pressure and with about 1/3 the amount of liquid usually applied. This has been under test and observation in Maryland.

A combination of cool nights and drought during August cut down the second generation by reducing the egg deposition. Many late plantings were not treated and satisfactory crops were harvested. Likewise most of the extra early snap beans were not dusted or sprayed and good crops were picked, but the amount of injury developed amazingly toward the last and, if plowing had not been done promptly, all the later plantings would have been more difficult to protect.

Thorough preparation for combating the pest was universal; a vast amount of insecticides was sold; one company alone sold 96 traction or power dusters and sprayers and over 300 hand dusters; other companies sold more machines than the most sanguine would have dared to predict; the recommendations in the main were followed carefully; and the result in education and actual control exceeded the normal expectancy.

PLOWING AS AN AID IN MEXICAN BEAN BEETLE CONTROL

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ABSTRACT

Several tests show that plowing may be effective in destroying the Mexican bean beetle, especially the immature stages. Observations are included on the longevity and food habits of beetles unfed since emergence; observations which apply to survivors of plowing done while the population is in the pupal stage.

Possibly no advice on insect control is more freely given than that of clean culture, plowing under of infested hosts and related practices. For such oft-quoted recommendation there is a surprising dearth of experimental evidence to indicate the ways that these methods are truly of economic value to an individual or to a community. We suspect that the originators of many such statements feel justified in the strength of the common sense principle that "every little bit helps." Far from quarreling with such obvious logic, we take the position that before more than the usual emphasis is placed on these control methods an attempt should be made to measure their worth.

This type of problem is admittedly one about which it is difficult to obtain much precise information. We have reported (Va. Truck Exp. Sta. Bul. 65; 691, 1928) on our 1928 observations in this connection as they apply to the Mexican bean beetle. These were burial tests conducted in wooden frames under more or less controlled conditions. The present paper is a report of field trials of burying by means of plowing—with additional related observations.

PLOWING EXPERIMENTS. *Experiment 1.* A field of snap beans on the Whitehurst Farms, Norfolk, Va. was used in this first test. It had been abandoned after the first picking because of severe damage caused by the bean beetle. On August 9, 1929 the population was mostly in the pupal stage. On August 10, this field was plowed with an 8-inch walking plow. The use of a small plow was contrary to advice, but its use did give opportunity to observe what would result from this type of treatment. The soil was a sandy loam and at the time of plowing rather dry. On August 11, however, 1.25 inches of rain fell, which, according to our 1928 experiences should have created soil conditions unfavorable to insect escape. From the standpoint of clean plowing a poor job was done. The furrows "ran with the rows" and one could readily distinguish rows of uncovered plant tips everywhere in the field. Cheesecloth was put down over two representative areas to retain any stages which were able to gain the soil surface. The record is as follows:

Plat	No. Sq. Ft. Observed	No. Beetles Recovered 8/15	8/19	Total	Acre Estimate of No. Beetles Gained Surface
1	315	399	79	478	66,100
2	305	347	110	457	65,200
Total or Average	620	746	189	935	65,650

It was perfectly evident from walking through the field that a considerable number of insects had survived the plowing operation. On August 15, one could find beetles crawling about on the soil surface, but most of them were clustered on the uncovered tips of bean vines. The stiffer bean vines and weeds (most of the weeds bore a heavy population of pupae) prevented packing of the earth and consequently created avenues of escape for beetles emerging under ground. So successfully had the stems held up the earth in many cases that a beetle emerging below ground had simply to crawl up a stem to gain freedom. For the purpose of estimating the per cent killed by the plowing operation we placed the original population per acre at 1,200,000 individuals mostly pupae (based upon estimates in Experiment 3). Because of the unfavorable location of many pupae, possibly 25 per cent of this number would normally have succumbed to the hot weather[1] prevailing at this time, although several thousand pupae collected in this field actually showed a lower mortality. From these assumptions, however, we arrive at 7 per cent as the number reaching the soil surface alive.

The majority of the beetles seen on August 15 had disappeared by August 19, and since dead individuals were uncommonly found we concluded that most of the "plow-survivors" had flown to new fields.

[1]Howard and English. U. S. Dept. Ag. Bul. 1243, p. 28.

Experiment 2. The experimental plat was a small patch of snap beans on the Station grounds. The bean beetles present were principally pupae with a few larvae and adults. Soil a Norfolk loam. On August 13 the plat was plowed, and here too an 8-inch walking plow was used. We attempted to do a thorough job, but in spite of our best efforts an occasional plant top remained visible.

We covered 120 square feet with cheesecloth and three days later found three adults and 8 larvae on the surface—all dead. Seven days after plowing nine additional adults were discovered and these too were dead.

Experiment 3. A small planting of Fordhook lima beans was selected for this test. Bean beetle damage was pronounced, although there was enough bulky growth remaining to offer a problem in clean plowing. A census of the bean beetle stages present before plowing was made by examining plants from selected samples totaling 25 square feet. On an acre basis these would approximate the following:

Egg Masses	Larvae (Mostly Full-Grown)	Pupae and Prepupae	Adults
1500	200,000	335,000	65,000
Total All Forms			601,500

The soil, a Norfolk loam, was in excellent condition for plowing on August 15. In order to test several cultural methods the following procedure was followed. First the eastern half of the plat was gone over twice with a disk harrow which had been so set that the vines were thoroughly cut up and the soil pulverized. After this operation the entire plat was plowed. We used two fourteen-inch bottom plows which were drawn by a tractor. The plowing depth was about 8 inches. A rather good job resulted, although an occasional tip was visible in that part of the field where the vines had been turned under direct. Finally, a spike tooth harrow was used on the southern half of the plat. To avoid pulling out buried vines the teeth in this harrow had been set at such an angle that it functioned more as a drag. Cheesecloth was then stretched over each of the four areas to entrap surviving larvae and beetles. The following records were taken:

Area	Treatment	No. Sq. Ft. Observed	No. Insects Came to Surface			Acre Estimate of Insects Surviving as Adults	
			Larvae	Adults	Total	Number	Per cent
1	Plowed	136	35	22	57	7,046	1.17
2	Plowed and Harrowed	194	16	41	57	9,206	1.53
3	Disked and Plowed	136	0	0	0	0	0
4	Disked, Plowed and Harrowed	194	0	0	0	0	0

BEHAVIOR AND FATE OF INSECTS SURVIVING PLOWING. When clean plowing has been done, the larvae which reach the surface have little chance to survive. Those at the field margins may, of course, crawl to food in another field if such is near enough at hand; we have abundant evidence of third or fourth instar larvae crawling 12 to 15 feet in search of food.

An appreciable mortality takes place even among beetles that have reached the soil surface. A plowed field offers little protection from the direct rays of the sun which, if of sufficient intensity, apparently results in deaths, especially among weakened individuals. Others, when transforming to beetles underground, and subsequently struggling to escape, may become so weakened or deformed that they are unable to fly to food and hence soon die. There appears to be, furthermore, a pronounced need for food after emergence before any prolonged flights are made. And if food is at too great a distance or if it is not soon found, still others may die. This brings up the question of how long beetles may live without having food after emergence. We have the following records.[2]

Date Emerged	No. Used	No. Dead Days After Emergence																Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
August 26–27	100	0	4	4	3	—	27	16	38	10	1							
Mean Temp.		79	74	71	68	78	73	73	72	77	83							75
Oct. 25–26	100	0	1	—	8	15	12	31	20	8	3	0	0	0	0	1		
Mean Temp.		62	58	60	63	66	70	70	72	60	51							63
Oct. 28–29	123	0	2	1	13	4	3	16	11	17	7	9	8	8	28	4	2	
Mean Temp.		63	66	70	70	72	60	51	50	56	57	55	48	53	56	65	68	60

It is erroneous to assume, of course, that beetles would recover should food be supplied within a day or more of the time when death would take place. It is likewise erroneous to assume that in the event of survival, such beetles would continue life in a normal manner. These are problems which may be considered at a future time.

Newly emerged beetles which have been unable to find food in the immediate vicinity of the site where they transformed are responsible in part for rather unusual food records. These are the individuals which we have found feeding commonly on stems, flowers, and pods of beans when the leaves are unsuitable. Cowpeas, soy beans, and alfalfa are also readily attacked. On August 26, 1929, 464 marked beetles, which had had no food after emergence, were liberated 50 yards from a snap bean field, but only 6 to 8 feet from some soy beans. This soy bean field lay between the snap beans and where the beetles were liberated. Several days later we failed to locate a single beetle in the snap beans, although what appeared to be the entire lot was found at the edge of the soy

[2]Live beetles taken in plowing experiment No. 1 gave similar data.

bean field. These beetles were kept under observation for several weeks. No eggs were laid, that we could find, and it was not long before the insects disappeared. About September 9, however, a single marked beetle was found in the snap beans.

A similar lot of marked beetles was liberated 50 yards south of another snap bean field. The wind at the time of liberation and for several days following was from the northeast. No beetles of this lot could be located in the snap beans. Some 50 yards to the south of the liberation point, however, marked beetles were found on alfalfa and soy beans.

INFLUENCE OF WEEDS ON SURVIVAL. The presence of weeds in crops severely infested with bean beetle may influence the number of individuals reaching maturity in two ways. (1) Weeds, especially those with broad leaves, are commonly sought out as sites for pupation, even when infestations are only moderate. If, however, larvae destroy most of the bean leaves and weeds are not available, many will be forced to pupate in situations exposed to the direct rays of the sun. Pupae so located are likely to die should high temperatures prevail during the pupation period. (2) To a slight extent, a few species of weeds may serve as food to larvae in the absence of beans. At the Whitehurst Farms, Norfolk, Va., August 9, 1929 we found a number of black mustard (*Brassica nigra* (L.)) plants with leaves that had been skeletonized by larvae. And on November 1, 1929 a single larva was discovered feeding on shepherd's purse, *Capsella bursa-pastoris* (L.). In the Whitehurst field no feeding, as such, could be found on lamb's quarters, jimson weed, dock, ragweed, pigweed, smartweed, purslane and spurry, although all of these bore numbers of pupae. There is, therefore, this rather hypothetical possibility: some larvae in the absence of more desirable food may obtain enough sustenance from certain weeds to complete their growth.

DISCUSSION. The immediate plowing under of bean vines at the completion of harvest should be encouraged in areas where the bean beetle occurs. This practice may benefit either the individual directly, or may be a less tangible value as it improves the conditions of the community. Emphasis should be placed particularly on the importance of reducing the number of bean beetles entering hibernation. In this area semi-abandoned lima bean fields support large numbers of insects until late in the fall. The destruction of these and all "spent" bean vines as the hibernation period approaches should result in appreciable benefits.

Where growers plant a succession of snap bean crops, plowing under of the old vines may be of direct value to an individual in lessening damage to younger plantings. Under such intensive culture the practice

is already common to plow fields shortly after a crop is harvested in order that another kind of crop may be put in; the presence of the bean beetle should simply be an additional incentive to early and thorough plowing.

Snap beans such as the Bountiful variety mature so rapidly that only a single brood of bean beetles may mature on a given planting. One frequently finds the population predominantly in the pupal stage at the end of picking. If such fields are immediately and thoroughly plowed, few insects should survive. Lima beans, on the other hand, have a long growing and bearing period. In this locality three broods often complete their development on a single planting. A brood may mature before beans are ready to pick, and a grower would hardly plow under a field before it comes into bearing or shows promise of bearing later, unless bean beetle damage is extreme. Too often such lima bean fields remain the season through, unprofitable to the owner from the standpoint of production, yet serving the species in providing an abundance of individuals for hibernation.

We believe, in conclusion, that disking before plowing, at least under certain conditions is a distinct aid towards creating soil conditions unfavorable for bean beetle escape.

THE EUROPEAN CORN BORER WITH RESPECT TO SWEET CORN IN NEW YORK

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ABSTRACT

Results are here given of two years experiments in the control of the corn borer. It appears that the infestation is somewhat lighter this season than in 1928 which is probably due to late planting and a poor stand of corn. Plowing as a means of disposing of corn refuse has given very satisfactory results in reducing the infestation. This is illustrated by the results of a two-year survey in the Eden Valley section where clean up measures are practiced. Experiments with insecticides indicate that this is a possible means of combating the insect. Calcium fluosilicate appears effective against the young larvae. White oil emulsion also offers promise when used with aresnate of lead. Various dusts have been tried but have not given an appreciable reduction in infestation.

Owing to the threatened invasion of the European corn borer to the sweet corn industry in New York State it was considered advisable to begin investigations into the nature of the injury and possible means of control of the pest. Accordingly in the fall of 1927 studies were undertaken with a view to attacking the problem from several angles, such as, determining the extent of the injury to sweet corn in New