FACTORS DETERMINING THE REDUCTION IN YIELD OF FIELD CORN BY THE EUROPEAN CORN BORER [1]

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INTRODUCTION

With the development of severe infestations of the European corn borer (*Pyrausta nubilalis* (Hbn.)) in the cornfields of Canada and the United States, questions arose regarding the reduction in yield resulting from definite populations of borers and also regarding the effect of plant development at the time of attack. The type and fertility of the soil were other factors that required consideration. All this information was needed as a guide in measuring crop losses and developing and interpreting control methods. It was also important to determine whether strains of corn (*Zea mays* L.) exist that will maintain their yields in the presence of a given population of borers to a greater degree than other strains of equal yielding capacity. Incidental to the study of these primary factors the data obtained provided an opportunity for studying the effect of the normal yield and the weather on borer damage.

The relation between type and fertility of the soil and yield of corn at definite borer populations was studied in northwestern Ohio with the variety Clarage from 1929 through 1933. The relation of plant development at the time of infestation and of the strain of corn to reduction in yield were studied primarily with hybrids and open-pollinated strains of corn at Sandusky and Toledo, Ohio, from 1930 through 1934.

METHODS

Several methods for determining the reduction in yield of plants containing different numbers of borers were tried. One method depended on obtaining the average yields of groups of plants containing the same number of borers in each plant and then comparing these yields with those produced by uninfested plants of the same strain. However, the moths' habit of laying more eggs on the taller, thriftier plants, which gave greater yields, and the higher rate of borer survival on such plants were complicating factors. Finally, the use of average yields and borer populations from plants in replicated plots was found to be the desired method. Different borer populations were induced by infesting the plants by hand with egg masses produced

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[2] The authors are indebted to members of the staff of the Ohio Agricultural Experiment Station for providing the seed of Clarage corn and a plot of ground at Holgate, Ohio, in 1932 and 1933. G. W. Conrey, J. S. Cutler, and J. B. McLaughlin, of the Station staff, assisted in the study by selecting the soil types, conferring with the authors during the progress of the work, and making equipment available for drying and shelling the samples. J. R. Holbert, formerly of the Bureau of Plant Industry, U. S. Department of Agriculture, furnished the seed of most of the hybrids. P. T. Ulman, of the Division of Entomology, Indiana Department of Conservation, provided a location for an experiment in 1933. The authors are indebted also to the following members of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture: D. J. Caffrey and W. A. Baker, for general supervision; and B. A. App, C. A. Crooks, and R. T. Everly, for assistance with the field work.

in the laboratory according to methods described by Patch and Peirce.[3] The eggs hatched within a day of their placement on the plants. The date of hatching was about 9 days later than the average date for eggs laid naturally. This delay is believed to have reduced borer damage, for it is shown later that the reduction in yield of plants becomes less as the stage of development at this time becomes more advanced.

Each replicated plot was divided into as many equal subplots as there were borer levels planned for in the experiment. Each subplot, except one left for natural infestation, was infested with a definite number of egg masses per plant, the number depending on the borer population desired. To keep newly hatched larvae from being wind-blown from higher to lower infestation levels, the infestations in the subplots decreased from left to right in the row of plots on the left side of the experimental field, but increased from left to right in the row of plots next to the right, and this alternation was repeated across the field. Prior to the migration of many full-fed borers in August, a sample of plants from each subplot was dissected to determine the mean number of borers per plant for each population level. The number and size of the replicated plots, the number of population levels, and the size of the plant samples varied with the experiment. In most of the tests with the Clarage variety 5 population levels were replicated 3 or more times, from 30 to 50 plants per population level were dissected to determine the mean borer populations, and about 300 plants per borer level remained for yield determination. In the tests with the hybrids samples of 150 plants were adequate for the determination of yields. The yields were calculated in bushels of shelled corn per acre on the basis of a moisture content of 15.5 percent.

RELATION BETWEEN YIELD OF CORN AND BORER POPULATION

In areas heavily infested with the borer, it appeared to some observers that a slight reduction in yield due to the borers occurred in fields infested with less than about 5 borers per plant and that increasingly greater damage was caused as the borer population increased above this level. To determine whether the regression of yield on borers was linear or curvilinear, the average yields for the hybrids for the years 1930, 1931, and 1932 were plotted against the different borer populations. Yields for Clarage were also plotted against borer populations, but in this case the results for each of 3 degrees of soil fertility were averaged for the entire period 1929–32. From a supplementary experiment with Clarage and Smoky Dent in 1931 and 1932, data for various population levels up to 22.5 borers per plant were available. Inspection of each year's data obtained from Clarage and Smoky Dent indicated a linear relationship, which justified their combination for graphical presentation in figure 1. In the case of the hybrids, however, the data from the individual hybrids for each year were not extensive enough to warrant a test of linearity, but a grouping of all hybrids for each year, as was done for figure 1, indicates a linear relationship. The conclusion may be made, therefore, that in the case of Clarage and Smoky Dent, and possibly in the case of the hybrids, the reduction in the yield of corn was proportional to the number of corn borers per plant.

[3] PATCH, L. H., and PEIRCE, L. L. LABORATORY PRODUCTION OF CLUSTERS OF EUROPEAN CORN BORER EGGS FOR USE IN HAND INFESTATION OF CORN. Jour. Econ. Ent. 26: 196–204, illus. 1933.

EFFECT OF NORMAL YIELD

While the effect of plant development at the time of borer attack and the effect of soil type and fertility on borer damage were being studied, it became apparent that direct comparisons were possible only when the estimated normal yields in the absence of borers were about the same. For this reason the effect of level of yield is discussed first.

The direct effect of yield level on the yield reduction per borer per plant was first observed on plantings of 24 hybrids at Sandusky and Toledo, Ohio. Five plantings were selected for study. Since in one planting the hybrids yielded from 57 to 105 bushels per acre and in

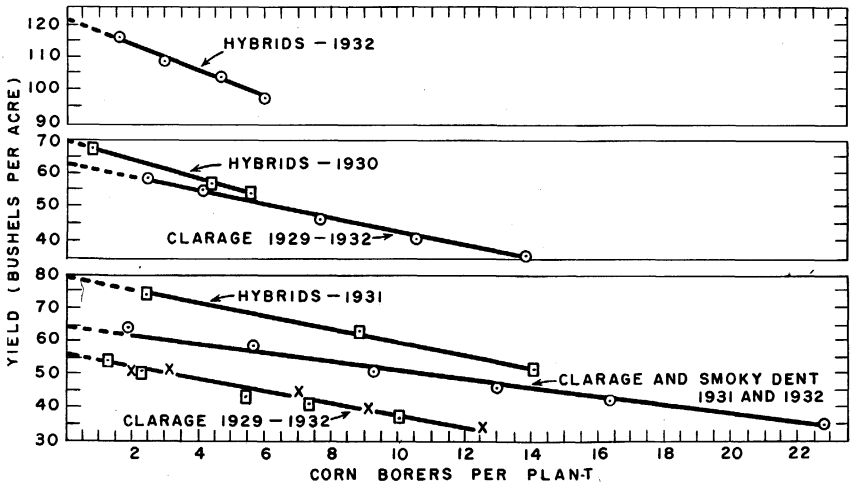

FIGURE 1.—Relationship between yield of corn and level of borer population induced experimentally. In the case of Clarage, 1929–32, plotted data from three levels of soil fertility are shown as follows: No fertilizer by squares, a single application of fertilizer by crosses, and a double application of fertilizer by circles.

another they yielded from 85 to 140 bushels, each planting included the range from 85 to 105 bushels. The average rate of yield reduction (B) in bushels per acre for each unit increase in borers and the estimated yield in the absence of borers (A) were calculated for each hybrid. In almost all cases the lowest population level was approximately 1 or 2 borers per plant; hence these estimates could be made with some confidence. The regression of B on A was then calculated for each planting (table 1). With the mean regression coefficient ($+0.078 \pm 0.0129$), the mean yield of the five plantings ($A=99.3$ bushels), and the mean yield reduction per borer per plant ($B=3.69$ bushels), the calculated yield reduction (B') was found to average 2.57 bushels when A was 85 bushels and 4.13 bushels when A was 105 bushels. Expressed in percentages, the rates of yield reduction were 3.02 and 3.93 percent when the normal yields were 85 and 105 bushels, respectively.

TABLE 1.—*Regression of yield reduction per unit of borer infestation (B) on the estimated yield of hybrid field corn in the absence of borers (A), Sandusky and Toledo, Ohio, 1931–34*

Planting date	Hybrids [1]	Average yield per acre in absence of borers (*A*)	Average per-acre yield reduction per borer per plant (*B*)	Regression of *B* on *A*
	Number	*Bushels*	*Bushels*	*Bushels*
May 25, 1931	15	82.0	2.97	+0.052±0.0197
May 13, 1932	22	120.8	4.05	+.070± .0136
May 26, 1933 [2]	11	99.3	3.30	+.058± .0205
May 17, 1934	17	96.6	3.61	+.095± .0413
May 31, 1934	18	97.9	4.53	+.115± .0384
Mean		99.3	3.69	+.078± .0129

[1] Hybrids having a statistically significant value for *B* were used.
[2] Since the mean values of *A* and *B* for the May 19 and June 2 plantings were nearly the same, data from both plantings were considered as one set.

Studies of the relation between level of yield and unit reduction in yield due to the borer under variable conditions of weather and soil fertility were made also on plantings of the Wooster strain of Clarage corn in several localities in northwestern Ohio from 1929 to 1933. The data for 18 of these plantings, including the estimated reduction in yield on the basis of regression, are given in table 2.

TABLE 2.—*Reduction in yield of shelled corn of the Clarage variety by the European corn borer, in various plantings in northwestern Ohio, 1929–33; plantings arranged in order of increasing yield*

Locality	Planting date	Estimated yield per acre in absence of borers (*A*)	Reduction in yield per acre per borer per plant (*B*)	Estimated reduction in yield per acre on basis of regression (*B'*)	Range in borer population per plant
		Bushels	*Bushels*	*Bushels*	*Numbers*
Sandusky [1]	May 13, 1929	28.2	1.6±0.35	1.37±0.204	1.2– 5.3
Holgate	May 26, 1933 [2]	40.8	1.7± .18	1.57± .137	.3– 6.6
Huron [1]	May 15, 1929	42.4	1.2± .25	1.59± .130	1.6– 9.2
Toledo	May 10, 1932	42.4	1.5± .10	1.59± .130	1.6– 8.0
Huron [1]	May 9, 1930	43.5	1.8± .14	1.61± .126	1.1– 5.8
	May 7, 1931	43.7	2.0± .02	1.62± .125	2.3–13.7
Maumee	May 11, 1932	45.5	1.6± .22	1.64± .118	1.3–10.1
	May 26, 1933 [2 3]	48.1	4.4± .29	1.69± .110	.6– 4.4
Toledo	May 17, 1929	50.4	1.0± .04	1.72± .105	5.8–32.1
	May 13, 1931 [1]	52.5	1.7± .16	1.76± .103	.4– 9.9
Sandusky [1]	May 7, 1930	53.8	2.5± .19	1.78± .102	1.3– 6.1
Toledo	May 6, 1931	55.0	1.0± .14	1.80± .102	1.0–27.3
Holgate	May —, 1932	56.8	2.1± .47	1.83± .103	1.4– 8.0
Toledo	May 11, 1932	59.4	1.8± .19	1.87± .107	2.4–11.4
Sandusky [1]	May 6, 1931	66.5	1.9± .08	1.98± .130	2.6–19.3
Toledo	May 26, 1933 [2]	80.4	2.8± .35	2.20± .201	3.2–14.4
	May 5, 1932	80.8	1.9± .24	2.21± .204	2.0–22.7
Sandusky [1]	May 17, 1932	84.6	2.3± .22	2.27± .226	2.7– 8.9
Mean	May 13	54.5	1.79		1.8–12.4

[1] Average of 3 levels of soil fertility.
[2] Average of 2 plantings made on May 19 and June 2.
[3] Not included in calculating the regression coefficient.

From the values in table 2 the regression of *B* on *A* was calculated. With 15 degrees of freedom the regression coefficient, 0.016 ± 0.0067 bushel, may be regarded as significant. With this regression coefficient, the mean yield of the 17 plantings ($A = 54.5$ bushels), and the mean yield reduction per borer per plant ($B = 1.79$ bushels), it was calculated that B' would average 1.37 bushels when A was 28.2

bushels and 2.27 bushels when A was 84.6 bushels. Expressed in percentages the rates of yield reduction were 4.86 and 2.68 percent when the normal yields were 28.2 and 84.6 bushels, respectively. The estimated reduction in yield on the basis of regression was also calculated for each planting of Clarage listed in table 2.

Before comparisons are made between the data from Clarage and from the hybrids, the conditions under which the two sets of data were obtained should be examined. Since the reduction in yield due to the borer increases as the stage of plant development at the time of borer hatch becomes less advanced, the question arises whether the greater unit reduction in yield for the hybrids at the highest level was directly associated with increase in the level of yield or was caused by greater damage to later silking hybrids that yielded more. In the five plantings under consideration (table 1), on an average 82.6 percent of the hybrids silked within 3 days, and on one planting in each of 3 years 13, 14, and 11 hybrids, respectively, silked within 2 days. For hybrids having the same or the succeeding day as their average silking date, it was determined that for each planting the regression of B on A was significant. As an average of these 3 plantings, for each unit increase in the normal yield the yield reduction per borer per plant increased 0.072 ± 0.0154 bushel as compared with 0.078 bushel, the average value for the five plantings. The generally narrow range in silking dates and the highly significant regression of B on A obtained for the hybrids silking within 2 days indicate that greater damage per borer at higher levels of yield was directly associated with the increase in the level of yield in the plantings considered.

In the case of Clarage there were only slight differences in plant development at time of infestation between the plantings giving the largest and the smallest yields. No reason is known why the greater unit reduction in yield at the high yield level may not be considered as being also directly associated with increase in the level of yield.

From a study of the data from Clarage and the hybrids the following comparisons are noteworthy:

(1) On the basis of a purely mathematical relationship a constant percentage of the crop would be expected at all yield levels. In Clarage, however, the loss was found to be 4.86 percent of the yield per borer per plant at the yield level of 28.2 bushels and 2.68 percent at the yield level of 84.6 bushels. Evidently there were factors involved to change the expected relationship. It is possible that the uninjured tissue within the stalk is progressively able to do more of the work of the injured tissue as the plant's environment enables it to yield more. As a matter of fact, with hybrids a given number of borers were found to reduce the yield of plants in the same field only about half as much in the relatively wet season of 1931 as in the 1930 season of drought.

(2) In Clarage the percentage reduction in yield was considerably greater at the lowest level of yield than at the highest level, whereas in the hybrids the percentage reduction was greater at the highest level of yield. The reason for this reversal in trend is not known.

(3) At the yield level of 85 bushels, B' was calculated to be 3.02 ± 0.249 percent per borer per plant for the hybrids and 2.68 ± 0.268 percent for Clarage. The difference is not significant. It is possible, however, that some of the difference in favor of Clarage may have

been due to the difference in planting date, which averaged 9 days earlier for Clarage. At the time of infestation Clarage was in a more advanced stage of development than the hybrids. Another study [4] showed that hybrids were more tolerant to the corn borer than open-pollinated varieties in the same plantings, the percentage of yield reduction being less for the hybrids. In the present study it is impossible to compare the hybrids and open-pollinated Clarage for relative tolerance.

EFFECT OF WEATHER

In the planting of Clarage made on May 7, 1930, at Sandusky (table 2), the difference between the observed and the predicted rate of yield reduction may be regarded as highly significant. The drought of 1930 is suggested as an explanation for the high observed rate. The rainfall from 6 showers during the critical period of growth, from June 20 to August 20, totaled only 1.83 inches with a maximum of 0.60 inch, and the temperature averaged 2.2°, 1.8°, and 1° F. above normal for June, July, and August, respectively. Moreover, in another field on the same farm 28 hybrids and open-pollinated varieties also showed a high yield reduction per borer per plant. The hybrids and open-pollinated varieties were planted a day earlier than Clarage. Their estimated average normal yield of 69.3 bushels was reduced on an average 2.9 ± 0.11 bushels per borer per plant as compared with an average reduction of 1.5 ± 0.14 bushels from 14 strains planted in the same field on May 5 and 12, 1931, on which the normal yield averaged 70 bushels per acre. From June 20 to August 20, 1931, 18 showers of more than 0.04 inch rainfall totaled 7.60 inches with maxima of 0.65 0.35, and 1.68 inches in June, July, and August, respectively. The temperature averaged 1.0°, 4.6°, and 2.1° above normal in the 3 months. The corn-growing season of 1931 was therefore more favorable than that of 1930, for only about half as much yield reduction per borer occurred in strains planted in the same field and having about the same level of yield.

The rates of reduction in yield due to the borer for the 1931 planting at Huron and especially for the 1933 planting at Maumee were also significantly greater than those predicted on the basis of normal yield (table 2). A planting in 1932 at the Maumee location showed little difference between observed and estimated reduction in yield. The level of yield was the same, but the field was planted earlier than in 1933. Although weather records were not taken at the Maumee location, the 1933 season was in general drier than the 1932 season. Dry conditions may have contributed to the high rate of borer damage on this planting as well as at Sandusky in 1930.

EFFECT OF SOIL FERTILITY

In eight of the plantings of Clarage the experiment was conducted at three levels of soil fertility—(1) on soil receiving no fertilizer, (2) on soil receiving a unit application of fertilizer, and (3) on soil receiving twice as much as (2). The fertilizer varied in amount and formula with the soil type. The differences in yield reduction per borer per plant between the three fertility levels were not significant

[4] PATCH, L. H., STILL, G. W., APP, B. A., and CROOKS, C. A. COMPARATIVE INJURY BY THE EUROPEAN CORN BORER TO OPEN-POLLINATED AND HYBRID FIELD CORN. Jour. Agr. Res. 63: 355-368. 1941.

in most of the plantings. When averaged for the eight plantings, the estimated yield of 48.3 bushels per acre in the absence of borers was reduced 2.0 ± 0.17 bushels per borer per plant where no fertilizer was applied, the yield of 50.7 bushels was reduced 1.7 ± 0.10 bushels where the unit amount of fertilizer was applied, and the yield of 56.8 bushels was reduced 1.9 ± 0.09 bushels where twice the amount of fertilizer was applied. Since the differences in yield reduction are not statistically significant, and the differences among the normal yields are not large, it appears that the fertility of the soil had little effect, if any, on the damage by the corn borer in these tests.

EFFECT OF TYPE OF SOIL

In the plantings listed in table 2 the type of soil also varied. At Huron the field was a clay loam derived from shale-sandstone, at Sandusky it was a very fine sandy loam, at one location in Toledo the soil was a very fine sandy loam and at another silty clay, at Maumee the soil was light-colored Fulton silt loam, and at Holgate it was black Brockston clay. On the very fine sandy loam at Sandusky in 1929, 1930, and 1931 the average estimated yield of Clarage in the absence of borers was about 49.7 bushels per acre; the corn borer reduced this yield at the average rate of 2.0 ± 0.10 bushels per borer per plant. On the clay loam from shale-sandstone at Huron the average yield of 43.8 bushels for the same years was reduced at the rate of 1.7 ± 0.11 bushels per borer per plant. The difference between the rates of yield reduction on these two types of soil is only what might be expected if the rate of reduction is considered a function of the level of normal yield. Other comparisons between types of soil furnished no evidence that any factors other than level of yield are involved.

EFFECT OF STAGE OF PLANT DEVELOPMENT

In studies on the effect of stage of plant development at the time of borer hatch on yield reduction due to the corn borer, the interval between the hatching of the borers and the silking of the corn was varied (1) by infesting samples of plants of the same planting on different dates and (2) by infesting samples of different plantings on the same date.

In 1932 an experiment was conducted to determine the rate of yield reduction of plants infested at different times. Two open-pollinated varieties and four hybrids were planted on May 16 in 8-hill plots replicated 15 times. Four borer levels were used, the plants were infested on 3 dates, and the yield was based on a total of about 160 plants from the 6 strains of corn for each borer level of plants infested on each date. The average date of silking was July 26, and in the absence of borers the estimated yield should have averaged 84.1 bushels per acre. This potential yield was reduced 3.5 ± 0.85 bushels per borer per plant when the plants were infested on June 27, 2.8 ± 0.53 bushels when infested on July 8, and 1.9 ± 0.31 bushels when infested on July 18.

Although the earliest infested plots showed the greatest reduction in yield, the differences between the rates were not found to be significant. It is probable, however, that larger samples of plants,

or more borer levels, would have reduced the variability of the data sufficiently to show significance, since data derived from other sources show a significant trend of change in the rate of reduction of yield associated with stage of plant development.

The rates of yield reduction in various plantings in which the infestation date for the plantings within a season was uniform are given in table 3. Since the mean levels of yield for the earliest and latest plantings differ by less than a bushel, the rates of yield reduction are directly comparable. The difference of 1.6 ± 0.30 bushels may be regarded as highly significant with the 156 degrees of freedom available. This difference is associated with the difference of 23 days between the average dates of the earliest and latest plantings, and an interval of 11 days from egg hatching to corn silking. The yield reduction per borer was 2.85 percent of the normal yield of the earliest plantings as compared with 4.71 percent for plantings made 23 days later. An average of five borers per plant in each of the earliest plantings would have reduced the yield nearly as much as an average of three borers per plant in each of the latest plantings, because a larger percentage of the late-planted crops was destroyed by the borer. It is probable that the plants of the late plantings infested early in their development were subject to greater reductions in yield, owing to the longer duration of borer feeding before the critical period of ear production and the consequent weaker condition of the plants and the larger average size of the borers during the period of ear production.

TABLE 3.—*Reduction in yield of shelled corn by the European corn borer, Ohio and Indiana, 1931–34*

Locality	Date of planting	Mean date of silking	Period from egg hatching to corn silking	Estimated yield per acre in absence of borers	Observed reduction in yield per acre per borer per plant	Degrees of freedom
	1931		*Days*	*Bushels*	*Bushels*	
Sandusky, Ohio	May 5	July 27	11	84.8	1.6±0.10	24
	May 12	July 28	12	80.2	1.7±.10	24
	May 19	July 31	15	74.9	2.2±.21	24
	May 25	Aug. 1	16	76.5	2.5±.21	24
	1932					
	May 7	July 14	9	94.0	2.9±.46	11
	June 7	Aug. 2	26	96.7	6.1±1.00	11
	1933					
Toledo, Maumee, and Holgate, Ohio, and Auburn, Ind.[1]	May 19	July 30	16	67.1	2.7±.10	19
	June 2	Aug. 5	22	71.9	3.0±.22	19
	1934					
Toledo, Ohio	May 3	July 17	9	91.1	2.3±.12	24
	May 17	July 25	17	91.4	3.3±.17	24
	May 31	Aug. 2	25	94.9	4.3±.19	24
Mean for period 1931–34:						
Earliest planting	May 9	July 22	11	84.3	2.4±.12	11
Latest planting	June 1	Aug. 3	22	85.0	4.0±.27	22

[1] Data are averages from the 4 localities.

EFFECT OF STRAIN OF CORN

The data from the hybrids obtained over the period 1930–34 were used to test the significance of the deviation of each hybrid from the regression line of B on A. The basic data were the same as those used for calculating the data in table 1. The observed rate of yield reduc-

tion, B, was found to be significantly less than the rate predicted on the basis of regression on A in only 4 out of 149 tests, 2 of which were of the single-cross hybrid Ill. A × Ind. TR. Apparently few hybrids are able to maintain their yield in the presence of a given number of borers to a greater degree than other hybrids of equal yielding capacity.

The yield of hybrid Ill. A × Ind. TR should have been reduced 3.67 bushels per acre for each additional borer per plant had it reacted to the borer according to prediction. Actually its yield was reduced on an average 2.35 bushels per borer per plant. Patch and others [5] [6] have found, however, that the survival of borers on this hybrid is higher than the average. Hence, any advantage from having smaller losses in yield per borer is partly, if not wholly, offset by the greater than average number of borers to cause reductions in yields.

In 1931 and 1932 a small-stalked early variety, Smoky Dent, and a medium-stalked midseason variety, Clarage, were compared with each other and with a large-stalked late variety, Johnson County White. The interval from planting to silking averaged 71, 78, and 89 days, and the height of the plants at maturity averaged 90, 103, and 108 inches, respectively. The peak of hand infestation was 15 days later than the peak of natural infestation in 1931 and 14 days later in 1932. In another experiment with the same varieties in 1933 the diameter of the plants averaged 0.81, 0.83, and 1.02 inches at the second internode.

As an average of the tests of 1931 and 1932, the normal yield of Smoky Dent of 63.6 bushels was reduced 1.3 ± 0.06 bushels per borer per plant, the yield of Clarage of 67.9 bushels was reduced 1.5 ± 0.14 bushels, and the yield of Johnson County White of 79.1 bushels was reduced 2.2 ± 0.21 bushels. These rates of yield reduction are lower than the rates expected for the yield levels indicated, probably because the plants were infested later than usual. The small difference in the rate of yield reduction between Smoky Dent and Clarage is not significant. The difference of 4.3 bushels between the normal yields of the two strains is also small. A greater reduction in yield that possibly might have been expected on account of the smallness of Smoky Dent might well have been offset by the decrease due to its earliness, for the interval between borer hatch and the beginning of ear development would have been shortened, and consequently its plants were probably in a less weakened condition than were those of Clarage during the period of ear development.

Johnson County White had an average yield of 11.2 more bushels per acre than Clarage, and it silked 11 days later. Its yield was reduced at a significantly greater rate than the yield of Clarage. A decreased rate of yield reduction that possibly might have been expected on account of the large size of Johnson County White might well have been offset by the increase due to its lateness and higher level of yield. Because of its lateness Johnson County White would have been in a more vulnerable condition than Clarage during the period of ear development.

Neiswander and Herr [7] also studied the reduction in yield of early and later maturing strains infested by the corn borer. Using Burr

[5] PATCH, L. H. RESISTANCE OF A SINGLE-CROSS HYBRID STRAIN OF FIELD CORN TO EUROPEAN CORN BORER. Jour. Econ. Ent. 30: 271–278. 1937.

[6] PATCH, L. H., BOTTGER, G. T., and APP, B. A. COMPARATIVE RESISTANCE TO THE EUROPEAN CORN BORER OF TWO HYBRID STRAINS OF FIELD CORN AT TOLEDO, OHIO. Jour. Econ. Ent. 31: 337–340. 1938.

[7] NEISWANDER, C. R., and HERR, E. A. CORRELATION OF CORN BORER POPULATION WITH DEGREE OF DAMAGE. Jour. Econ. Ent. 23: 938–945, illus. 1930.

Leaming and Smoky Dent, silking 6.7 days earlier than Burr Leaming, as two field-corn varieties, and Golden Bantam, a sweet-corn variety silking 4.1 days earlier than Smoky Dent, they concluded that their data indicated "considerable variation in the damage resulting to different varieties from a given borer population, the amount of damage per borer increasing as the length of growing season of the variety decreases." Comparisons were made on the basis of yields taken after the ears of the field-corn varieties were mature and while Golden Bantam was in the roasting-ear stage. In the present study of field corn no evidence was found to support their conclusion. Other studies indicate that field- and sweet-corn varieties are not directly comparable as to damage by the corn borer.

SUMMARY

The degree of reduction in yield of field corn resulting from definite levels of population of the European corn borer was determined by manually infesting plants with various numbers of egg masses. Reduction in yield within cornfields is shown to be proportional to the number of borers present up to 22 borers per plant. Within the range from 28 to 85 bushels per acre the fields that would have produced greater normal yields in the absence of borers had smaller percentages of their crops destroyed by a given number of borers than the fields with lower yields. Data from plantings of the Clarage variety in various localities in northwestern Ohio from 1929 to 1933 showed that the rates of yield reduction were 2.68 and 4.86 percent per borer per plant when the normal yields were 85 and 28 bushels per acre, respectively. The rate of yield reduction for the hybrids was 3.93 percent per borer per plant when the normal yield was 105 bushels per acre as compared with 3.02 percent when the normal yield was 85 bushels.

The rate of yield reduction per borer in corn planted on soils differing in type or fertility is probably a direct function of the level of normal yield. In seasons of drought the damage per borer at given yield levels appears to be increased.

Stage of plant development at time of infestation is shown to be an important factor in yield reduction in the presence of the borer. Plants infested early in their development suffered greater rates of yield reduction, owing to the longer duration of borer feeding before the critical period of ear production and the consequent weaker condition of the plants, and to the larger average size of the borers during the period of ear production. The average normal yield of 85 bushels per acre over a 4-year period, for corn planted on the average date May 9, was reduced 2.85 percent per borer as compared with 4.71 percent for the same hybrids giving about the same average yield but planted 23 days later. An average of five borers per plant in each of the earliest plantings, therefore, would have reduced the yield nearly as much as an average of three borers per plant in each of the latest plantings.

Attempts were made, without much success, to find hybrids having the ability to maintain their yields in the presence of a given level of borer population to a greater degree than would other hybrids of equal yielding ability.