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THE EUROPEAN CORN BORER IN WESTERN NEW YORK

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BULLETIN No. 603

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G. E. R. HERVEY

ABSTRACT

The experiments and observations concerning the European corn borer (*Pyrausta nubilalis* Hübner) reported in this bulletin were conducted from 1928 to 1931, in Chautauqua, Erie, Niagara, Monroe, Ontario, and Oswego Counties. The phases of the problem under study included the seasonal history of the insect, the effect on the rate of infestation of the disposal of infested corn remnants by plowing, and the time of planting.

Experiments indicate that plowing under infested stalks, stubble, etc., is efficient in destroying a high percentage of the overwintering borers. This practice has the effect of making the hibernating quarters of the borers so unfavorable that many of them are killed underground. The remainder are forced to migrate to the surface of the soil where they are killed by exposure, providing shelter is unavailable. The efficiency of the practice depends on the thoroness with which it is conducted. Spring and fall plowing appear about equally effective from the standpoint of mortality to the insect.

The value of community effort in clean-up operations is shown in the record of the infestation in the Eden Valley section in Erie County. In this area the rate of infestation has been held at a low level with little or no injury for the past 3 years. This is especially significant since it is an early sweet corn area and is located in a district where the insect has been very abundant.

Where it is possible to delay the planting date until the first week in June or later it has been found that the crop will escape much of the infestation. However, the degree of protection secured is relative and depends chiefly on the intensity of the infestation in any area.

INTRODUCTION

The corn crop in New York had been comparatively free from insect injury prior to 1919 but at that time became subject to a disturbing menace in the introduction of the European corn borer (*Pyrausta nubilalis* Hübner). This insect was first reported from

Massachusetts in 1917 and has since spread over a large territory comprising a considerable part of the states bordering on the Great Lakes from New York westward to Indiana. It is also present over a large part of the New England states from Maine to New Jersey. In Canada it is found in practically all parts of Ontario where corn is grown and also in large areas in the provinces of Quebec, New Brunswick, and Nova Scotia. In New York the corn borer has spread from two small centers of infestation, one at North Collins and the other at Schenectady, over approximately the whole State.

The insect increased rather slowly in New York up to 1931 and was not particularly troublesome except in Chautauqua, Erie, and Niagara Counties. In these counties some injury was encountered, especially to early sweet corn. During the season of 1931 the insect showed large increases in all the counties bordering on Lake Ontario and also in some counties further inland, resulting in considerable injury to corn. There was also a rather serious outbreak of the insect in Suffolk County on Long Island causing much injury to corn and to some extent to other vegetable crops as well.

Investigations undertaken in New York in 1927 had for their purpose the study of the insect in relation to sweet corn culture, the ultimate object being to discover some means of protecting this crop from the ravages of the borer. The various lines of endeavor included a study of the seasonal history, the effect of burying infested corn stalks by plowing, the relation of the time of planting to the rate of infestation, varietal susceptibility, and the possible use of insecticides against the newly hatched larvae. Light infestations in western New York up to 1931 made the results indicative rather than significant.

THE SITUATION IN 1931

The season of 1931 showed a very decided increase in European corn borer abundance in western New York as compared with the two previous seasons when there had been, with few exceptions, little perceptible change in the status of the insect. The increase took place in all parts of the State where the insect occurs. In many instances it was attended by considerable injury to early sweet corn grown for roasting ears and to sweet corn grown for the canning factory. In Oswego and Jefferson Counties silage corn was also rather badly infested and in some cases was broken down. The insect seems to have accumulated in greatest abundance in western New York in

those counties bordering on Lake Ontario, including Niagara, Orleans, Monroe, Wayne, Oswego, and Jefferson. Counties further inland, such as Genesee, Livingston, and Ontario, also had occasional badly infested fields.

Table 1 shows the records from several fields of sweet corn grown for the canning factory from various parts of western New York in 1931. Since these fields were indicated by the canners as being the most seriously infested in their immediate territory, the record should give some index as to the rate of infestation between these counties. The only plantings shown here which were a total loss are the two fields in Orleans County. In these cases the corn was infested to such an extent as to make it unprofitable to attempt to sort out the infested ears from the uninfested.

Some idea of the increase may be obtained from the records of an experiment conducted at Brockport in Monroe County in 1930 and 1931. Plats of Golden Bantam planted early in May in 1930 yielded approximately 94 borers in each 100 plants. The same plats on the same soil and same planting date contained an average of 884 borers per 100 plants in 1931. Weather conditions have doubtless contributed toward the large increase in borer population in 1931. The writer assumes that the influence of weather would be most striking during the month of July since it is during this period that the majority of the eggs are being laid and the young larvae are becoming established. In 1931 the average temperature in western New York during the month of July was 3 to 4 degrees higher than for the same period during the two previous years. Precipitation was also nearly normal as compared with deficiencies in 1929 and 1930, especially the latter year when drouth conditions were in evidence from the beginning of July to the end of the summer. Apart from the direct effect of drouth on the corn borer it probably had an indirect influence thru its effect on the growth of the host plant. Because of high temperatures and an adequate supply of moisture in 1931 growth conditions for corn were far more favorable than in either 1929 or 1930.

LIFE HISTORY OF THE CORN BORER IN NEW YORK

The life history and general habits of the corn borer have been thoroly worked out and reported in various publications, hence, no extended account will be given here. In New York, with one excep-

TABLE 1.—THE RATE OF CORN BORER INFESTATION IN SWEET CORN GROWN FOR THE CANNING FACTORY IN WESTERN NEW YORK, 1931.

PLACE	COUNTY	VARIETY	NO. OF ACRES	DATE PLANTED	NO. OF STALKS EXAMINED	PER-CENTAGE INFESTED	NO. OF BORERS IN 100 STALKS
Geneseo	Livingston	Golden Bantam	10	May 12	500	11.4	20.5
Fowlerville	Livingston	Golden Bantam	6	June 1	500	28.0	44.8
Caledonia	Livingston	Hickox	5	May 22	500	20.2	32.3
Mt. Morris	Livingston	Golden Bantam	4	May 12	500	15.4	29.3
Holcomb	Ontario	Golden Bantam	4	May 21	500	40.2	116.5
West Batavia	Genesee	Charlevoix	4	May 15	500	23.4	32.7
Lacona	Oswego	Evergreen	3	May 26	500	56.6	237.7
Albion	Orleans	Charlevoix	1½	June 4	500	68.0	238.0
West Kendall	Orleans	Golden Bantam	2	June 10	500	65.2	241.2
Brockport	Monroe	Charlevoix	3	June 14	500	34.0	61.2
Honeoye Falls	Monroe	Hickox	4	May 20	500	22.0	30.8
Newark	Wayne	Evergreen	2½	May 16	500	45.0	166.5
Newark	Wayne	Early Crosby	5	May 9	500	55.6	211.3
Clyde	Wayne	Golden Bantam	2	May 28	500	55.6	94.5

tion, there is but one generation of the insect each year.[1] The exception to this is a small area on the eastern end of Long Island where the insect is said to be two-brooded. In western New York and in other parts of the State where the one-generation form occurs, the chief host of the insect is corn, altho certain weeds are often found infested either in or near infested corn fields. On Long Island, however, where the two-generation form occurs, it is reported that the second generation of the insect attacks various weeds, flowers, and vegetable crops in addition to corn.

THE LARVA

The larva when full grown is about 1 inch long, whitish or greyish in color, with a rather indistinct stripe on the back (Fig. 1). The younger stages of the larva are often much darker in color. The winter is passed in the mature larval stage in the tunnels in which it has been feeding in corn stalks and occasionally in large-stemmed weeds.

THE PUPA

During the early part of June, usually in the first week, the larvae begin transforming to the pupal stage in the tunnels where they have passed the winter. Pupation continues thruout June and is usually completed shortly after July 1. The pupa is brown and about ¾ inch long (Fig. 1).

THE ADULTS

The adult moths commence to emerge the latter part of June and are present in the field and are laying eggs thru the greater part of July. In 1930 the moths had ceased laying eggs and had disappeared by July 25, but in 1931 some were still present and ovipositing until approximately August 1. Egg laying commences 2 or 3 days after the moths emerge. The female is cream colored or light yellow with two stripes across the outer parts of the wings. When the wings are spread out they measure from 1¼ to 1½ inches. The male is somewhat smaller than the female and brownish in color (Fig. 1). The

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[1]Recent reports from the federal Plant Quarantine and Control Administration indicate that the regulated area of the two-generation strain of the European corn borer has been modified to include the following counties in eastern New York: Albany, Bronx, Columbia, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Saratoga, Schenectady, Suffolk, Sullivan, Ulster, Washington, and Westchester.

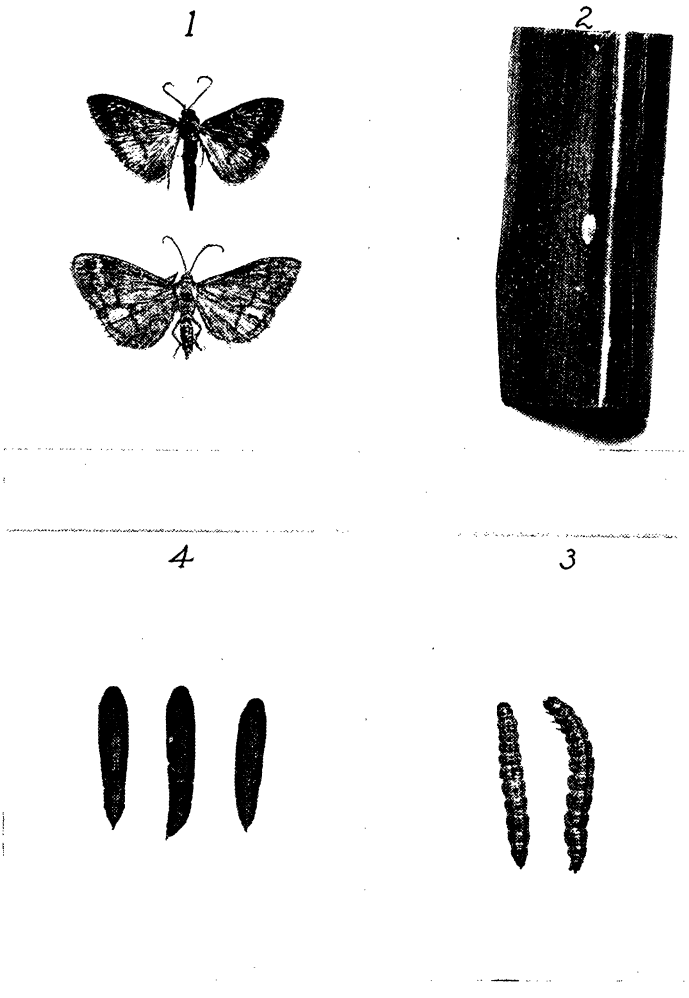

FIG. 1.—STAGES IN THE LIFE HISTORY OF THE EUROPEAN CORN BORER.

1. Adult moths, male above and female below. 2. Egg mass. 3. Full-grown larvae. 4. Pupae. All approximately natural size.

moths are active at night and egg laying takes place at that time. During the day they take shelter under the leaves of corn and other plants.

FIG. 2.—SECTION OF AN INFESTED SWEET CORN STALK.
Showing entrance holes of the borers and castings from tunnels within the stalk.

THE EGGS

The eggs are laid in masses varying in number from 2 to 75. They are more often deposited on the underside of the leaves of the corn plant but are occasionally placed on the tassel or stalk. They are white when first laid but turn darker just before hatching (Fig. 1). They usually begin hatching in from 5 to 7 days, but there is considerable variation depending on the temperature.

FIG. 3.—EARLY EVIDENCE OF THE PRESENCE OF THE CORN BORER.
Showing castings and broken tassel stems.

INJURY

The insect causes injury to the corn by feeding on the stalk, leaves, and ears. The young larvae upon hatching feed between the tender leaves rolled around the developing tassel, often boring their way thru and attacking the tassel buds and pollen. Some may enter the mid-rib of the leaves causing them to break down and often to dry out

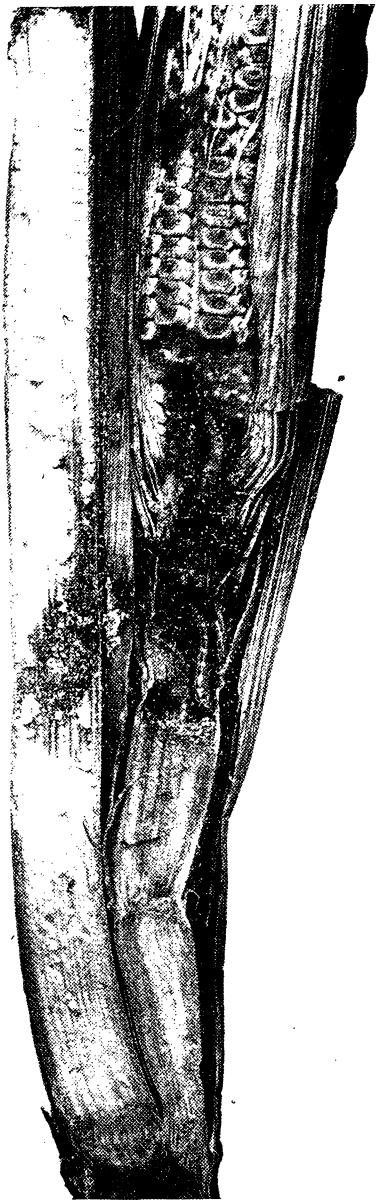

FIG. 4.—A SWEET CORN STALK SPLIT OPEN.
Showing the borers and tunnels in the ear shank and stalk.

As the tassel expands and pushes out of the leaves, the larvae enter the stalk and begin tunnelling thru the pith (Fig. 2). Often they enter the stalk at the base of the tassel causing it to break over (Fig 3).

The borer may enter the ear thru the tip, thru the side, or up thru the shank (Fig 4). Within the ear the insect eats large areas of the kernels, and is commonly followed by molds and fungous diseases which render the ear unfit for human consumption (Fig. 6). In the case of heavy infestations the stalk commonly becomes so riddled with tunnels as to cause it to break over in the wind (Fig. 5).

DISTINCTION BETWEEN CORN BORER AND CORN EAR WORM

During 1930 and 1931 there have been rather serious outbreaks of the corn ear worm in western New York and on Long Island, particularly on late sweet corn and field corn. Numerous inquiries have been received which indicate that this insect has apparently been

FIG. 5.—A SWEET CORN FIELD SHOWING EXTREME INJURY BY CORN BORER IN WESTERN NEW YORK IN 1931.

This field contained an average of 10 borers per stalk and produced no marketable ears.

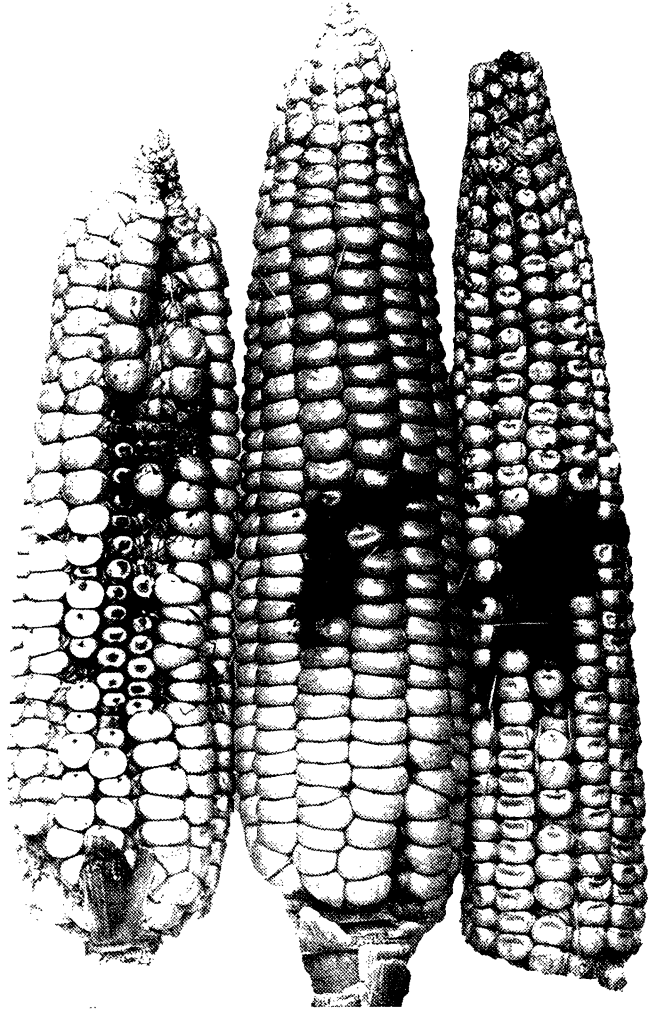

FIG. 6.—BORER INJURY TO SWEET CORN EARS.

mistaken for the corn borer. These two insects are quite different in appearance and feeding habits and are rather easily distinguished from each other (Fig. 7). The corn ear worm is much the larger of the two being nearly 2 inches in length when full grown. It is usually strikingly marked with either black or brown and sometimes

green or pink. It feeds on the silk and kernels near the tip of the ear and rarely burrows thru the kernels toward the base of the ear. It never tunnels in the stalk.

PLOWING EXPERIMENTS

Plowing under infested corn remnants as a means of reducing the corn borer population has been emphasized by investigators in the United States Bureau of Entomology and in various state experiment stations and seemed to be the most promising line of attack. The problem, then, appeared to be concerned chiefly with determining whether this practice could be relied upon to give sufficient protection to sweet corn. In order to study the effect of burial at different depths and at different times of the year on the activities of the larvae, certain experiments were carried thru a period of 2 years. In one series of experiments in which plats 50 feet square were used with the idea of simulating field conditions, infested stalks were buried at different depths by means of a plow. After the plowing was completed an 8-inch board wall was erected around the plat and a continuous strip of corrugated paper held in place on the inside of the board by laths to entrap any larvae emerging from the soil. Previous to the flight of the moths the boards were removed and a tobacco cloth cage was placed over the plat.

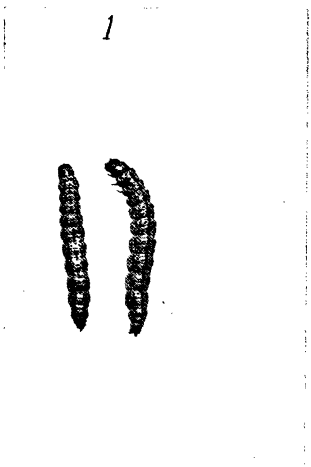

FIG. 7.—DIFFERENCE IN SIZE AND IN GENERAL MARKINGS BETWEEN CORN BORER (1) AND CORN EAR WORM (2) LARVAE. BOTH NATURAL SIZE

To study the effect of burial at depths of 4, 6, 8, 10, and 12 inches and at different periods in the hibernating stage of the larvae, small

nursery boxes 3 feet long and 2½ feet wide were used. These boxes were set in the ground at the desired depth and the infested stalks placed in them and covered with soil until the level inside the boxes was the same as that outside. Traps similar to those described above were erected around the boxes. For closer observation of the effect of burial on the larvae, galvanized iron cylinders 6 inches in diameter were placed in the soil and the larvae buried in them at various depths. The cylinders were covered with small mesh wire netting to prevent the escape of the borers.

It is well known that the burial of stalks infested with corn borer does not result in the immediate destruction of all the insects. In fact as many as 85% of them may regain the surface of the soil under certain conditions. The number which reach the surface seems to depend in a general way on the time they are buried. Table 2, which gives the results of a plowing experiment conducted in 1928 and 1929, shows the number of larvae recovered in traps from plats plowed in the late fall and early spring, using three different depths. It is apparent that the number of larvae surviving the burial and migrating to the surface following late fall plowing is approximately one-half that coming to the surface after spring plowing. This is shown in columns 6 and 7 in Table 2. It is also brought out in the last two columns in Table 3 which show the average number of larvae recovered in traps when the burials were made in the early fall, late fall, and early spring. It is indicated in this table that the average migration of larvae from burials made in the early fall is similar to that from spring burials.

When infested stalks are plowed under in the late fall some of the larvae begin at once to come to the surface of the soil. Migration continues thru November or until the temperature of the soil becomes such that the activity of the larvae ceases. The larvae which are still in the stalks remain in them underground during the winter. Migration begins again early in the spring and continues until approximately the middle of June, altho the majority of the larvae come out of the stalks during May. The number of larvae recovered in the fall and spring from burials made in the late fall is shown in columns 4 and 5 of Table 2. Burial between 4 and 8 inches does not appear to make any difference with respect to the number of larvae which regain the surface of the soil. As shown in Table 3, however, the average recoveries from the 10- and 12-inch burials is somewhat less than for the other depths.

TABLE 2.—THE NUMBER OF LARVAE RECOVERED IN TRAPS FROM PLATS 50 FEET SQUARE WHEN THE INFESTED STALKS WERE PLOWED UNDER IN THE LATE FALL AND EARLY SPRING, USING THREE DIFFERENT DEPTHS.

DATE STARTED	ESTIMATED NO. LARVAE BURIED IN EACH PLAT	DEPTH OF BURIAL, INCHES	LARVAE RECOVERED			PERCENTAGE	MOTHS RECOVERED		PERCENTAGE PERISHED
			In fall	In spring	Total		Number	Percentage	
Oct. 30	500	5	102	99	201	40.2	4	0.8	59.0
Oct. 30	500	7	75	142	217	43.4	5	1.0	55.6
Oct. 30	500	9	57	118	175	35.0	1	0.2	64.8
Apr. 19	500	5	—	359	359	71.8	4	0.8	27.4
Apr. 19	500	7	—	392	392	78.4	4	0.8	20.8
Apr. 19	500	9	—	441	441	88.2	1	0.2	11.6

The larvae which are forced from their burrows in the stalks underground by the unfavorable conditions exhibit a marked tendency to find other quarters immediately upon arriving at the surface of the soil. This is shown by their readiness to enter the corrugated paper which was placed around the plats to entrap them. Observations made on the larvae in the experimental plats, as well as under actual field conditions, have shown that they will take shelter in a variety of objects, such as corn remnants, pieces of weeds, leaves, and pieces of wood. In one experiment conducted in the autumn uninfested corn stalks were scattered around the edge of a plat after plowing. Upon dissection these stalks were shown to contain 13.2 per cent of the estimated number of larvae buried. The stalks from the same experiment duplicated in the spring yielded 10.8 per cent of the estimated number of larvae buried.

In this search for shelter the larvae are capable of migrating considerable distances, mostly at night. During the day they are often found under clods of earth or stones. A number of larvae under observation for several hours each night for a period of 2 weeks migrated, under very favorable weather conditions, a distance of 150 feet or more, altho many of them were not very far from the starting point. The results of an experiment in which 500 larvae were rereleased in the center of a plat are shown in Table 4. Of the larvae liberated on October 6, 190, or 38 per cent, were recovered in the traps around the plat. These larvae had migrated a minimum distance of 25 feet. In the case of the larvae liberated May 13 only 9.4 per cent were recovered. This was probably due to the weather conditions the week following liberation, as shown in Table 5. The average temperature for the week following the October liberations was 59.3°, while for the May liberations it was only 53.7°. In order to obtain information on the number of larvae that might migrate from a plowed field and take shelter in the weeds and grass along the margin, a field containing corn stalks was selected and 1 acre plowed in the fall and the other in the spring after first estimating the number of borers per acre. Traps were erected around the margins of the fields. The number of larvae recovered is shown in Table 6. It seems probable that most of these had migrated from points rather close to the margin.

The length of time that the larvae can exist on the surface of the soil without shelter appears to depend somewhat on weather conditions. During the early autumn it has been observed that some of the

TABLE 3.—THE NUMBER OF LARVAE RECOVERED IN TRAPS FROM NURSERY FALL, AND SPRING AT

DATE STARTED	ESTIMATED NO. LARVAE BURIED IN EACH BOX	TYPE OF SOIL	4-INCH DEPTH		6-INCH DEPTH	
			No. recovered	Percentage recovered	No. recovered	Percentage recovered
Nov. 12	52	Gravel	48	92.3	25	48.0
Nov. 12	52	Clay	21	40.3	16	30.7
Apr. 11	50	Gravel	33	66.0	47	94.0
Apr. 11	50	Clay	42	84.0	47	94.0
Sept. 5	50	Gravel	53	106.0	31	62.0
Sept. 5	50	Clay	48	96.0	19	38.0
Average for each depth...	—	———	40.8	80.7	30.8	61.1

larvae may live for upwards of a month. Observations made daily of an experiment in which 500 larvae were released in a plat on October 3 and the board wall treated with tanglefoot to prevent their escape showed that large numbers were present up to October 20. A drenching rain at that time appeared to cause a heavy mortality, altho an occasional larva was found under stones or clods of earth as late as November 7.

Larval mortality on the surface of the soil seems to result largely from exposure to weather. From our observations it appears that heavy rains occurring while they are on the surface of the soil without shelter kills many of them. On other occasions it was noted that direct sunlight causes some mortality. Other factors responsible for their death are predatory insects and birds. Ants have been noted carrying off larvae. In experiments in which galvanized iron cylinders were used to study the habits of the larvae, it was observed several times that a small red ant had killed practically all the larvae in the container. In the spring of the year robins have been observed in the plats picking up borers from the surface of the soil.

It is very doubtful if any larvae are able to pupate in the soil and emerge as moths where the soil is stirred at intervals by cultivation. A few moths have emerged from the plats as shown in Table 2, but an examination of these plats showed that the larvae had pupated beside the board where there was a certain amount of protection. Two plats were used to secure information on this point in 1928 and 1929. Five hundred larvae were placed in one plat in the fall and 500 in the

BOXES WHEN THE INFESTED STALKS WERE BURIED IN THE EARLY FALL, LATE FIVE DIFFERENT DEPTHS.

8-INCH DEPTH		10-INCH DEPTH		12-INCH DEPTH		AVERAGE NO. RECOVERED PER CAGE	AVERAGE PERCENTAGE RECOVERED PER CAGE
No. recovered	Percentage recovered	No. recovered	Percentage recovered	No. recovered	Percentage recovered		
31	59.6	23	44.2	11	21.1	27.6	53.0
37	71.1	23	44.2	28	53.8	25.0	48.1
50	100.0	23	46.0	49	98.0	40.4	80.8
30	60.0	24	48.0	36	72.0	35.8	71.6
46	92.0	13	26.0	23	46.0	32.6	65.2
23	46.0	37	74.0	21	42.0	29.6	59.2
36.1	71.4	23.8	47.1	28.0	55.4	31.8	62.9

other in the spring. The board wall surrounding these plats was treated with tanglefoot to prevent the escape of the larvae. Tobacco cloth cages were placed over the plats previous to the flight of the moths. In the case of the plat in which the larvae were released in the fall no moths were recovered. In the other plat only one moth was taken. During 1928 two cages, each 20 feet square, were placed in

TABLE 4.—THE DATE AND NUMBER OF RECOVERIES FROM AN EXPERIMENT IN WHICH 500 LARVAE WERE RELEASED ON THE SURFACE OF THE SOIL IN THE CENTER OF PLATS 50 FEET SQUARE.

RELEASED OCT. 6, 1928		RELEASED MAY 13, 1929	
Date recovered	Number recovered	Date recovered	Number recovered
Oct. 8	124	May 17	24
Oct. 9	26	May 20	7
Oct. 10	3	May 23	1
Oct. 11	12	May 29	8
Oct. 12	2	June 4	1
Oct. 15	3	June 10	1
Oct. 19	15	June 22	5
Nov. 13	0	June 24	0
Dec. 1	1		
May 1	2		
May 9	0		
May 18	0		
May 29	0		
June 2	2		
June 4	0		
Total recovered....	190		47
Percentage recovered	38.0		9.4

plowed fields which were known to have been badly infested the year previous, but no moths were recovered.

In 1928 reference[2] was made by the author to observations on the corn borer in relation to sweet corn culture in the Eden Valley section

TABLE 5.—RAINFALL FOR THE WEEK FOLLOWING CORN BORER LIBERATIONS IN OCTOBER, 1928, AND IN MAY, 1929.

DATE, 1928	RAINFALL IN INCHES	DATE, 1929	RAINFALL IN INCHES
Oct. 6	—	May 13	0.01
Oct. 7	0.01	May 14	0.92
Oct. 8	—	May 15	1.10
Oct. 9	0.10	May 16	0.11
Oct. 10	—	May 17	—
Oct. 11	—	May 18	—
Oct. 12	—	May 19	0.66
Total	0.11	Total	2.80

in Erie County, New York. This is a section in which there is considerable sweet corn grown for the market. The growers have for a number of years consistently practiced certain cultural methods which should have the effect of keeping corn borer injury to a moderately low level. In general most of the corn stalks in this area are cut and placed in the silo as soon as the ears are picked. The stubble is disked three to four times and rye is sown as a cover crop. The rye is plowed under the following spring, together with any crop remnants left on

TABLE 6.—THE NUMBER OF LARVAE RECOVERED IN TRAPS AT THE MARGIN OF THE FIELD WHEN 1 ACRE OF INFESTED CORN STALKS WAS PLOWED UNDER IN OCTOBER, 1928, AND 1 ACRE IN MAY, 1929.

DATE STARTED	ESTIMATED NO. LARVAE BURIED IN EACH ACRE	DEPTH OF BURIAL, INCHES	NO. OF LARVAE RECOVERED	PERCENTAGE RECOVERED
Oct. 26, 1928	3,195	6	111	3.5
May 23, 1929	2,717	6	99	3.6

the surface. In some cases the stalks are not cut and placed in the silo but are disked down in the fall while still green and then plowed under in the spring. The land is plowed deeply and there is little or no debris dragged to the surface by later cultivation. In view of the fact that these practices should indicate the value of community effort in

[2]Circular No. 107 of this Station.

the control of the insect, a survey of the infestation here has been made since 1928. Table 7 shows the rate of infestation during the years 1928, 1929, 1930, and 1931.

TABLE 7.—THE RATE OF CORN BORER INFESTATION IN THE EDEN VALLEY SECTION DURING THE YEARS 1928 TO 1931, INCLUSIVE.

YEAR	NO. OF FIELDS EXAMINED	NO. OF STALKS EXAMINED	AVERAGE PERCENTAGE INFESTED	AVERAGE NO. BORERS PER 100 STALKS
1928	25	4,550	23.5	53.4
1929	23	5,100	11.9	23.4
1930	17	2,100	3.4	6.3
1931	11	1,700	11.7	17.0

The corn from which these records were taken was planted over a period beginning approximately with April 25 and extending to about June 15. The samples were as representative as possible and the records should show the general trend of the infestation in this area. It will be observed that the highest infestation occurred in 1928 which was followed by marked decreases in 1929 and 1930. In 1931 there was a rather striking increase, ranging from an average of 6.3 borers per 100 stalks to 17.0, which can doubtless be accounted for by the general increase in the level of the infestation for the whole area. Aside from the season of 1928, the losses from the corn borer in this section have been of a very minor character.

SUMMARY OF PLOWING EXPERIMENTS

Plowing under infested stalks and similar measures directed toward reducing the carry-over of caterpillars will give control of the corn borer within certain limits. It is true also that even a small number of borers escaping control measures represent a potential menace to the corn crop, since with favorable weather conditions they are capable of a high rate of reproduction. This point is illustrated by the small carry-over of borers in some areas in New York in 1930 which was sufficient, however, to give rise to large populations in the same areas in 1931. It is also brought out in our records of the infestation in the Eden Valley section, where voluntary community effort has been consistently followed for a number of years. In spite of this, however, in this area, in 1930, there was an average of 6.3 borers per 100 stalks followed by an average of 17.0 borers per 100 stalks in 1931. To obtain commercial control it will be necessary to keep the carry-over

of borers at a low point so that even with favorable conditions the total number of insects of the next generation will be of minor importance so far as losses are concerned.

The practice of plowing under infested corn remnants for corn borer control must necessarily be very thoro with all infested material completely covered. Whether it is done in the spring or fall makes little difference from the standpoint of efficiency. While the migration of caterpillars from buried material is greater from spring plowing than from fall plowing, it has apparently little significance since they cannot exist on the surface of the soil when it is free from any debris that might afford them shelter. In some types of soil, such as heavy clay in parts of western New York, corn remnants plowed under in the fall have a tendency to heave out of the ground during the winter. In such cases it would undoubtedly be better to plow in the spring.

As for depth of plowing, it is only necessary that the infested material be completely covered and at a sufficient depth so that it will not be pulled to the surface by later cultivation. In cases where sweet corn stalks are not put in the silo or fed direct from the field, some farmers have found it advantageous to disk them three or four times after the ears are picked and sow a cover crop, such as rye. Such fields may then be plowed comparatively easily the following spring. It is advisable to dispose of weeds on the edge of the field as in many cases they harbor borers which have migrated from the field. Owing to the fact that the moths are capable of flying considerable distances, clean-up measures must be on a community basis if satisfactory results are to be obtained.

TIME OF PLANTING IN RELATION TO RATE OF INFESTATION

Experiments conducted during 1928 and 1929 indicated clearly that the time of planting bears an important relation to the rate of infestation by corn borer. In general, it appears that the earliest planted corn suffers the most severe injury, while later plantings show a gradual reduction in infestation. Table 8 illustrates the relation between planting dates and infestation. This table shows the results of an experiment made in the Eden Valley section in 1928 in which six plantings of Golden Bantam were made at weekly intervals from May 1 to June 8. The plantings were made in duplicate and each plat was approximately 1/40 acre in size. It will be noted that the

corn borer population varied from an average of 104.5 borers per 100 stalks in the first planting to 10 borers per 100 stalks in the last planting.

TABLE 8.—RATE OF INFESTATION IN A TIME OF PLANTING EXPERIMENT IN THE EDEN VALLEY SECTION IN 1928.*

PLAT NO.	DATE PLANTED	NO. STALKS COUNTED	NO. STALKS INFESTED	PERCENTAGE INFESTED	NO. BORERS IN 100 STALKS
1	May 1	200	81	40.5	104.5
2	May 8	200	70	35.0	88.0
3	May 15	200	53	26.5	53.0
4	May 22	200	52	26.0	54.0
5	May 29	200	30	15.0	28.0
6	June 6	200	13	6.5	10.0

*Golden Bantam was the variety used.

During the season of 1930, experiments were planned to study the relation between planting dates and infestation in four localities where sweet corn is grown more or less extensively for the market or for the canning factory in western New York. These localities were Sheridan in Chautauqua County, Brockport in Monroe County, Mt. Morris in Livingston County, and Geneva in Ontario County. The weather and soil conditions were such at Mt. Morris and at Geneva that plantings could not be started until the latter part of May. Owing to this condition, and probably to other factors as well, the infestation which developed in the corn in these experiments was too light to give any indication of the effect of the time of planting on the activities of the insect. In the case of the experiments at Sheridan and Brockport five plantings of Golden Bantam were made beginning early in May and continuing at 10-day intervals until the first or second week in June. Each planting was replicated five times and the plats were about 1/80 acre in size. The records from these experiments were obtained by counting the number of borers in the plants from 10 hills in each plat.

Table 9 shows the average number of borers in 100 plants from each planting in the experiment conducted at Sheridan. This experiment was on a light gravel soil typical of the market garden soils in that area. An examination of the table shows that the corn from the first planting was only infested to the extent of 18.9 borers per 100 plants, while the second planting was infested at the rate of 75.5 borers per 100 plants. There is the possibility that the corn planted May 2

may have passed the stage when it is most subject to attack when the majority of the moths were ovipositing.

Table 10 shows the results of the experiment conducted at Brockport. This experiment was located on Ontario fine sandy loam which

TABLE 9.—RESULTS OF A DATE OF PLANTING EXPERIMENT AT SHERIDAN IN 1930.*

PLAT NO.	DATE PLANTED	NO. PLANTS EXAMINED	NO. BORERS FOUND	AVERAGE NO. BORERS IN 100 PLANTS
1	May 2	137	26	18.9
2	May 12	139	105	75.5
3	May 21	147	38	25.8
4	June 3	126	27	21.0
5	June 11	138	12	8.6

*Golden Bantam was the variety used.

is not as early as the gravel soil at Sheridan. It will be observed that the first planting was subject to the heaviest infestation with a decrease in later plantings. The last planting made June 12 had only an average of 1.9 borers in each 100 plants.

During the season of 1931 further experiments were carried out on the time of planting in relation to the rate of infestation. One of these experiments was located at Brockport in Monroe County in the same situation as the year previous. Another experiment was at Lacona in the northern part of Oswego County. At Brockport three varieties of sweet corn were used, two of which were typical of the varieties

TABLE 10.—RESULTS OF A DATE OF PLANTING EXPERIMENT AT BROCKPORT IN 1930.*

PLAT NO.	DATE PLANTED	NO. PLANTS EXAMINED	NO. BORERS FOUND	AVERAGE NO. BORERS IN 100 PLANTS
1	May 5	156	148	94.8
2	May 17	146	34	23.2
3	May 27	146	48	32.8
4	June 6	132	8	6.0
5	June 12	156	3	1.9

*Golden Bantam was the variety used.

used for canning in that area. Golden Bantam was the earliest maturing variety used, with Bantam Evergreen about 10 to 12 days later and Charlevoix about midway between. The plantings were started

May 4 and continued at approximately 10-day intervals until June 10, with a total of five plantings. Each planting of each variety was replicated five times giving a total of 75 plats in the experiment. The plats were well distributed in an effort to overcome the variation in

TABLE 11.—THE EXTENT OF THE INFESTATION IN FIVE DIFFERENT PLANTINGS OF THREE VARIETIES OF SWEET CORN GROWN AT BROCKPORT IN 1931.

DATE PLANTED	GOLDEN BANTAM		CHARLEVOIX		BANTAM EVERGREEN	
	No. plants examined	Ave. No. borers per 100 plants	No. plants examined	Ave. No. borers per 100 plants	No. plants examined	Ave. No. borers per 100 plants
May 4	304	884.76	278	846.76	295	696.27
May 12	312	463.46	240	576.25	283	524.02
May 22	290	520.34	222	529.72	288	425.51
June 1	310	296.45	285	214.73	274	334.31
June 10	312	129.48	295	113.89	297	129.29

infestation. The records of the infestation were taken from 20 hills in the center of each plat. The plants were pulled up, dissected, and the number of borers in the stalks, suckers, and ears recorded. Table 11 shows the results of this experiment.

The experiment at Lacona was conducted in the same manner as the one at Brockport, with the exception that only two varieties were used. The season being shorter at Lacona than at Brockport the first planting could not be made until May 15. Subsequent plantings

TABLE 12.—THE EXTENT OF INFESTATION IN FIVE DIFFERENT PLANTINGS OF TWO VARIETIES OF SWEET CORN GROWN AT LACONA IN 1931.

DATE PLANTED	GOLDEN BANTAM		BANTAM EVERGREEN	
	No. plants examined	Ave. No. borers per 100 plants	No. plants examined	Ave. No. borers per 100 plants
May 15	363	354.26	294	310.20
May 21	332	432.22	276	330.43
May 28	339	324.18	292	303.42
June 4	371	181.79	288	159.72
June 12	391	187.21	343	132.07

were made at weekly intervals. The results of this experiment are shown in Table 12.

There is apparently no consistent difference in the rate of infesta-

tion between the different varieties at Brockport. At Lacona the Golden Bantam showed a slight increase in infestation over Bantam Evergreen. As in the case of the experiments conducted in previous years, there is a marked reduction in borer abundance in later plantings as compared with the first planting. This is true especially of the experiment at Brockport where there is a decrease of more than 80 per cent between the first and last planting. At Lacona the decrease is not so striking. In fact, the first three plantings show little difference in the rate of infestation. This is possibly due to the fact that there was practically no difference in the size of the plants of these plantings, as indicated by the average height, during the period of oviposition.

SUMMARY OF TIME OF PLANTING EXPERIMENTS

The amount of protection obtained from the corn borer by delayed planting seems to depend on many factors, the most important of which is the intensity of the infestation in the area. As an illustration of this, one canning company in western New York, has for 2 or 3 years withheld its sweet corn seed until June 1, or later, in an effort to combat the corn borer by delayed planting. During the seasons of 1929 and 1930, when the level of the infestation in the area was low, corn planted after the first of June was harvested practically free from injury. In 1931, however, when there was a large increase in the level of infestation, corn planted the first week in June, while showing much less injury than plantings made earlier, still contained sufficient infestation to cause losses in many cases. In other words, the degree of protection obtained by delayed planting appears to be relative and dependent in a general way on the abundance of the insect in any particular area, with seasonal conditions acting as a contributing factor.

Late planting as a means of protecting sweet corn from attacks of the borer will probably not be feasible in the case of varieties which take a long time to mature or in areas where the growing season is short. This procedure will have little significance for the market gardener owing to the fact that it is necessary for him to get his corn on the market while the high prices prevail. On the other hand, for the farmer who is growing sweet corn for the canning factory it has some possibilities since he may wait until June 1 and in some cases later before the first planting is made without serious inconvenience.

CONCLUSIONS

Observations in western New York indicate that the European corn borer is rather sensitive to weather conditions and will doubtless fluctuate greatly in abundance from year to year. It would also appear that the insect will be more destructive in some areas than in others. For example, up to the present time the areas of most dense populations have been in the counties bordering on the Great Lakes with relatively fewer insects in the counties further inland. Furthermore, as in the case of other insects that are not native to this country, the corn borer has been abnormally destructive in each new locality invaded. In the older infested areas of the State there has been a tendency for the insect to become less abundant, probably due to parasites and other natural enemies and to the operation of environmental factors not well understood.

The corn borer has proved a difficult pest to combat for two main reasons. First, the use of poisons or other practices which are commonly used to give direct control of other insect pests have been found impractical against this insect principally because the amount of damage to ensilage, field corn, and canning corn would not offset the expense involved. Furthermore, the relatively low per acre value of most corn crops, with the possible exception of sweet corn grown for the early market and high-priced seed corn, obviates the feasibility of attempting to use expensive control measures even if these might be effective.

Second, to be most efficient, the clean-up method, which is the accepted practice for controlling the corn borer, must be on a community basis. A control measure which depends for its success on the cooperation of even a small number of individuals is almost always inefficient when put to the test of actual operation since it often results in the failure of one or more individuals to carry out their part of the program.

Clean-up practices for corn borer control require no additional equipment by the farmer and certainly add little or no expense to his farm operations. In effect it constitutes little more than should be done in good farm practice even if the corn borer were not present. In those areas where the corn borer is abundant and destructive the following practices should be borne in mind and adhered to when considering the handling of the corn crop:

1. Cut the stalks low and as early as practical. When these stalks

are placed in the silo or fed direct to livestock, large numbers of the borers are removed from the field and killed. When the stalks are fed either whole or after being put thru the cutting box, uneaten portions should be gathered up and burned or trampled deeply in the manure.

2. Stalks left standing in the field during the winter should be broken down, raked into piles, and burned.
3. Clean plowing of the stubble or other litter left on the field should be covered to a sufficient depth so that it will not be dragged to the surface by later cultivation. Any crop remnants which afford shelter to migrating borers should not be left on the surface of the soil after the field is plowed.
4. All weeds near the margin of the field should be destroyed by burning as they often harbor borers which have migrated from the field.
5. Delaying the time of planting to the first week in June or later will tend to give considerable protection to the crop.