.0	5.0	2.90	.63	3.53	.56	.12	.68
G2	do	7.84	July 10	28.0	3.6	2.80	.94	3.74	.36	.12	.48
			July 30	35.0	4.5	3.50	.94	4.44	.45	.12	.57
			Aug. 13	32.0	4.1	3.20	.94	4.14	.41	.12	.53
G3	do	5.16	Aug. 1	25.0	4.8	2.50	.62	3.12	.48	.12	.60
			Aug. 14	21.5	4.2	2.15	.62	2.77	.42	.12	.54
G4	Lead arsenate, undiluted	3.46	Aug. 1	13.0	3.8	2.21	.42	2.63	.64	.12	.76
			Aug. 14	12.0	3.5	2.04	.42	2.46	.60	.12	.72
G5	Magnesium arsenate	4.00	Aug. 1	29.0	7.3	5.95	.48	6.43	1.50	.12	1.62
			Aug. 14	24.5	6.1	5.02	.48	5.50	1.25	.12	1.37
G6	Sodium fluosilicate	4.00	Aug. 1	27.0	6.8	3.24	.48	3.72	.81	.12	.93
			Aug. 14	25.0	6.3	3.00	.48	3.48	.75	.12	.87
G7	Zinc arsenite	5.32	Aug. 1	21.0	3.9	3.78	.40	4.18	.71	.12	.83
			Aug. 14	20.0	3.8	3.60	.40	4.00	.68	.12	.80
L8	Lead arsenate, 1 part to 5 parts lime	.40	July 14	7.0	17.5	.32	.30	.62	.80	.75	1.55
			July 19	9.0	22.5	.41	.30	.71	1.02	.75	1.77
			Aug. 2	8.0	20.0	.36	.30	.66	.90	.75	1.65
T9	Calcium arsenate, 1 part to 5 parts lime	.30	Aug. 3	6.0	20.0	.20	.23	.43	.67	.75	1.42
B10	Calcium arsenate, 1 part to 3 parts lime	7.86	Aug. 10	96.0	12.2	3.84	1.18	5.02	.49	.15	.64
			Aug. 16	96.0	12.2	3.84	1.18	5.02	.49	.15	.64
B11	Magnesium arsenate, 1 part to 3 parts lime	7.63	Aug. 11	80.0	10.5	5.30	1.14	6.44	.69	.15	.84
			Aug. 16	80.0	10.5	5.30	1.14	6.44	.69	.15	.84
B12	Zinc arsenite, 1 part to 3 parts lime	7.63	Aug. 11	96.0	12.6	5.76	1.14	6.90	.75	.15	.90
			Aug. 17	96.0	12.6	5.76	1.14	6.90	.75	.15	.90

The insecticide used, area of plot harvested for yield records, yield per plot and per acre, percentage increase, and the value of increased yield are given in tables 10 and 12 for 1929 and 1930, respectively. The yields per acre are illustrated in figure 19 for 1929 and in figures 20 and 21 for 1930.

The tables and figures are self-explanatory as far as actual data are concerned, but other important factors should be considered before conclusions are drawn. The value of the crop and the cost of treatment in 1930 were both about half what they were in 1929. In 1930 the value of the hulls was not included in the reckoning. At the prices

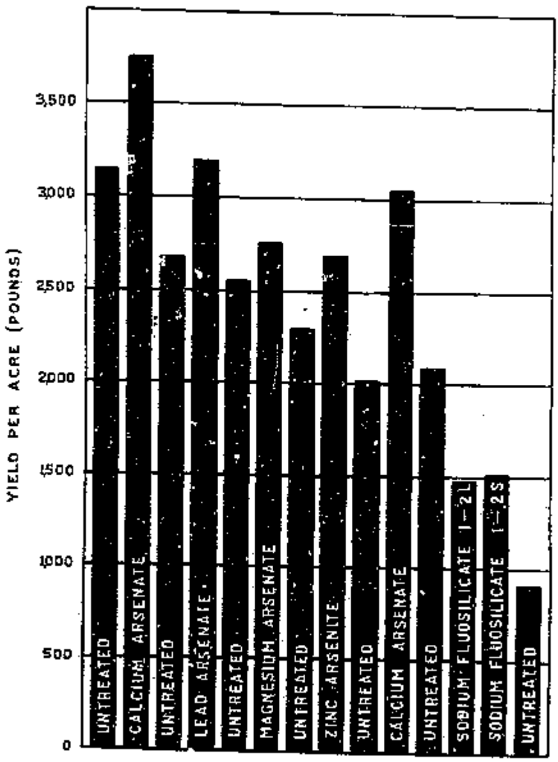

FIGURE 19.—Comparative yield per acre of unthreshed bean vines produced on treated and untreated plots in the Estancia Valley, N.Mex., in 1929.

shown for 1929 the hulls were counted as worth just one tenth as much as the cleaned beans from the same plot.

During the season of 1929 the yield of the magnesium-arsenate plot was probably reduced at least 200 pounds by a severe attack of bacterial blight (*Pseudomonas phaseoli*) during the first part of September. Light attacks of bacterial blight and rust (*Uromyces appendiculatus*) were noted on the other arsenical plots. These two diseases were not noted on the sodium fluosilicate plots, probably because of defoliation by the bean beetle before the disease became general. On September 17 the untreated plots were completely defoliated, while the sodium fluosilicate plots showed 90 percent defoliation, and the beetles were feeding on the green pods. Leaves on the plots treated with arsenicals were green, and beetles from devasted and harvested fields lower down the canyon were entering the plots in large numbers. In general, calcium arsenate gave the greatest protection to the foliage for the longest period of time. Table 10 shows that the yield of the sodium fluosilicate plots was greater than that of one untreated plot located on the edge of the field nearest the canyon, where it received a very heavy infestation of overwintered

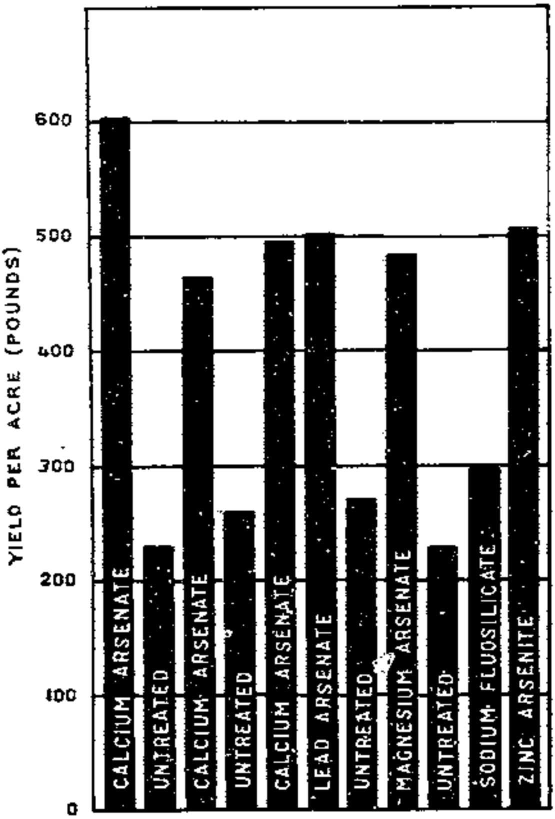

FIGURE 20.—Comparative yield per acre of recleaned beans produced on treated and untreated dry farmed plots in the Estancia Valley, N.Mex., in 1930.

beetles. Yet an examination of table 10 and figure 19 will show that their yields were far less than those of the remaining untreated plots.

No plant diseases were encountered during the season of 1930, and the infestation was the heaviest ever recorded. The increase in yields ranged from 27.4 to 162.2 percent, while the gain or loss due to control measures varied from a loss of 22 cents to a gain of $13.98 to the acre (table 12). The greatest returns were from the high-yielding irrigated plots, as shown in table 12, experiment L8. These plots received three heavy applications of lead arsenate diluted with hydrated lime 1 to 5 by weight. The second application produced burning of the foliage and stunting of the plants that was later overcome during favorable weather. Lead arsenate is not recommended for the following reasons: (1) Its cost; (2) its toxic effect upon bean plants, especially stunting; and (3) its poor physical properties for dusting. Special attention is called to experiment T9 (field B, fig. 21), in which only one application of calcium arsenate diluted with hydrated lime 1 to 5 by weight was applied at the rate of 20 pounds per acre just as the first larval injury was showing up in the field.

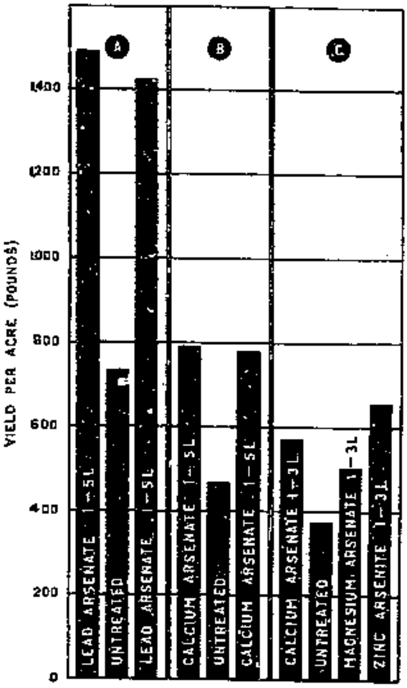

FIGURE 21.—Comparative yield per acre of recleaned beans produced on treated and untreated plots in the Estancia Valley, N.Mex., in 1930: A, Irrigated; B, dry farmed; C, late planted and irrigated. (See experiments L, T, and B, table 12.)

Successful results were obtained for the two seasons with all the arsenicals tested, and in interpreting the results of this work the number of treatments and the per-acre application must be kept clearly in mind; also whether the field was irrigated or dry farmed, the percentage increase in yield over the untreated plots, and the toxicity to foliage. The cost of the arsenical and the physical properties of the insecticide for dusting have been taken into consideration in making control recommendations. In considering all factors, both economic and insecticidal, calcium arsenate has given the most consistently favorable returns per acre of all the materials tested.

TABLE 12.—*Summary of financial returns from the use of various insecticides on beans infested with the Mexican bean beetle in the Estancia Valley, N.Mex., 1930*

Experiment no.	Insecticide used	Area of plot [1]	Yield per plot [2]	Yield per acre [2]	Difference per acre between untreated and treated plots	Crop increase	Value of increased yield [3]	Cost of treatment per acre	Net increase (+) or decrease (−)
		Acre	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Dollars*	*Dollars*	*Dollars*
G1	Calcium arsenate, undiluted	0.30	181.0	603	373	162.2	9.33	1.91	+7.42
	Control or untreated	.30	69.0	230					
G2	Calcium arsenate, undiluted	.30	139.5	465	205	78.8	5.13	1.58	+3.55
	Control or untreated	.30	78.0	260					
G3	Calcium arsenate, undiluted	.30	149.0	497	237	91.2	5.93	1.14	+4.79
G4	Lead arsenate, undiluted	.30	151.0	503	233	86.3	5.83	1.48	+4.35
	Control or untreated	.30	81.0	270					
G5	Magnesium arsenate	.30	145.5	485	[4] 235	94.0	5.88	2.99	+2.89
	Control or untreated	.30	69.0	230					
G6	Sodium fluosilicate, undiluted	.30	88.0	293	63	27.4	1.58	1.80	−.22
G7	Zinc arsenite	.30	153.0	510	280	121.7	7.[illegible]	1.63	+5.37
L8	Lead arsenate, 1 part to 5 parts lime.	.0347	51.8	1,493	758	103.1	18.95	4.97	+13.98
	Control or untreated	.0347	25.5	735					
L8	Lead arsenate, 1 part to 5 parts lime.	.0347	49.5	1,427	692	94.1	17.30	4.97	+12.33
T9	Calcium arsenate, 1 part to 5 parts lime.	.0461	36.5	792	326	70.0	8.15	1.42	+6.73
	Control or untreated	.0461	21.5	466					
T9	Calcium arsenate, 1 part to 5 parts lime.	.0461	36.0	781	315	67.6	7.88	1.42	+6.46
B10	Calcium arsenate, 1 part to 3 parts lime.	.294	168.0	571	197	52.7	4.93	1.28	+3.65
	Control or untreated	.294	110.0	374					
B11	Magnesium arsenate, 1 part to 3 parts lime.	.294	148.0	503	129	34.5	3.23	1.68	+1.55
B12	Zinc arsenite, 1 part to 3 parts lime.	.294	193.0	656	282	75.4	7.05	1.80	+5.25

[1] Area of plot harvested, threshed, and recleaned.
[2] Recleaned beans.
[3] Figured at 2½ cents per pound.
[4] From average of checks on both sides.

The value of control measures in 1930 is illustrated in figure 22, which shows the progress of defoliation in an irrigated field. Dusting with lead arsenate and hydrated lime (1 to 5) was begun on July 14, when 155 overwintered beetles, on an average, were found per 100 feet of row. Three rows were left untreated as a check. A hard dashing rain fell immediately after the dust had been applied, so the treatment was repeated on July 19, but this was followed by 8 days of rainy weather, as shown in table 7. This application resulted in injury to the foliage and stunting of the plants. The third application was made on August 2. Figure 23 illustrates the difference in yield between the treated and untreated plants.

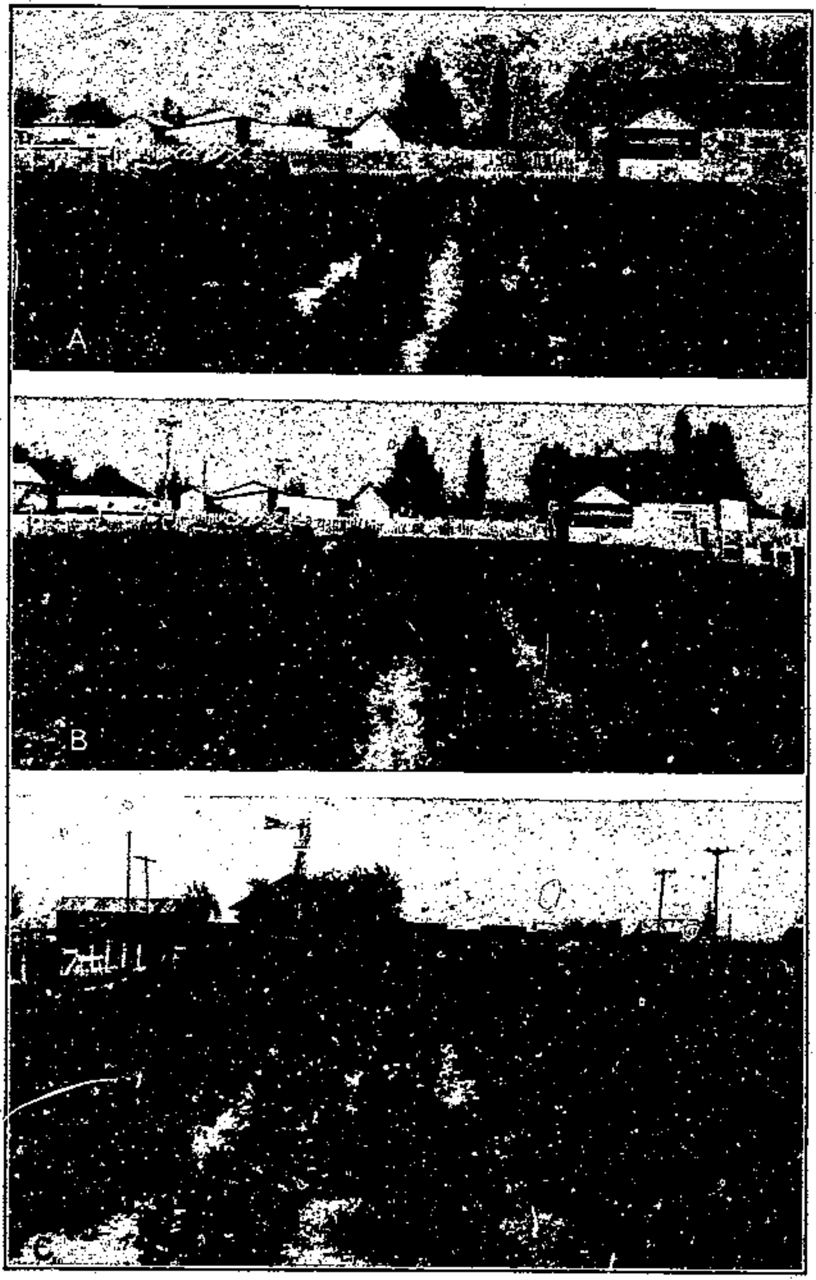

FIGURE 22.—Defoliation of bean plants by the Mexican bean beetle: A, Irrigated field early in the season; B, the same field on August 15 with defoliation showing on three untreated rows in the center; C, the same three rows later in the season, taken from the other end showing advanced defoliation.

HOW THE COSTS WERE DETERMINED

In determining the cost per application and per acre in 1929 and 1930, the following cost prices were used:

Calcium arsenate	per pound	$0.10
Lead arsenate	do	.17
Magnesium arsenate	do	.205
Zinc arsenite	do	.18
Sodium fluosilicate	do	.12
Sulphur, dusting	do	.06
Hydrated lime	do	.02
Hand duster, one third acre per hour	per hour	.25
Traction duster, 4-row, 4 acres per hour	do	.60
Power duster, 5-row, tractor-mounted, 6 acres per hour	do	.72

The foregoing prices for materials are based on the f.o.b. Estancia quotations in 100-pound lots. It is very difficult in experimental work, where comparatively small plots are used, to secure accurate

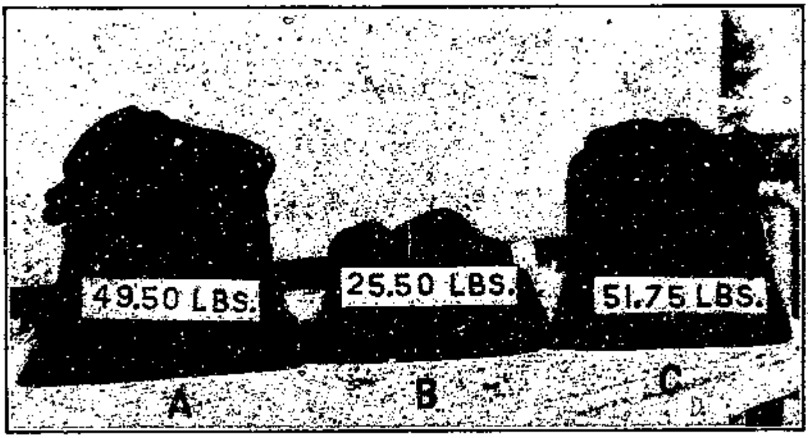

FIGURE 23.—Comparative yield of beans from treated and untreated plants, each sack containing the yield of recleaned beans from three rows: A and C, from treated rows; B, from untreated rows.

cost data on operating equipment. The grower should figure the cost of operating his team or tractor and adjust the cost of application accordingly.

FACTORS INFLUENCING RETURNS

There are many factors affecting the returns from control operations. Various seasonal factors are encountered which are determined by natural conditions prevailing over the area, such as the number of beetles in the initial infestation, time and appearance in the field, larval infestation, number and time of control applications possible, size and rate of growth of the bean plantings, and defoliation and reduction in yield. In addition there are constant factors, such as the initial cost of control equipment and interest on the investment; and variable factors, such as depreciation and upkeep of equipment, size and character of area to be treated, insecticide used, and operating expenses. However, the productivity of the land, the market price of beans, and the ability of the farmer to handle control equipment and to make applications at the most effective time, are the determining factors. Undoubtedly over a series of seasons the foresight and ability of the farmer to judge the conditions are of most importance, yet it is often true that for any one season natural conditions are the dominating influences.

TOXIC INJURY TO THE BEAN PLANT

Bean plants are susceptible to chemical "burning" from the use of arsenical insecticides only where excessive dosages are applied and under certain weather conditions. During the season of 1929 slight foliage injury was caused by the second application to all the plots treated with arsenicals. Lead arsenate caused the greatest injury, followed in order by calcium arsenate, zinc arsenite, and magnesium arsenate. This application was begun on August 5 and completed the next day. At this time the plants were 15 to 18 inches high and very bunchy and were putting out runners. The treatment was followed by 6 days of rainy and cloudy, foggy weather, with an average relative humidity of 88 percent. Rain totaling 3.82 inches fell during the period from August 7 to 12, inclusive. The evaporation during the period as recorded from Livingston spheres averaged 128 cc for the black and 69 cc for the white spheres, giving a difference of 59 cc per day. This shows that chemical burning is due to high humidity combined with low evaporation. The only visible burning or toxic injury to foliage during the season of 1930 was caused by the second application of lead arsenate diluted with hydrated lime 1 to 5 by weight. The material was applied on July 19, and 8 days of rainy weather followed. The average relative humidity for the period was 73.2 percent with higher humidities occurring the first 6 days. Evaporation for the period was very low, as is shown in table 8.

Although the per-acre applications of arsenicals in 1929 were excessive, only 1 of the 3 applications caused any toxic injury, and that was from the effects of cloudy, foggy weather following the application. The same type of weather was responsible for the single case of toxic injury in 1930. Weather of this type is unusual for the State. Figures showing the yields per acre indicate that there was no appreciable decrease in production due to the application of arsenicals.

CONTROL RECOMMENDATIONS

The recommendations offered are based on 8 years of experimental work. The 2 years presented are simply an example of the type of experiments and the methods of figuring the cost and returns. These and similar experiments show that the bean beetle can be successfully controlled in the Southwest by the use of calcium arsenate (fig. 24), applied according to the formulas here given, without any commercial injury or burning of the bean foliage. Spraying has given better results than dusting in heavy infestations and where high winds are encountered, but it is not practical in the dry-farmed areas.

Calcium arsenate dust

Calcium arsenate, undiluted ....4 pounds per-acre application.

Calcium arsenate-lime dust

Calcium arsenate, 1 pound
Hydrated lime, 3 pounds } ....12 pounds per-acre application.

Calcium arsenate spray

	For large areas	For small areas
Calcium arsenate	2 pounds	5 level tablespoonfuls.
Water	100 gallons	3 gallons.

Calcium arsenate-lime spray

	For large areas	For small areas
Calcium arsenate	2 pounds	5 level tablespoonfuls.
Hydrated lime	4 pounds	10 level tablespoonfuls.
Water	100 gallons	3 gallons.

FIGURE 24.—Bean plants at left protected from Mexican bean beetles by two applications of calcium arsenate dust; untreated rows at the right, between the white stakes at the far ends of the rows.

The calcium arsenate-lime dust [6] or spray should be used during periods of high humidity and low evaporation to avoid toxic injury, especially in the irrigated areas. One application has given good returns when applied as the first larval injury was apparent and eggs were numerous, but usually two will be necessary. The first should be made when there is an average of one beetle to each 5 feet of row.[7]

[6] Calcium arsenate-lime dust may be mixed by placing the ingredients in a steel drum together with several rocks about as large as the fist. The drum is then tightly closed and rolled for about 400 feet, at the same time being tipped on end at intervals of about 50 feet.

[7] Search for beetles on the larger plants should be begun after the summer rains have set in. They are most easily found early in the morning, when some of the beetles may be noted on the upper surface of the leaves. After they have been seen, count the beetles on 100 feet of row. To do this bend the plant over and look on the underside of the leaves or give the plant a quick slap with the hand and note the number that fall off each plant. Several counts in different portions of the field should be made.

As the eggs are not killed by the treatment and new unpoisoned foliage is developing, the second application should be made after from 7 to 12 days, the shorter interval in the southern portion of New Mexico and the longer period in the cooler elevated areas. Apply the dust when little or no wind is blowing. If rains occur within 2 days after the application is made, repeat as soon as conditions will permit. The beetles start dying about the second day, and the peak of mortality is reached on the third or fourth day after the application, but a few may not die for some time.

The treatment of snap beans after pods have set is not recommended. Under usual conditions, careful applications up to the time of full bloom will give sufficient protection.

BEETLE VERSUS LARVAL CONTROL

Infestation by the overwintered beetles follows immediately after the beginning of the summer rains, and therefore the time to start control operations is clearly indicated. This early infestation by the old beetles lasts but a short time, the females beginning to oviposit in about 10 days after emergence. During this period a very large percentage can be killed before any great injury has been done and before most of the females have laid any eggs. The plants are small at this time and can be more thoroughly covered with the dust, and less dust will be needed, than if control measures are delayed till after the larvae begin to feed.

If, on the other hand, control is delayed for from 15 to 30 days, when the larvae are present, the plants are larger and less easily dusted and the time to give the treatment not so easily determined. New eggs will be hatching over a longer period than that covered by the emergence of the old beetles from hibernation. The advantage of attacking the insect over a smaller area of foliage and when its numbers are at the lowest point in the season is well shown in experiment G1 in 1930. Calcium arsenate was applied on July 29, when there were 2,004 beetles per 1,200 feet of row. On August 4 there were only 216 to the same length of row, a reduction of 89.22 percent. It is apparent that the number of potential egg masses was correspondingly reduced. It would require a period of 4 weeks for the remaining females to deposit as many eggs as the original number of females were capable of producing during the first 10 days. Egg laying was greatly reduced and retarded, and the larval injury and consequently the defoliation of the plants were obviously delayed.

Control experiments performed in the laboratory over a period of several years show that the overwintered beetles are just as easily killed as are the larvae, while recently matured beetles are very resistant to arsenicals.

DUSTING VERSUS SPRAYING

Both spraying and dusting have been used successfully to control the bean beetle, although dusting has not given so good results on the average as spraying. Spraying is recommended in the irrigated areas where abundant water supply is available. Dusting is more practicable in the dry-farmed areas, as it requires about 100 gallons of water to spray an acre of beans. Spraying has the following advantages: (1) It can be applied during windier weather; (2) the material is more adhesive; and (3) less material is required per acre. Dusting has the following advantages when the weather permits its use: (1) Quick protection for large acreages; (2) facility of making applications at the proper intervals; (3) muddy fields do not delay the work as long as is the case with spraying. Other advantages with dusting are: Lighter outfits, lower initial cost, and lower upkeep and operating expenses. Dusters pulled by or mounted on tractors and utilizing power for operation from the power take-off will permit both cultivation and dusting at one operation.

DUSTING AND SPRAYING EQUIPMENT

At the present time there are upon the market the following types of dusters and sprayers: Hand, push, traction, power, and tractor-power take-off (fig. 25). Hand and push dusters and sprayers are

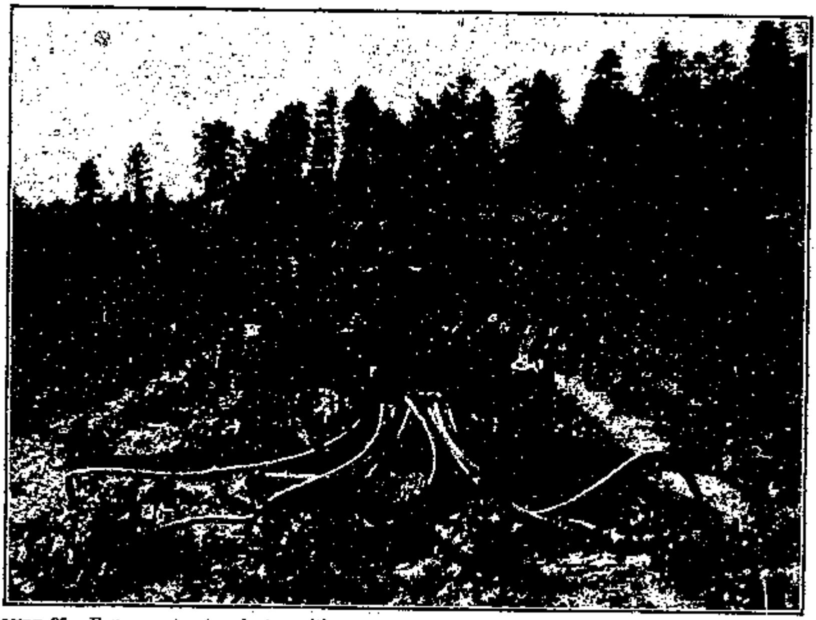

FIGURE 25.—Four-row tractor duster with power take-off permitting cultivating and dusting at one operation.

used on fields up to about 3 acres in size. Two-row traction dusters are used for larger fields, and traction and power dusters and sprayers covering 4 to 6 rows are adapted to the largest acreages. A few manufacturers are offering multiple traction and power dusters, that is, 2 units mounted on 1 cart. Some makes of dusters will not deliver an even distribution of dust to each nozzle, especially where the per acre application is as low as 4 pounds. Purchasers should demand a guarantee that the duster will give an even distribution at this rate of application.

The dust or spray can be effectively applied in only one way, and that is by coating the undersurfaces of the leaves with the poison, because that is where the insect does its destructive feeding.

Some dusters are equipped with special bean-beetle attachments and nozzles to apply the dust to the underside of the leaves as shown in Figure 25. These nozzles are constructed so as to force the dust upward to the undersides of the leaves. To accomplish this the nozzles

FIGURE 26.—Power duster mounted on tractor for rapid dusting. Note arrangement of nozzles, two per row. Nozzles made from tin grocery scoops and clamped to distributor pipe with automobile hose connections.

are set close to the ground and held in place by a nozzle arm that is swung from hinge brackets on a distributor bar to prevent their breaking off. Figure 26 shows efficient nozzles made from tin grocery scoops and clamped on to the outlet pipe with automobile hose clamps.

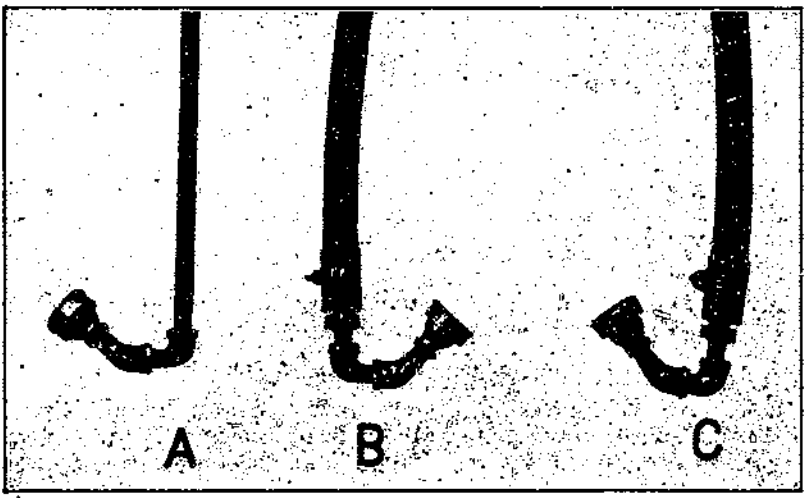

FIGURE 27.—Arrangement of nozzles for spraying the undersides of the leaves: A, for hand sprayers; B and C, for use on power or traction sprayers, with hose connections to prevent breaking of the pipes (N. F. Howard).

Where water is available and spraying is practicable, the nozzles should be properly set to spray the underside of the leaves. They should be attached to the discharge hose by a 90° elbow and a 45° elbow, as shown in figure 27, or a 45° nozzle in the latter place. These nozzles should be set so that one of them sprays slightly forward and the other slightly backward, to insure better coverage of the leaves. When a traction or power sprayer is used, it is advisable to have a third nozzle placed above the row (fig. 28).

The liquid in the spray tank must be agitated continuously so as to keep the arsenate from settling. A pressure of 150 pounds or more is necessary to blow the leaves about and insure thorough coverage. Pressure higher than 200 pounds is unnecessary. Some growers have used only one nozzle to the row, spraying the other side on the return trip, and claim that a better coverage was secured.

New disks should be placed in the nozzle after a total of 10 to 15 hours of spraying. The holes in the disks become enlarged with use, and unless disks are replaced an unnecessary quantity of spray material is used.

The boom should be adjustable in order to raise or lower the nozzles for different-sized plants, and rubber hose should be used instead of

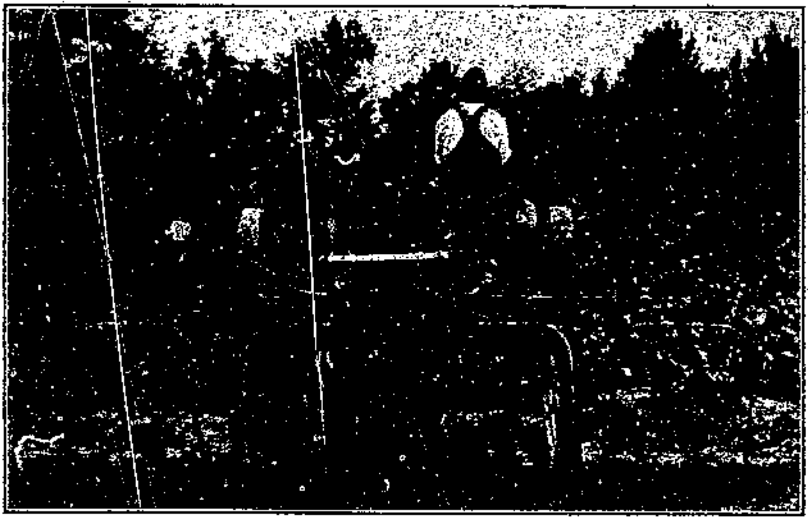

FIGURE 28.—Power sprayer, showing proper arrangement of the boom and nozzles for spraying the undersurfaces and tops of the leaves (N. F. Howard).

rigid vertical outlet pipes, so as to make them flexible and thus prevent breaking of the pipes when passing over rough ground.

COMMUNITY CONTROL

In the large bean-growing districts like the Estancia Valley, where the beetles overwinter only on one side of the valley and a 1-way infestation occurs, the beetles can be controlled more economically by cooperation than by individual effort. By reducing the number of overwintered beetles in the foothill fields the number reaching the valley plantings will not be of economic importance except in occasional years. In this manner at least 10 acres of valley beans are protected for each acre of foothill beans which is treated. By reducing the battle front, more applications can be made to the smaller area with the same funds that would be required to treat the larger area but once. The plan is feasible and economical and can be worked out by a cooperative agreement wherein each grower contributes his pro rata share and where the control operation is invested in a central unit or head.

EARLY AND LATE PLANTING TO ESCAPE INJURY

The fact that the beetles remain in hibernation until the coming of the summer rains has an economic application, particularly in the irrigated areas of the State where the time of planting is not governed by natural soil moisture. In the southern part of the State, especially in the Pecos, Rio Grande (*6*), and Nimbres Valleys, beans can generally be planted sufficiently early in the spring to avoid economic loss. In the same areas moderately late plantings escape injury, and the plants mature before killing frost. Very late plantings are often injured by frost. Climatic conditions influence the growing season, and wherever possible the grower should time his plantings to avoid injury by both frost and beetles. Commercial growers of beans in the various communities should adopt a non-bean-growing period during midsummer to prolong the fasting period and thus

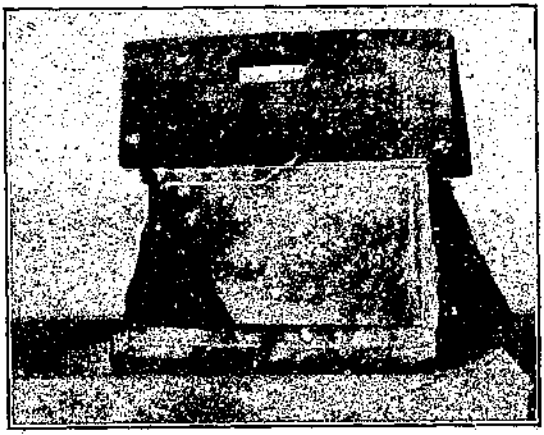

FIGURE 29.—Collecting pan made from a 5-gallon oil or gasoline can, and a thin board to be used for jarring the beetles off the plants into the pan.

starve the beetles. If beans are grown during this period for the string-bean market or for home use, the vines should be plowed under at least 6 inches immediately after the last picking. This will destroy a large number of all stages of the insect.

COLLECTION AND DESTRUCTION OF BEETLES

In consolidated bean areas like the Estancia Valley, cooperative community collection of beetles along the foothills in the fall will contribute to the control of this insect. In the fall newly emerged beetles will congregate on green plantings by the hundreds, and they are easily collected by being jarred from the plants with a thin board, into the type of pan shown in figure 29. The pan is made from a 5-gallon oil or gasoline can cut as shown. After several hundred beetles have been collected they can be emptied into cloth sacks hung from the belts of the collectors. Later, when a large number have been collected, they can be killed by being dipped in used motor oil, or burned or crushed. If several rows of beans are left unharvested in a field thousands of beetles can be collected from them in a comparatively short time. The writer has collected unassisted over 30,000 beetles in 3 hours. Figure 30 shows a pile of at least 300,000 beetles collected in the above manner, or enough beetles, if all survived the winter, to infest a row of beans over 56 miles long with 1 beetle per linear foot of row.

BEETLES NOT CONTROLLED BY BURNING FORESTS

During periods of bean-beetle devastation a few growers urge the burning of the forest under the assumption that burning the forest-floor litter before the beetles have emerged will eliminate the pest. Their plan is to do the burning, under proper supervision, in the early spring before the sap rises in the trees in order that the young growth may not be killed. Such a procedure would be of practically no value. During the heat of the day on May 8, 1930, a forest fire in the Manzano Forest burnt over an eastern-slope area in which was located hibernation cage 7. This fire occurred during one of the

FIGURE 30.—A pile of Mexican bean beetles estimated to contain at least 300,000 beetles.

driest periods of the season, as no moisture had fallen up to this time in May, and only 0.21 inch was recorded for this area in April. Examination on May 9 showed that all the material did not burn to the ground because the lower portion of the material and duff was damp. The beetles in the top layer of the hibernation material had been destroyed, but down deep in the material live beetles were common. The heat of the fire killed all young growth within the area burnt over, yet 14.89 percent of the beetles introduced in the fall in cage 7 survived the winter and the fire and emerged later in the season. In cage 6, on the same exposure and within 150 yards, 25.08 percent of the beetles survived the winter. Evidently the beetles cannot all be killed by burning. During the last six winters an average of 12.86 percent of the beetles introduced into cage 7 survived. If burning had been an effective control measure, the survival after the fire should have been much lower than the average, rather than higher. The economic loss and detrimental effect of burning our forests are so well known that any further comment is unnecessary.

THE UTILIZATION OF TREATED BEAN HULLS AS FOOD FOR LIVESTOCK

Because of the growing use of calcium arsenate for the control of the Mexican bean beetle in the Southwest, the writer is often asked about the danger of poisoning livestock with treated bean hulls. In an endeavor to answer this question the available literature has been reviewed, and the most important information is given herewith.

In his evidence in the Riverside dairy case before the United States District Court of Utah, Gardiner, of Montana, stated that 20 to 30 grains of arsenic (As_2O_3) could be fed to horses and cattle month in and month out without external evidence of injury or without any alteration discernible on post-mortem examination, the fatal dose being 300 grains (*4, p. 4*).

Reeves, in his bulletin on the alfalfa weevil (*7, p. 21*), reports:

> The arsenic content of sprayed [alfalfa] hay ranges from less than 1 grain in terms of white arsenic to nearly 29 grains for 30 pounds of hay, and is usually between 5 and 10 grains. The exceptionally large quantity of 29 grains in 1 day's ration is within the limit of tolerance of horses and cattle. It is, therefore, entirely safe to feed sprayed hay to livestock, and there need be no case of arsenical poisoning unless white arsenic, sodium arsenite, or some equally virulent poison is substituted, through carelessness or ignorance, for calcium arsenate.

Frederick (*4, p. 8*), reporting on some experiments in Utah, says:

> Alfalfa hay dusted with 3 pounds of calcium arsenate to the acre and fed for 40 days to horses, cattle, and sheep with no other feed except water and salt, showed no actual injurious effects on any of the livestock under experimentation.
>
> Alfalfa hay dusted with 6 pounds of calcium arsenate to the acre fed to the same livestock for a 40-day period showed no detrimental effect; however, some of the cattle did not gain in weight. The horses gained during the entire feeding period, each of them increasing over 100 pounds in weight and presenting a sleek, glossy appearance. The [10] sheep gained during the entire experimental period and weighed 139 pounds more at the close of the test than before; their fleece appeared as good, if not better, than did the fleece of sheep fed on untreated hay.

The alfalfa in question was dusted on June 19.

> Ten days later the treated alfalfa hay was cut and harvested as alfalfa is usually harvested. No rain or other unfavorable weather conditions between the time of dusting and stacking was encountered (*4, p. 5*).

The foregoing citations show that it is entirely safe to feed treated alfalfa hay to livestock. In order to obtain a comparison of arsenic content on treated bean hulls with alfalfa hay, samples of hulls were obtained as the treated plots were threshed and sent to the United States Bureau of Chemistry and Soils for analysis. Table 13 gives the results of the analysis of hulls that had received two applications of arsenicals at the proper time in 1930.

In 1931 the applications for the control of the Mexican bean beetle were delayed until later in the season to secure data on the analysis of late-treated bean hulls as shown in table 14. These delayed applications are not recommended, as they will not give the desired results.

TABLE 13.—*Data on the analysis of treated bean hulls grown in 1930*

Insecticide used	Date of application	Quantity applied per acre	Date harvested	As_2O_3 per pound of hulls
		Pounds		*Grain*
Calcium arsenate, undiluted	Aug. 1 Aug. 14	4.8 4.2	(1)	0.025
Lead arsenate, undiluted	Aug. 1 Aug. 14	3.8 3.5	Sept. 16	.035
Magnesium arsenate, undiluted	Aug. 1 Aug. 14	7.3 6.1	do	.042
Zinc arsenite, undiluted	Aug. 1 Aug. 14	4.0 3.8	do	.035

[1] Harvested on Sept. 16 or later.

TABLE 14.—*Data on the analysis of late-treated bean hulls in 1931*

Insecticide used	Date of application	Quantity applied per acre	Date harvested	As_2O_3 per pound of hulls	Remarks
		Pounds		*Grain*	
Calcium arsenate, undiluted	Aug 14 Aug. 20	4.98 5.36	Sept. 15	0.68	Sample was mostly leaves.
Do	Aug. 15 Aug. 20	3.30 4.72	do	.36	Do.
Do	Aug. 15 Aug. 20	3.30 4.72	do	.14	Sample was mostly pods.

The first two samples in table 14 were composed mostly of leaves, with very few pods and leaf stems or petioles, whereas the third sample was composed mostly of pods, with a few leaves and stems. In submitting samples for analysis, only that portion of the plants ordinarily consumed by horses and cattle was included.

Table 13 shows that where the plants were treated according to recommendations, the arsenic content of a day's ration (30 pounds) of treated bean hulls ranges from 0.75 grain, in terms of white arsenic, to 1.26 grains. Table 14 shows that in the delayed treatments, which are not recommended, a range of from 4.2 to 20.4 grains for 30 pounds of bean hulls resulted.

On the basis of Gardiner's evidence, it is apparent from the results of the analyses given in tables 13 and 14 that treated bean hulls may be fed to horses and cattle with safety, when the plants are treated according to recommendations; whereas table 14 indicates that it is not advisable to delay applications until late in the season when the plants are maturing. The quantity of white arsenic (arsenious acid, As_2O_3) per pound of hulls will depend on the quantity of material applied, the age and size of the plants, the atmospheric movement at the time of dusting, the quantity and character of precipitation, and the interval between application and harvest; as well as the length of time harvested vines are left in the field before being threshed, the methods followed, and the weather conditions encountered during threshing.

SUMMARY

The bean beetle passes the winter in only the adult or beetle stage. In the Estancia Valley, N.Mex., overwintering is confined primarily to the yellow pine forest zone with conditions becoming more favorable where oak trees are found in the association.

Contact moisture is the stimulus influencing emergence from hibernation. The time and intensity of the initial infestation of overwintered beetles depend on the summer rains and the prevailing temperature during the period of precipitation or subsequent thereto.

The period between emergence from hibernation and oviposition averages about 10 days in the cool elevated areas of the State.

The average number of eggs deposited per female is about 900.

The developmental period from egg to adult depends on the seasonal temperature; in the Estancia Valley 40 days or longer is necessary.

The bean beetle has no known natural enemies of economic importance in the Southwest.

Drought periods are detrimental to eggs and larvae, especially when they are accompanied by dry hot winds.

Investigations show that the bean beetle can be controlled with profit in dry-farmed areas where conditions warrant the use of control measures.

Evidence is given that insecticidal "burning" following the use of arsenicals is due to high humidity combined with low evaporation following the treatment.

Spraying or dusting with calcium arsenate are the most economical control measures.

Growers in the irrigated areas in the southern part of New Mexico can avoid injury to beans from the beetle by early and late planting.

In the consolidated bean areas cooperative community collection and destruction of beetles along the foothills in the fall will contribute to the control of this insect.

Evidence shows that burning forests in the spring is not effective in controlling the beetles.

Bean hulls from fields which have been properly treated may be utilized as food for cattle.

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