7-1973

Seasonal Abundance of the European Corn Borer Ostrinia nubilalis (Hbn.) Within the North Central United States

R. E. Hill

H. C. Chiang

A. J. Keaster

W. B. Showers

G. L. Reed

North Central Regional Publication No. 216

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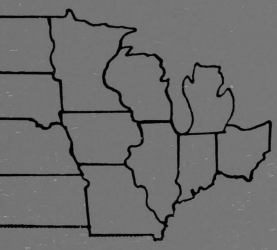
esearch Bulletin
255

July 1973



Agricultural Experiment Stations of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin

University of Nebraska – Lincoln
College of Agriculture
The Agricultural Experiment Station
E. F. Frolik, Dean; H. W. Ottoson, Director

CONTENTS

Issued July 1973, 2,500

AUTHORS

R. E. Hill
H. C. Chiang
A. J. Keaster
W. B. Showers
G. L. Reed

CONTRIBUTING PROJECT LEADERS

T. A. Brindley,* Iowa & ARS, USDA
H. C. Chiang, Minnesota
A. J. Keaster, Missouri
R. E. Hill, Nebraska

TECHNICAL COMMITTEE ON EUROPEAN CORN BORER STUDIES NORTH CENTRAL REGION**

Illinois . .William H. Luckmann
Indiana .....R. T. Huber
Iowa .....T. A. Brindley
Kansas .....Gerald Wilde
Michigan ....Robert F. Ruppel
Minnesota ....H. C. Chiang***
Missouri .....Armon J. Keaster
Nebraska .....Roscoe E. Hill
North Dakota .Richard D. Frye
Ohio .....Gerald Musick
South Dakota ..R. J. Walstrom
Wisconsin .....James W. Apple
Entomology Research Division, ARS, USDA Philip Luginbill, Jr.
Cooperative State Research Service, USDA ..Robert C. Riley
Administrative Advisor .....Floyd Andre

AGRICULTURAL EXPERIMENT STATIONS OF COOPERATING AGENCIES AND PERSONNEL

Iowa, Department of Zoology and Entomology, Iowa State University and ARS, USDA European Corn Borer Research Laboratory at Ankeny, Iowa. T. A. Brindley, Project Leader, W. B. Showers, G. L. Reed.

Minnesota, Department of Entomology, Fisheries & Wildlife, University of Minnesota, St. Paul. H. C. Chiang, Project Leader, Edwin Beylerian, Joseph Cinereski, Clifford Hokenson, Richard Seifert, Mark Windels.

Missouri, Department of Entomology, University of Missouri, Columbia. A. J. Keaster, Project Leader, D. V. Allemann, M. D. Fairchild, Gary Lentz, E. L. England, L. M. English.

Nebraska, Department of Entomology, University of Nebraska, Lincoln. R. E. Hill, Project Leader, David Keith, Donald Short, Jon Tollefson, Chong Park.

Entomology Research Division, ARS, USDA, Ankeny, Iowa.

*In recognition of his many contributions to the knowledge on the habits of the European Corn Borer, *Ostrinia nubilalis* (Hbn.), the authors affectionately dedicate this bulletin to Dr. Thomas A. Brindley.

**As of November 1969

***Chairman

Seasonal Abundance of the European Corn Borer, *Ostrinia nubilalis* (Hbn.) Within the North Central United States

INTRODUCTION

Annual changes in corn borer populations in the North Central States were measured as a phase of a Regional Project, NC-20, entitled "Factors Influencing Corn Borer Populations" in Minnesota, Iowa, Kansas, Nebraska, Missouri and Ohio over a period of years. Standardized procedures were followed to estimate the seasonal abundance of the European corn borer, *Ostrinia nubilalis* (Hbn.), under cropping procedures in different locations within the North Central States.

Much information has accumulated on the abundance and effects of various physical and biotic factors on corn borer populations. Results obtained from 1955 through 1959 were summarized in a regional publication (Chiang *et al.* 1961) and a similar bulletin (Hill *et al.* 1967) presented a compilation for the years 1960 through 1964.

The primary purpose of the present bulletin is to present results for the 1965 to 1969 period and to compare these results with the previous 10 years and thus attempt to analyze in a "gross way" certain aspects of the population changes for the entire 15-year period. In 1964, measurements of borer populations were discontinued in two counties, Jefferson in Kansas and Van Wert in Ohio. Therefore, the present bulletin will be concerned only with six counties with long-term records from the four states of Iowa, Minnesota, Missouri and Nebraska.

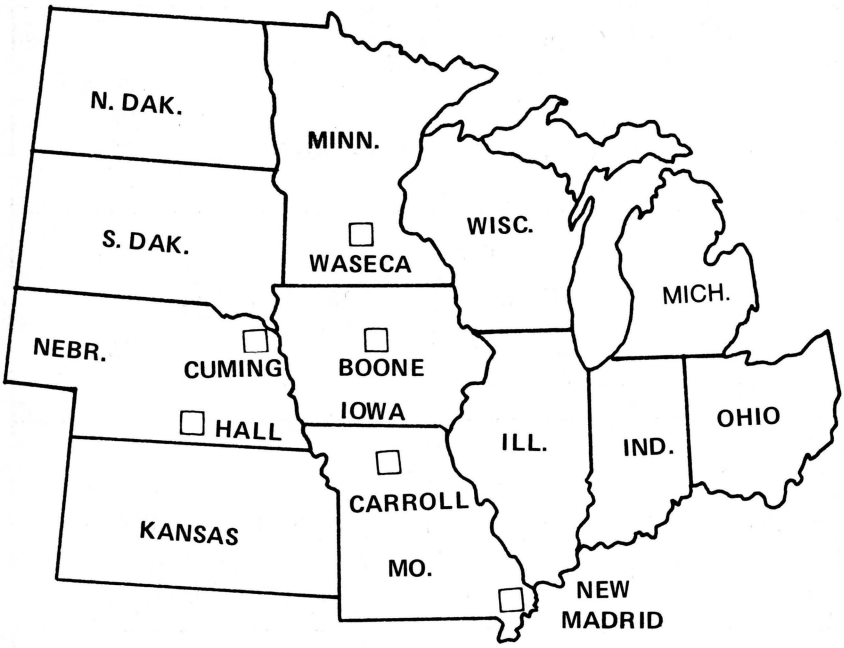


Fig. 1. Distribution of the counties studied in the North Central Region of the United States.

CENSUS PROCEDURES

The most significant feature of this census study is that the procedures followed in each state were standardized. Although these procedures were presented in the previous bulletins (Chiang *et al.* 1961 and Hill *et al.* 1967, they are being restated here for the sake of completeness.

1. Counties studied. A census of the borer population was taken in one or two counties in each of the participating states. The location of the counties is shown in Figure 1. The counties and the number of townships in each county are:

Iowa– Boone, 17 townships but with the area of 16 regular townships.

Minnesota – Waseca, 12 townships.

Missouri – Carroll, 22 townships.
New Madrid, 11 townships but the county was divided into 12 regions for census purposes not necessarily coinciding with townships.

Nebraska – Cuming, 12 townships.
Hall, 12 townships.

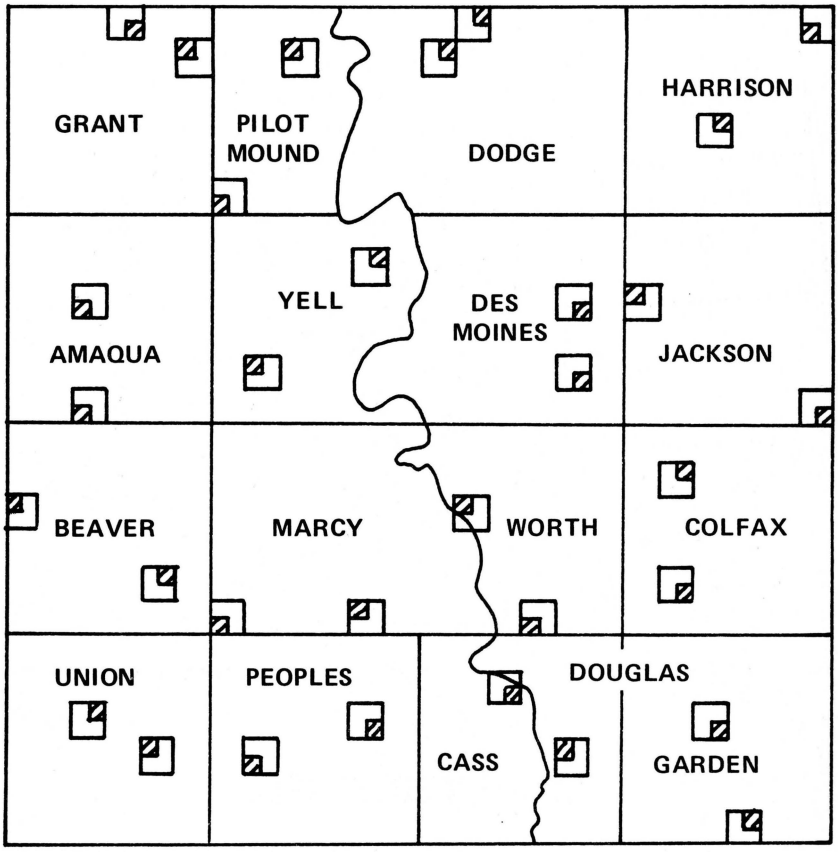


Fig. 2. Approximate locations of fields used in Boone County, Iowa.

2. Selections of fields. Two fields in each township in a county were used. At the start of the study, sections and quarter sections containing each field were chosen at random. These same quarter-sections were used throughout the study. Within the quarter-section picked, the field with the greatest accessibility to an all-weather road was then selected; the planting date, variety of corn and the method of planting were not factors determining the selection of fields. Because of crop rotation practices, the actual fields used were often different from year to year. The map of Boone County, Iowa is given as an example showing the distribution of fields within a county (Figure 2).

3. Number and time of annual censuses. Basically censuses were made three times a year when populations were relatively stable. (1) Spring censuses were made soon after the spring thaw and after a particular field had been prepared for seeding. In Iowa and Mis-

souri, two spring censuses were made: (a) An "early spring" census was made before any spring operations began. This was to measure the larval mortality due to natural factors since the crop was harvested the previous fall. (b) The "late spring" census was conducted after all of the fields used had been planted or prepared for the current season's crop. This was to measure the larval mortality due to all factors (natural and cultural). (2) The summer census was made at the end of the first brood, i.e., when the majority of the first brood borers had become full grown, or were starting to emerge as adults. (3) The fall census was made at the time of corn maturity, borer maturity or first killing frost, whichever came first. In Carroll and New Madrid Counties, Missouri a late fall census was conducted after the third brood had developed. A post-harvest census was made in Iowa. Variations in procedures were given in the respective state summaries.

4. Census method. Three areas were checked in each field. The first was located according to a predetermined number of paces (a randomly selected number between 30 and 50) from the edge of the field. The second and third were located along a diagonal line across the field and at predetermined distances from the first area and from each other (randomly selected number of paces between 30 and 50).

Each area was 6½ x 6½ feet (for practical purpose, the area was 1/1,000 acre), except in Boone County, Iowa[1] where the area checked was 1/2,000 acre.[2] All plants in the areas were checked regardless of the method and the rate of planting.

The same fields were checked during the summer and the fall of the same year and during the spring of the following year. One exception was in Boone County[1] where the same fields were checked during the late spring if they had been seeded to oats. When a field was not seeded to oats, a substitute field which was in oats was selected in the manner described below.

During the spring census, plants were down and broken. In such instances, all surface material was dissected and examined for borers.

5. Field histories. The following information was obtained regarding each field each year. (1) The method of planting, (2) the hybrid of corn (complete information is given in the Appendix), (3) the date of planting, (4) crop history during the past 3 years, and (5) fertilizer practices during the past 3 years.

6. Borer population and plant injury records. The information secured varied with the time of census. (1) In the spring, the number of living larvae were recorded, (2) in the summer, the number of

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[1]The difference in procedures is due to the fact that the Boone County study was started before the beginning of the present regional project.

[2]In Nebraska the area checked was reduced to 1/2,000 acre but with six sites added for years 1967 through 1969.

plants in the sample, the number and stages of living borers, and the number of plants with injury and/or tunnels, (3) in the fall, the number of plants in the area, the number and stages of living borers and the number of plants with tunnels.

7. Weather conditions were analyzed on the basis of official records of the respective counties published by the Weather Bureau.

8. Quantitative changes of borer populations from one season to the next are analyzed in terms of "multiple changes." For example, an increase from 100 borers per acre in the summer to 200 borers per acre in the fall represents a multiple change of 2.0, and a decrease from 200 borers per acre in the fall to 100 in the next spring represents a multiple change of –2.0.

BOONE COUNTY, IOWA

Area Description

In Iowa the study was made in Boone County in an area of 576 square miles. Fields under observation were located at random within each of 16 equal 36 square mile areas within the county. Boone County is divided into 17 townships, one of the 16 equal areas being divided into 2 townships.

Boone County is almost in the center of Iowa. It lies entirely within the Wisconsin drift soil area and hence its soils are all of glacial origin. As presented in Soil Survey Report No. 34 of the Iowa Agricultural Experiment Stations, the soils of Boone County can be divided into 17 different types. Drift soils cover 93.3% of the total area, terrace soils 1.9% and riverbottom soil 4.8%. Drift soils have been formed in the prairie areas and are characterized by a black color, the result of an accumulation of organic matter. Terrace and riverbottom soils have been deposited by streams and are found mainly in the valley of the Des Moines River and along Beaver Creek.

The topography of the greater part of Boone County is level to gently rolling. Flat, poorly drained areas with small moraines arising occasionally are common in some areas. The largest stream is the Des Moines River which flows from north to south almost through the middle of the county. The topography on both sides of the river is rough and broken with steep bluffs extending from 1 to 3 miles back from the river. The river valley itself is about 250 feet below the level of the prairie upland.

The general drainage of the county is toward the south, the Des Moines River and its tributaries affording most of the drainage. In most of Boone County surface drainage is rather poor except in areas adjacent to the Des Moines River, Beaver Creek and Squaw Creek. In many places tilling is necessary to make soil satisfactorily productive.

The type of agricultural practice is mainly cash grain farming and livestock. The most popular crop rotation system used is corn-corn-oats-legumes, with corn and soybeans being the two most important crops and occupying the most acreage.

Weather Conditions

The average temperatures and total rainfall for each month of the active borer season throughout 5 years (1965-69) are presented in Appendix I A. The monthly deviations of these two factors from the long term normal are shown in Appendix I B. The general weather conditions for each year are summarized as follows:

1965 – Temperature was above normal during May, below normal in June and July and near normal during August. Rainfall was near normal except in July when it was below normal.

1966 – Temperature was below normal except in July when it was above normal. Rainfall was near normal in May, above normal in June and below normal in July and August.

1967 – Temperature was below normal for the entire growing season. Rainfall was below normal in May, July and August, but considerably above normal in June.

1968 – Temperature was below normal in May and July, above normal in June and normal in August. Rainfall was below normal in May and July, above normal in June and normal in August.

1969 – Temperature was near normal in May, July and August, but considerably below normal in June. Rainfall was below normal in May and August, above normal in July and near normal in June.

Agronomic Practices

The compilation of information concerning agronomic practices in Boone County was discontinued in 1967, thus the following information is based on 1965 and 1966 only. Fertilizer practices during 1965 and 1966 continued much as they had during the 1963-64 period. Over half of the fields received NPK combinations of anhydrous ammonia for starter fertilizer. Fertilizer was not used in 6% of the fields in 1965 and 10% of the fields in 1966. Fertilizer practices are summarized in Appendix I C.

Crop rotations in 1965 and 1966 continued much the same as during the 1960 to 1964 period. There was a decrease in the amount of corn-following-corn during 1966. Crop rotation information is summarized in Appendix I D.

The corn crop was planted earlier in 1965 and 1966 than previously. During 1965, 63% of the corn was planted by May 10. During 1966, 17% of the corn was planted by May 1, with an additional 70% planted by May 10. In 1965 an additional 37% was planted by May 20. In both years planting was finished by May 20. Dates

Table 1. Planting dates in fields used in Boone County, Iowa.

Planting dates	Percent of fields	
	1965	1966
Late April	0	17
May 1–10	63	70
May 11–20	37	13
May 21–31	0	0
June 1–10	0	0
June 11–21	0	0
Total fields observed	32	30

of planting corn in Boone County are summarized in Table 1.

Plant populations in Boone County increased considerably during 1965 and 1966. Only 3% of the fields had plant populations of less then 16,000 plants/acre at seeding in 1965 and none of the fields sampled in 1966 had seeding populations of less than 16,000. An

Table 2. Summary of borer populations and injury at various times each year in Boone County, Iowa.

	Average number plants per acre	Total number plants checked	Per cent plants with injury	Number of			
				Tunnels per 100 plants	Larvae per 100 plants	Tunnels per acre	Larvae per acre
1965							
Early spring							3,417
Late spring							1,725
Summer	15,396	739	.....	14.1	17.1	2,167	2,625
Fall	13,792	662	47.7	89.0	31.6	12,270	4,354
Post-harvest							1,625
1966							
Early spring							3,042
Late spring							1,625
Summer	14,583	700	.....	10.7	12.7	1,563	1,854
Fall	14,354	689	.....	65.0	11.2	9,333	.....
Post-harvest							6,271
1967							
Early spring							3,833
Late spring							1,050
Summer	13,938	669	.....	20.2	25.3	2,813	3,521
Fall	13,875	666	55.1	75.2	47.3	10,438	6,563
Post-harvest							1,250
1968							
Early spring							1,375
Late spring							313
Summer	17,313	831	.....	16.5	7.2	2,854	1,250
Fall	15,896	763	92.9	194.1	177.9	30,854	28,271
Post-harvest							11,756
1969							
Early spring							7,396
Late spring							3,357
Summer	19,125	918	.....	.....	1.6	.....	2,771
Fall	18,438	885	.....	.....	133.0	.....	24,521
Post-harvest							5,417

increased acreage of corn is being drilled to accommodate the larger populations. A comparison of the average number of plants/acre during the fall survey (Table 2) shows a gradual increase in the plant population at harvesting time. Harvesting populations are currently averaging above 18,000 plants/acre. Planting methods and plant populations are summarized in Appendix I E.

During 1965 and 1966, 38 different corn hybrids were used in the 32 randomly selected fields. Information of corn hybrids is summarized in Appendix I F.

Borer Populations

Five surveys were taken annually in Boone County. The results of these surveys are indexes of borer population fluctuations and in some cases the fluctuations can be related to known factors. The results of all 5 of the annual surveys are presented in Table 2. Pertinent information concerning weather data and quantitative changes in borer populations are given in Tables 3 and 4. The range in numbers of borers/acre as well as the average size of the population at the time of each survey is presented in Table 5.

Table 3. Changes in borer populations from spring to summer to fall in Boone County, Iowa, and certain weather data for months of June, July and August 1965–1969. (T—temperature; R—rainfall).

	1965	1966	1967	1968	1969
No. borers/A—late spring	1,724	975	1,050	312	2,938
—summer	2,625	1,854	3,521	1,250	2,771
Multiple change— spring to summer	+1.5	+1.9	+3.4	+4.0	−1.1
No. borers/A—fall	4,354	6,271[a]	6,563	28,271	24,521
Multiple change— summer to fall	+1.7	+3.4	+1.9	+22.6	+8.8
June weather					
Departure of mean (T) from normal	−2.2	−1.3	−1.8	+1.7	−4.5
Departure of mean (R) from normal	−0.80	+3.23	+5.90	+3.55	+0.60
No. of days 90° or more	0	3	0	9	2
No. of days 100° or more	0	0	0	0	0
No. days .50″ rainfall	4	4	7	6	5
July weather					
Departure of mean (T) from normal	−1.5	+2.3	−3.9	−2.3	−0.5
Departure of mean (R) from normal	−2.32	−2.76	−1.66	−2.20	+2.68
No. of days 90° or more	7	15	6	6	8
No. of days 100° or more	0	0	0	0	0
No. days .50″ rainfall	1	0	2	2	4
August weather					
Departure of mean (T) from normal	−0.8	−3.1	−3.3	−0.3	0.0
Departure of mean (R) from normal	−0.32	−1.83	−2.34	−0.11	−2.61
No. days 90° or more	11	3	0	8	0
No. days 100° or more	1	0	0	0	0
No. days .50″ rainfall	3	2	0	2	1

[a] Post-harvest survey.

Table 4. Quantitative changes in borer populations in Boone County, Iowa.

Multiple changes	1965	1966	1967	1968	1969	Average
Summer to fall	+1.7	+3.4[a]	+1.9	+22.6	+8.8	+7.7
Fall to post-harvest	-2.7	.....	-5.3	- 2.4	-4.5	-3.7
Post-harvest to late spring	+1.7	+1.9	-1.6	+ 1.1	-1.6	+0.3
Early-spring to late spring	-2.0	-1.9	-3.7	- 4.4	-2.2	-2.8
Late-spring to summer	+1.5	+1.1	+3.4	+ 4.0	-1.2	+1.8
Fall to late spring	-4.3	-2.7	-6.0	-21.0	-8.4	-8.5
Inactive season mortality (percent reduction, fall to late spring)[b]	71.1	62.7	83.3	95.2	88.1	80.1

[a] Post-harvest survey.

[b] Mortality includes natural death and death caused by farm operations from post-harvest to sowing in the spring.

The early spring survey was taken as soon as weather permitted, generally during the last few days of March or early April. The effect of the winter weather has in recent years been compounded with agronomic practices due to increased fall plowing or disking and shredding of the corn stalk. Since the early spring survey was intended to measure winter mortality due to weather and not due to agronomic practices, fields used during 1965-67, in which farm operations had been conducted after the post-harvest survey and before the early spring survey, were substituted with fields which had not been touched since harvest. The substitution resulted in population increase from post-harvest to early spring survey during 1965 and 1967; thus substitution did not allow measurements of winter mortality. No substitution was made during the period from 1968 and 1969. This survey will be discontinued in the future as the total effect of winter weather is confounded with the partial effect of field preparation for the next season; thus, it does not serve the purpose for which it was designed.

The last spring survey was conducted in fields sown to oats. From 1955-59, 54.4% of the previous year's cornfields were disked and seeded to oats. Fields treated in this manner were the primary source of the first-generation European corn borer population (chiang *et al.* 1961). From 1960-64, 24.4% of the cornfields from the previous year were sown to oats (Table 6). From 1965-69 only 12.3% of the cornfields from the previous year were sown to oats. Since acreage

Table 5. Population range and average number of borers per acre in Boone County, Iowa, 1965–69.

Survey	Number of borers per acre	
	Range	Average
Early spring	1,375– 7,396	3,812
Late spring	313– 3,357	1,614
Summer	1,250– 3,521	2,404
Fall	4,354–28,271	13,996
Post-harvest	1,250–11,756	5,264

Table 6. Percentage of previous years' cornfields planted in oats in Boone County, Iowa, based on the total acres of oats planted each spring and the total acreage of corn the previous fall.[a]

Year	Summer population	5-year average	Percent of previous years cornfields planted in oats	5-year average
1953	3,312		55.3	
1954	26,812		52.3	
1955	5,280		55.6	
1956	4,800		50.4	
1957	6,856	5,672	66.4	54.4
1958	10,608		51.9	
1959	816		47.9	
1960	963		36.2	
1961	1,992		21.5	
1962	1,800	2,626	24.7	24.4
1963	2,958		23.5	
1964	5,416		16.1	
1965	2,625		12.8	
1966	1,854		13.1	
1967	3,521	2,404	12.5	12.3
1968	1,250		10.6	
1969	2,771		12.6	

[a] Data from the Iowa Annual Farm Census 1952–1969.

of oats in Boone County currently comprised only 12.3% of the acreage in corn from the previous year as compared to 54.4% from 1955-59, the importance of the cornfield seeded to oats as a source of first-generation corn borer infestation decreased. Due to the small acreage of oats the number of fields substituted during 1965, 1966 and 1967 was very high. The substitution of plowed fields, etc., with oat fields was stopped, because those fields were no longer as important as the source of first-generation borers and because the survey did not allow an accurate estimate of population. The survey from 1968 on was conducted in the original fields without any substitution, allowing an accurate population estimate.

Summer borer populations are estimated from a survey conducted in the latter part of July after the first-generation eggs have hatched and prior to the beginning of the second-generation ovipositional period. An examination of Table 2 and Figure 3 indicates the late spring and summer populations are not consistently correlated.

The fall survey is taken as late as possible but prior to the beginning of harvest. Data in Tables 2 and 4 indicate that fall populations increased an average of 7.7 times over summer populations compared to 5.7 times from 1960 to 1964. Summer diapause averaged only 14% during 1965-69. The population increase is probably due to host plant resistance to the first-generation borer followed by a high percentage of pupation and emergence by the survivors and a lack of host plant resistance to the second generation borer. Fall popula-

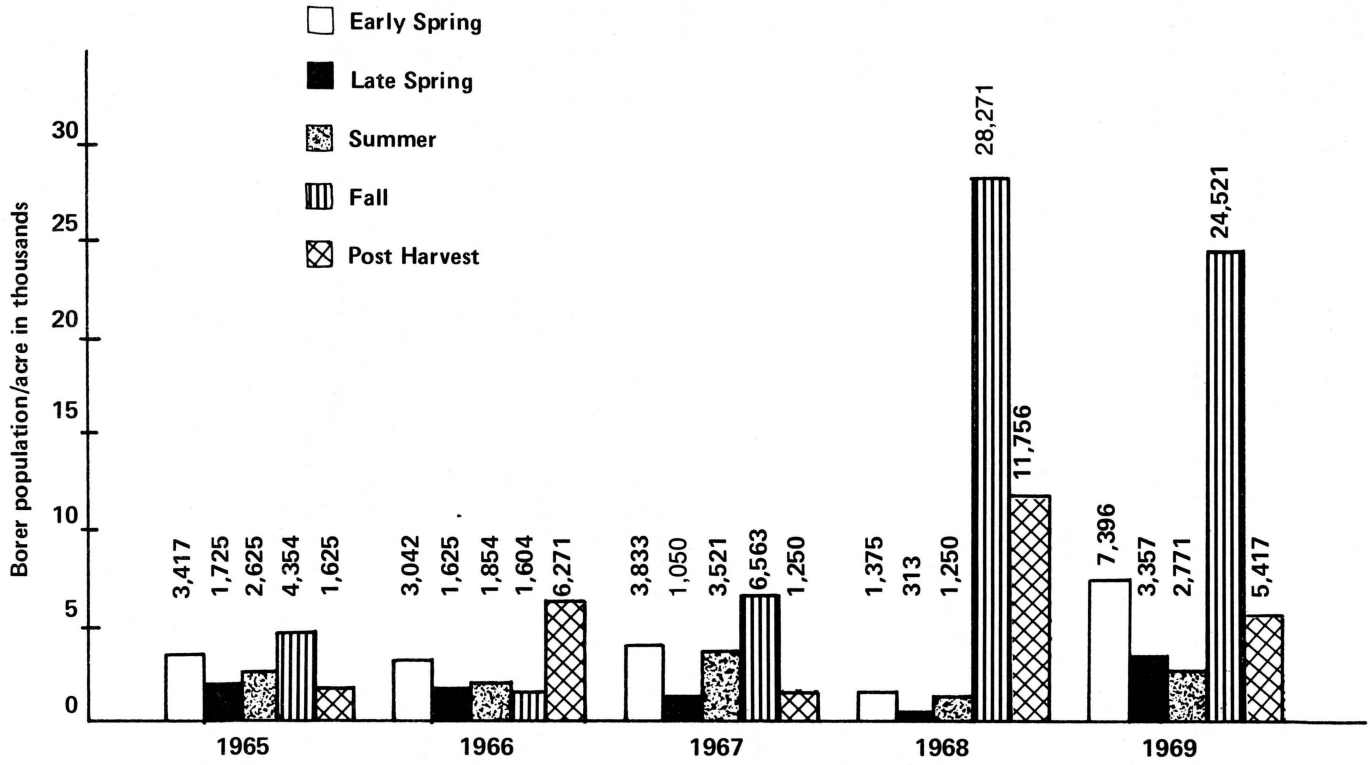

Fig. 3. Average number of borers per acre, Boone County, Iowa, 1965-69.

Table 7. Percent of Boone County, Iowa, borer population infected with *Perezia pyraustae* at designated survey times.

	Early spring	Late spring	Summer	Fall	Post-harvest
1965	....	....	....	....	56
1966	50	16	8	....	8
1967	9	19	8	2	3
1968	....	....	....	2	2
1969	4	....	....	21	....
1970	14	....	21	20	....

tions in 1968 and 1969 were higher than any since 1957. Optimum weather and decreased incidence of *Perezia pyraustae* contributed to the increased fall population. Incidence of *Perezia pyraustae* (Table 7) fell to a low level in 1966 and has remained relatively low since then.

The post-harvest survey is taken in late fall after all fields have been harvested. The objective of the post-harvest survey was to determine the effect of harvesting operation on the population. However, currently many farmers follow the harvesting operation almost immediately with chopping of stalks, disking and plowing, thus confounding the effects of harvesting with other agronomic practices. Therefore, this survey will be discontinued in the future.

During the period from 1965-69 the population ranged from 313 to 28,271/acre. The largest population increases occurred from summer to fall and the largest population decreases occurred from fall to late spring. Reduction of population from fall to late spring averaged 80.1%.

WASECA COUNTY, MINNESOTA

Area Description

Waseca County, in southern Minnesota, has a land area of about 430 square miles and an elevation of 1,050 to 1,200 feet (Thiel 1944).

Soils and surface topography are influenced by what is presently called the Mankato sub-stage of the Late Wisconsin Drift. The topography of the eastern and northern tier of townships is influenced by a moderately rolling end moraine. A small glacial outwash occurs in the southern part of the county. The southwestern part of the county is nearly level lake plain or lake washed till plain. The remainder of the county is a gently undulating ground moraine with the prairies predominating southwest to the LeSueur River. The valley of the LeSueur River is broad and shallow, not exceeding 50 feet in depth, and usually less than 25 feet below the adjoining plain. Wasting of glacial ice left many scattered ice blocks that developed into lakes and potholes.

The majority of the county drains northwestward to the Minnesota River by way of the LeSueur and Cobb Rivers. The northeastern part of the county drains to the Mississippi by way of Crane Creek and tributaries of the Cannon River. Well, moderately well and somewhat poorly drained soils include Gray-Brown Podzol, Prairies and Prairie-Gray-Brown intergrades. The intergrade soils predominate. The poorly drained soils are predominantly Humic Clays. By capability classes Waseca soils may be grouped as follows: Class I, 7.6%; Class II, 59.6%; Class III, 25.8%; Class IV, 2.8%; Class V, 0.3%; Class VI, 2.7%; Class VII, 1.1%.

By capability subclasses they may be grouped as follows: Erosion problem, 41.8%; wetness problem, 55.7%; soil problem, 2.5%.

A strong shift in types of farming is underway in Waseca County. A diversified type of farming with dairying as the principal enterprise is being replaced by a corn-soybean-hog-beef operation.

Distribution of annual precipitation of 28.7 inches is such that 70% falls during the growing season.

Weather Conditions

The monthly average temperature and monthly total rainfall for the years 1965 to 1969 are presented in Appendix II A. The departures from the long-term normal are given in Appendix II B. It may be noted that 21 of the 24 temperature deviations are negative. Namias (1970) presented a map of U.S. showing the average surface temperature departure from the 1931-60 normal of the winters 1960-61 through 1969-70. In southern Minnesota, the decade of 1960 had a winter temperature (December through February) about 1.5° F below normal. This means that lately winter has been colder than usual. Deviations observed in present data suggest that the years involved in the present study were colder also during the growing season.

The general weather conditions in the various years may be summarized as follows:

1965 – Very warm in May. Near normal termperature in June, July and August. Rainfall near normal in May, July and August. Somewhat higher than normal in June.

1966 – Cool in May, near normal temperature in June and August. Warmer than normal in July. Rainfall above normal in May through July. Slightly dryer in August.

1967 – Cool in May, July and August. Only slightly warmer than normal in June. Rainfall was near normal except June which was dry.

1968 – Cool in May. Near normal through August. Dry conditions in May through July. Normal rainfall in August.

1969 – Warm in May, cool in June. Near normal temperature in

July and warm again in August. Near normal rainfall in May, June and August. Somewhat above normal in July.

Agronomic Practices

Over the 3-year period of 1965-67, about 35% of the fields in Waseca County were planted to corn continuously, about 51% were in two-crop rotations and 14% in three-crop rotations (Appendix II C). There was a consistent increase in continuous planting of corn, and a very low percent of fields in corn-oats rotations.

Regarding the use of commercial fertilizers, only 3% of fields in this study did not receive them (Appendix II D). This is the same as in 1960-64, but was much lower than in 1954-59 when 25% of fields did not receive any fertilizer. There were 29 varieties of NPK combinations used in 1965-69, compared to 13 varieties in 1960-64. This may be the result of more refined formulations catered to the needs of individual farms.

In the present 5-year period, there was a consistent increase in drilled planting and a corresponding decrease in hill drop (Appendix II E). These changes and a reduction in row widths were responsible for the increase in plant populations. The same trend was observed since 1954.

The date of planting was affected by weather conditions. Suitable soil moisture conditions and early seasons encouraged early planting, such as in 1968 (Table 8).

Borer Populations, 1965-69

Borer populations and plant injury levels are summarized in Tables 9, 10, 11, and Figure 4. There was always an increase in populations from spring to summer. These increases varied from 1.6 to 13.9 fold. From summer to fall, there was a decrease in the 1965 and 1967 seasons. As shown by Chiang and Hodson (1959 and 1972) such conditions were due to a significant summer pupation and a high fall mortality among the second generation larvae. In the other years, there were increases from summer to fall of 2.3 to 5.5 fold.

Table 8. Planting dates in the fields used in Waseca County, Minnesota, 1965–69.

Planting dates	Percent of fields					
	1965	1966	1967	1968	1969	Average
April 21–30	.....	.....	4.5	21.7	.....	5.2
May 1–10	25.0	79.2	54.5	65.2	58.3	56.4
11–20	54.2	20.8	27.3	8.7	37.5	29.7
21–31	20.8	.....	9.2	4.4	4.2	7.7
June 1–10	.....	.....	4.5	.....	.....	0.9
Total fields observed	24	24	22	23	24	.....

Table 9. Summary of the borer population and injury at various times in Waseca County, Minnesota, 1965–69.

	Average number plants per acre	Total number plants checked	Percent plants with injury	Number larvae per 100 plants	Number larvae per acre
1965					
Spring	.....	.....	.....	.....	92
Summer	16940	2033	12.6	1.2	225
Fall	18610	2233	11.6	1.2	175
1966					
Spring	.....	.....	.....	.....	18
Summer	14060	1688	8.4	1.2	250
Fall	13980	1678	19.9	4.7	583
1967					
Spring	.....	.....	.....	.....	100
Summer	13320	1599	11.8	5.6	800
Fall	14760	1770	13.8	3.4	525
1968					
Spring	.....	.....	.....	.....	10
Summer	16780	2014	4.8	0.8	133
Fall	12540	1506	27.7	5.6	733
1969					
Spring	.....	.....	.....	.....	532
Summer	24740	2969	18.5	3.5	900
Fall	20560	1954	35.7	14.8	3100

Borer Populations, 1954-69

Population levels of the corn borer, as of other insects, are affected by host characteristics, agronomic practices and weather conditions. The present study was started in Minnesota in 1954. The results of 1954-59 and of 1960-64 were published in two bulletins, Chiang *et al.* (1961) and Hill *et al.* (1967), respectively. Several of the factors changed during the 16-year period. It is now possible to examine the effects of these changes on borer populations (Table 12).

The plant population showed a consistent increase, resulting from an increase in drilled planting and a decrease in row width. It is expected that high plant density tends to increase insect density, thus the effect is a positive one.

There was a consistent decrease in corn-oats rotation. It was

Table 10. Quantitative changes in borer populations in Waseca County, Minnesota, 1965–69.

	1965	1966	1967	1968	1969
Multiple changes:					
Previous fall to spring	–13.0	–9.7	–5.8	–52.5	–1.3
Spring to summer	2.4	13.9	8.0	13.3	1.6
Summer to fall	–1.3	2.3	–1.5	5.5	3.4
Winter mortality (%)[a]	90.0	82.8	98.1	27.4	90.1

[a] Mortality includes natural mortality and mortality caused by farm operations from harvest to sowing in the next spring.

Table 11. Changes in borer populations from spring to summer to fall in Waseca County, Minnesota, and certain weather data for June, July and August, 1965–69. (T—temperature; R—rainfall).

	1965	1966	1967	1968	1969
No. borers/A—spring	92	18	100	10	532
—summer	225	250	800	133	900
Multiple change spring to summer	+2.4	+13.9	+8.0	+13.3	+1.6
No. borers/A fall	175	583	525	733	3100
Multiple change—summer to fall	–1.3	+2.3	–1.5	+5.5	+3.4
June weather					
Departure of mean (T) from normal	1.8	–1.8	–2.4	–1.3	–8.3
Departure of mean (R) from normal	–1.68	–0.64	4.43	2.01	0.89
No. days 90° or more	0	1	0	5	1
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	1	3	7	6	4
July weather					
Departure of mean (T) from normal	–3.6	0.3	–4.6	–3.4	–2.5
Departure of mean (R) from normal	0.37	–1.39	0.84	4.28	–0.16
No. days 90° or more	2	8	1	0	2
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	2	4	2	4	1
August weather					
Departure of mean (T) from normal	–4.6	–5.5	–5.7	–2.4	–1.6
Departure of mean (R) from normal	1.24	1.21	0.27	–0.35	–1.12
No. days 90° or more	1	0	0	4	0
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	3	4	3	2	1

reported by Chiang *et al.* (1961) that the heavy first-generation borer population coincided in a general way with the area which had a corn-oats crop sequence. Thus a decrease in this agronomic practice will have a negative effect on borer population.

It has been shown in Minnesota (Chiang 1964) that corn in cribs served as an overwintering site and contributed 26% of moths active in the field in the early summer. The increased use of picker-sheller would reduce the storage of corn in cribs and the population of overwintering larvae, thus should have a negative effect on borer population.

The survival of borers on hybrids popular in 1955 and in 1965 was compared in Minnesota (Chiang 1968). The results showed the host resistance level was about 5-15% higher in the more recent hybrids. Thus the host factor has become less favorable in recent years.

Temperature conditions showed an unusual feature, namely, a cool trend during the 1960's. It is a standard practice to compare the conditions of a given year with the long-term normal which is the average of the 3 preceding decades. A positive departure means

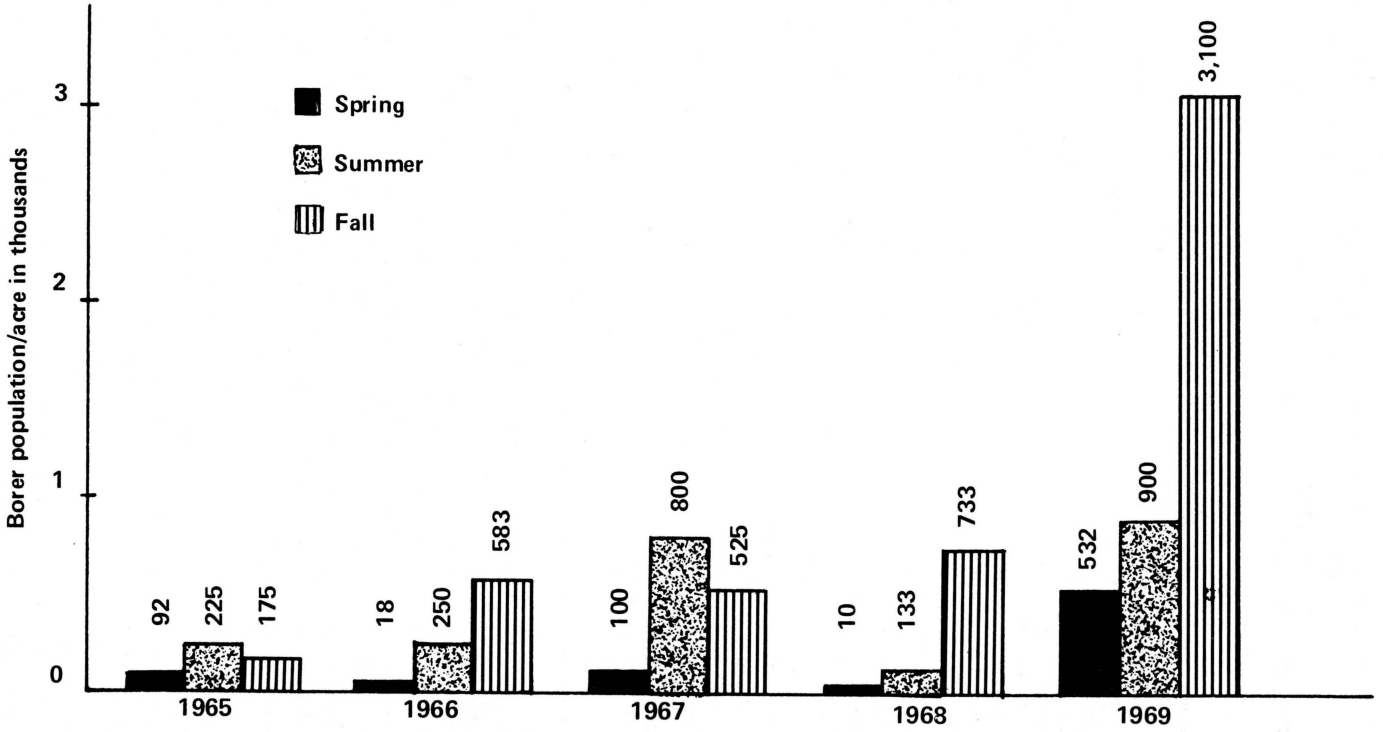

Fig. 4. Average number of borers per acre, Waseca County, Minnesota, 1965-69.

Table 12. The trend of changes of several ecological factors and of borer populations in Waseca County, Minnesota, 1954–69.

	1954–59	1960–64	1965–69	Overall effect
Plant population (no. plants per acre)	14,000[a]	15,400[b]	18,190	+
% fields with corn-oats rotation	26[a]	11[b]	7	–
% acres of corn harvested by picker-sheller	8[c]	21[c]	28[c]	–
Host effect (using borer survival on 1955 corn hybrids as 100%)	100[d]	.....	85–95[d]	–
Summation of monthly temperature departures from long-term normal	4.2[a]	–24.4[b]	–56.7	–
Average summer borer population (no./acre)	1,960	934	460	
Average fall borer population (no./acre)	4,560	2,375	1,023	

[a] Chiang, *et al.* (1961).
[b] Hill, *et al.* (1967).
[c] Chiang (1964).
[d] Chiang (1968).

that the year is warmer than normal; a negative departure, colder than normal.

The summation of monthly departures of May through August was 4.2 for 1954-59 (or 0.70 per year), –24.4 for 1960-64 (or –4.8 per year), –56.7 for 1965-69 (or –11.3 per year). Thus the growing season was colder in 1960-64 than in 1954-59, and colder still in 1965-69. It is of significance to note that the winter season of the 1960's was also colder than the long-term normal throughout the eastern U.S. (Namias 1970).

The borer population showed a consistent decrease both in the summer and in the fall from 1954 to 1969. This was to be expected in view of the negative effects of four factors indicated.

Thus it may be concluded that the borer populations were kept at low levels in the 1960's due both to manipulated factors in crop sequence, harvest method and genetic characteristics of host, and to temperature conditions.

CARROLL AND NEW MADRID COUNTIES, MISSOURI

Two counties in Missouri, Carroll and New Madrid, were selected as being representative of the two different types of corn growing areas of the state. Carroll County is in central Missouri in the Corn Belt while New Madrid County is in southeastern Missouri in the cotton growing area.

The study was initiated in 1956 and was conducted in a manner similar to that followed by the other cooperating states. However,

in New Madrid County there are only 11 townships so the county was divided into 12 districts to agree with the procedure outlined. Since there are more than 12 townships in Carroll County, an attempt was made to select fields in townships which were representative of larger areas.

CARROLL COUNTY

Area Description

Carroll County is in the northcentral part of the state bordering the Missouri River on the south. The southern quarter of the county is a fertile, flat land area in the Missouri River floodplain while most of the remainder of the county is divided among 22 townships. The principal crops are corn and soybeans, with small acreages of wheat and grain sorghum. A summary of corn production and planting rates in Carroll County is given in Tables 13 and 14.

Weather Conditions

Average monthly temperature and total monthly rainfall are presented in Appendix III A. Deviations from average long-term normal temperature and rainfall for Chillicothe are found in Appendix III B. The weather conditions during the 5 years may be briefly described as follows:

1965 – Warm and dry during April and May, cooler and wet during the remainder of the season.

1966 — Cool except for a hot July. Normal or slightly below normal rainfall.

1967 – Warm during April but cool for the rest of the season. Excessive rainfall during early and late portions of the growing season. Dry during July and August.

1968 – Warm or near normal throughout the season. Wet during April and July. Dry during June.

1969 – Hot and wet except for cool June.

Agronomic Practices

Fertilizer treatments used in Carroll County are summarized in

Table 13. Summary of corn yield production in Carroll County, Missouri, 1965–69.

Year	Acreage	Bu/A yield	Production bushels
1965	72,300	92.7	6,704,600
1966	71,000	70.6	5,012,600
1967	73,700	62.0	4,569,700
1968	75,900	86.1	6,532,900
1969	60,000	58.7	3,522,000

Table 14. Planting dates in Carroll County, Missouri.

Planting dates	Percent of fields					
	1965	1966	1967	1968	1969	Average
April 1–10	0	8.3	0	12.5	0	4.16
April 11–20	8.7	20.8	12.5	4.2	0	9.24
April 21–30	30.4	29.2	8.3	41.7	21.7	26.26
May 1–10	30.4	20.8	41.7	29.2	21.7	28.76
May 11–20	21.7	8.3	12.5	12.5	21.7	15.34
May 21–31	8.7	4.2	8.3	0	4.3	5.10
June 1–10	0	8.3	4.2	0	26.1	7.72
After June 10	0	0	12.5	0	4.3	3.36
Total fields observed	23	24	24	24	23	.....

Appendix III C. About 63% of the cooperators used NPK combinations but only 5% used a starter fertilizer. About 97% made applications of nitrogen, the most common form utilized being anhydrous ammonia. Only about 3% failed to use any fertilizer over the 5-year period. Fertilizer usage was greater than for the previous 10 years.

Crop history indicated that an average of about 75% of the cooperators followed corn with corn over the 5-year-period (Appendix III D). This is an increase of about 25% and 10% over the comparable periods of 1956-59 and 1960-64, respectively.

Carroll County plant populations are shown in Appendix III E. There were from 14,735 to 17,277 with an average of 15,809 plants per acre for the five years. There is a trend toward thicker plant populations from 1956 to 1969.

A summary of planting dates is presented in Table 14. The greater percentage of the corn was planted from April 20 to May 20. Some plantings were made prior to April 10 during 1966 and 1968. Delayed plantings, after June 1, were made during three of the five years.

About 40 different hybrids were planted by the cooperators over the five years. Pioneer hybrids tended to be the choice of most cooperators. All hybrids planted are listed in Appendix III F.

Borer Populations

Early spring borer populations averaged 766 and late spring populations averaged 148 borers per acre for 1965-69. Summer and early fall populations averaged 2,454 and 14,073 borers per acre, respectively. The late fall population averaged 2,058 borers per acre for 3 years of the 5-year period. This is about a 7-fold reduction over the early fall population (Table 15). The borer populations for Carroll County are also presented graphically in Figure 5. The early spring populations in Carroll County were less than one-half those found in New Madrid County, yet the late spring population averaged only 39 borers per acre less. The average late fall compared to the early spring population the following year in Carroll County

Table 15. Summary of borer populations at various times each year in Carroll County, Missouri. Number per acre.

	Early spring	Late spring	Summer	Early fall	Late fall
1965 Larvae	967	125	1,665	12,668	1,013
tunnels			2,983	13,262	.....
1966 Larvae	739	101	4,194	25,819	2,930
tunnels			5,888	39,930	.....
1967 Larvae	736	261	909	6,958	.....
tunnels			2,030	10,402	.....
1968 Larvae	111	42	1,250	12,000	2,231
tunnels			2,792	24,097	.....
1969 Larvae	1,278	212	4,254	12,919	.....
tunnels			6,861	33,335	.....
Average larvae	766.2	148.2	2,454	14,702	2,058
tunnels			4,101	24,205	.....

shows a 2.2 fold or 62.8% decrease while the New Madrid County population only shows an average of a 1.8 fold or 49.3% decrease (Tables 16, 22). The comparison of these qualitative changes reflects the possible effect of more unfavorable winter climatic conditions in Carroll County.

The overwintering populations and early summer populations have shown considerable fluctuation over the past 15 years but are comparable for each of the 5-year periods of study. However, the early fall populations continued to increase during each of the 5-year periods. This trend indicates a possibility that the borer is undergoing further transition of multiple generation characteristics. This trend may also be the result of a low incidence of natural enemies which allows for a greater increase in the borer population from the first generation to the second generation. If this trend continues, corn producers can expect increased economic losses from second generation borer damage.

Corn planted prior to May 10 in Carroll County appeared to receive heavier first generation infestations than corn planted after May 10. This tendency is shown in a summary of borer populations in relation to planting dates in Table 17. These plantings also received heavy infestations from second generation borers. Plantings after May 10 generally escaped or received only light infestations from

Table 16. Quantitative changes in borer populations, Carroll County, Missouri, 1965–69.

Multiple changes	1965	1966	1967	1968	1969	Average
Previous fall to early spring	–1.74	–1.37	–3.98	.....	–1.74	–2.21
Early spring to late spring	–7.74	–7.31	–2.82	–2.64	–6.03	–5.30
Late spring to summer	13.32	41.52	3.48	29.76	20.07	21.63
Summer to early fall	7.61	6.15	7.64	9.60	3.04	6.81
Early fall to late fall	–12.50	–8.81	.....	–5.38	.....	–8.90
Late fall to late spring	–1.37	–3.98	.....	–1.74	.....	–2.36

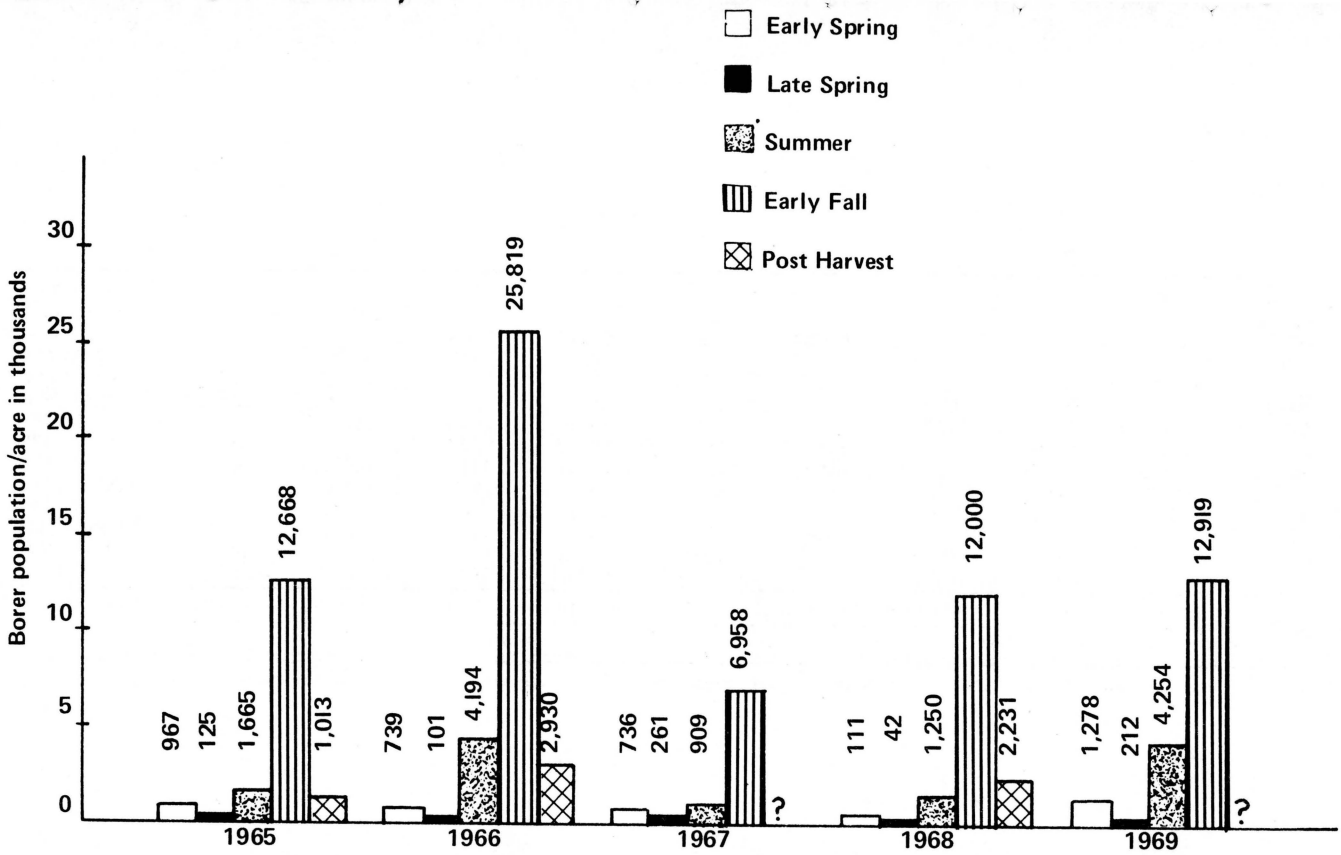

Fig. 5. Average number of borers per acre, Carroll County, Missouri, 1965-69.

Table 17. Summary of borer populations by planting date for Carroll County, Missouri. Number per acre.

Date of planting	1965		1966		1967		1968		1969	
	Summer	Early fall	Summer	Early fall	Summer	Early fall	Summer	Early fall	Summer	Early fall
April 5–10	.....	.....	1,667	21,000	.....	.....	1,833	5,000	.....	.....
April 11–15	5,328	10,656	15,333	23,333	4,667	1,000	1,333	3,667	.....	.....
April 16–20	1,332	2,997	4,417	11,083	3,834	5,167	.....	.....	.....	.....
April 21–25	2,497	2,497	6,222	20,445	.....	.....	2,666	11,888	9,000	12,333
April 26–30	3,197	4,329	3,334	36,000	667	3,333	857	11,553	4,500	26,167
May 1–5	666	18,049	5,111	32,889	1,200	5,000	1,166	15,401	3,555	22,000
May 6–10	666	10,989	1,667	21,333	444	6,111	667	6,667	4,834	13,667
May 11–15	0	33,966	2,667	20,667	.....	.....	833	8,500	334	17,667
May 16–20	888	24,753	0	47,383	0	7,889	0	29,667	7,333	10.000
May 21–25	0	40,293	.....	.....	0	12,667	.....	.....	.....	.....
May 26–31	0	3,663	2,000	2,333	.....	.....	.....	.....	.....	46,667
June 1–5	.....	.....	1,667	40,500	333	15,000	.....	.....	0	5,333
June 6–10	.....	.....	.....	.....	.....	.....	.....	.....	0	19,917
June 11–15	.....	.....	.....	.....	.....	.....	.....	.....	0	9,333

Table 18. Changes in borer populations from spring to summer to fall in Carroll County, Missouri and certain weather data for June, July and August, 1965–69. (T—temperature; R—rainfall)

	1965	1966	1967	1968	1969
No. borers/A—spring (late)	125	101	261	42	212
—summer	1,665	4,194	909	1,250	4,254
Multiple change spring to summer[a]	13.32	41.52	3.48	29.76	20.07
No. borers/A early fall	12,668	25,819	6,958	12,000	12,919
Multiple change summer to early fall[b]	7.61	6.15	7.65	9.60	3.04
June weather					
Departure of mean (T) from normal	−0.9	−2.7	−1.3	+3.2	−3.3
Departure of mean (R) from normal	−0.23	+0.58	+4.19	−2.59	+4.45
No. days 90° or more	3	4	1	14	7
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	4	3	7	2	7
July weather					
Departure of mean (T) from normal	−2.7	+2.7	−3.5	−0.2	+1.9
Departure of mean (R) from normal	+2.10	−0.91	−1.38	+2.39	+6.70
No. days 90° or more	4	23	14	10	18
No. days 100° or more	0	4	0	0	0
No. days with .50″ rainfall	3	2	2	3	6
August weather					
Departure of mean (T) from normal	−2.6	−4.3	−3.6	+1.7	+0.7
Departure of mean (R) from normal	−1.08	−1.30	−3.23	−0.41	+0.41
No. days 90° or more	7	3	5	12	9
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	2	4	3	2	2

[a] Overwintering generation to completion of first generation.
[b] First generation to completion of second generation.

first generation borers but were heavily infested by second generation borers.

Departures from the normal temperatures and rainfall presented in Table 18 do not appear to define the fluctuations of spring and summer populations of borers the same year or following year.

NEW MADRID COUNTY

Area Description

New Madrid County is in the fertile Mississippi Delta of southeastern Missouri about 175 miles south of St. Louis. The county consists of almost 700 square miles of land divided among 11 townships. Soybeans, corn, cotton and wheat are the most important crops. Small acreages of grain sorghum and alfalfa are also grown. A summary

of the corn production in New Madrid County during 1965-69 is given in Table 19.

Weather Conditions

The average monthly temperature and the total monthly rainfall are given in Appendix IV A. Deviations of temperature and rainfall from the long-term normal readings are given in Appendix IV B. General weather conditions for the 1965-69 period may be summarized as follows:

1965 – Temperatures were well above normal during April and May but slightly below normal from July through October. Rainfall was near normal except during September when 12.29 inches of rainfall was recorded.

1966 – Temperatures were below normal except for April and July. Rainfall was well above normal in April, May and September; mid-summer rainfall was near normal.

1967 – April was warm but the remaining season was cool. The months of May and October were wetter than normal with near or slightly below normal rainfall during the mid-summer months.

1968 – The season was slightly cooler than normal with the months of April, May and September wet.

1969 – Seasonal temperatures were near normal to hot in July. The entire season was dry.

Agronomic Practices

The use of fertilizer by New Madrid County cooperators is summarized in Appendix IV C. Combinations of NPK were used by about 93% of the farmers. This is a 10% increase in NPK combinations over the 1960 to 1964 census period and an increase of 17% over the 1954 to 1959 study period. About 93% of the fields received a starter application of fertilizer at or prior to planting and 88% received an application of nitrogen, most often in the form of anhydrous ammonia.

Table 19. Summary of corn yield and production in New Madrid County, Missouri.

Year	Acreage	Bu/A yield	Production bushels
1965	47,800	75.8	3,624,500
1966	40,000	62.6	2,504,000
1967	41,000	84.0	3,444,300
1968	42,000	80.5	3,379,300
1969	41,000	71.0	2,913,000

Table 20. Planting dates in New Madrid County, Missouri.

Planting dates	Percent of fields					
	1965	1966	1967	1968	1969	Average
Before March 31	0	12.5	11.8	4.3	11.8	8.08
April 1–10	5.6	29.2	41.2	13.0	17.6	21.32
April 11–20	33.3	4.2	35.3	30.4	17.6	24.16
April 21–30	33.3	4.2	5.9	21.7	23.5	17.76
May 1–10	27.8	37.5	0	21.7	29.4	23.28
May 11–20	0	4.2	0	4.3	0	1.70
May 21–31	0	0	5.9	4.3	0	2.04
After June 1	0	8.3	0	0	0	1.66
Total fields observed	18	24	18	23	17	.....

Crop rotations or cropping sequence used by New Madrid County cooperators show an average of only 32% of the fields planted to corn following corn during the 5-year period (Appendix IV D.). This is a slight decrease from the previous 5-year period. A gradual increase in acreages of soybeans and wheat was apparent over the previous 10 years of study. A decrease in cotton production accounted for a decrease in corn following cotton.

Less than 15% of the fields had populations below 14,000 plants per acre with about 50% of the fields ranging from 15,000 to 19,000. Slightly less than 5% of the fields averaged over 22,000 plants per acre. The average plant population for New Madrid County was 17,252 over the 5-year period (Appendix IV E.). Most farmers continued to plant rows spaced 38 inches apart but increased plant populations over the 15 years the census was conducted.

Planting dates were usually spread over a time period from April 1 to May 10 with the greater percentage planted prior to April 20. An average of 8% was planted prior to April 1. During 1968 the cool wet early season contributed to about 8% of the corn being planted after May 10. A summary of all planting dates may be found in Table 20.

Forty different hybrids were planted over the 5-year period as shown in Appendix IV F. Pfister hybrids appeared to be the most popular during 1965-67 but a trend toward use of Pioneer hybrids was apparent in 1968-69.

Borer Populations

A summary of borer populations for five annual censuses in New Madrid County for 1965 through 1969 is presented in Table 21 and Figure 6. The data in Table 21 also include the number of larval tunnels for the summer and early fall census which gives an indication of borer damage caused by the first and second generation larvae. The late fall census during 1966 reflects the only increase of the

Table 21. Summary of borer populations at various times each year in New Madrid County, Missouri. Number per acre.

	Early spring	Late spring	Summer	Early fall	Late fall
1965 Larvae	1,330	200	2,101	18,449	2,496
tunnels			4,217	32,014	
1966 Larvae	1,762	200	2,097	4,917	8,022
tunnels			3,625	11,139	
1967 Larvae	3,200	247	1,019	9,926	1,241
tunnels			2,167	18,426	
1968 Larvae	278	33	697	4,203	1,293
tunnels			1,833	10,681	
1969 Larvae	1,551	255	702	7,333	3,421
tunnels			3,526	11,825	
Average larvae	1,624	187	1,323	8,965	3,294
tunnels			3,073	16,817	

third generation over the second generation. A third generation does not occur annually but much of the corn is harvested in New Madrid County in late August and early September. Thus harvest by picker-shellers followed by stalk shredders destroys many larvae of both the second and third generations. High populations of third generation larvae were normally only found in the late planted fields that had not been harvested or the stalk residue shredded and/or disked.

Borer populations were higher from 1965 through 1969 than for either of the previous two 5-year census periods of 1956-69 or 1960-64.

The 1965 season had the heaviest second generation population of 18,445 borers and 32,014 tunnels per acre. The lowest populations encountered were during 1968 when 4,203 borers and 10,681 tunnels per acre were observed.

Quantitative changes in borer populations showed only an average 1.8 fold reduction in borers from late fall until the following spring for the 5-year period (Table 22).

There were from 6.08 to 12.96 times fewer borers found in the late spring census than at the time of the early spring census. This reduction indicates the effectiveness of thorough spring soil preparation in the county and region of Missouri. Many of the soil preparation procedures used for cotton production are also used for corn, such as disking several times, deep fall or spring plowing and, on many farms, the forming of elevated seed beds.

Table 23 presents a summary of the borer populations in relation to planting dates. Corn planted before May was infested by both the first and second generations. Plantings after May 5 were heavily infested by second and third generation borers. Regardless of planting dates farmers in New Madrid County can expect infestation from at least two borer generations. Earlier planted corn receives infestation from the first and second generations while later planted corn

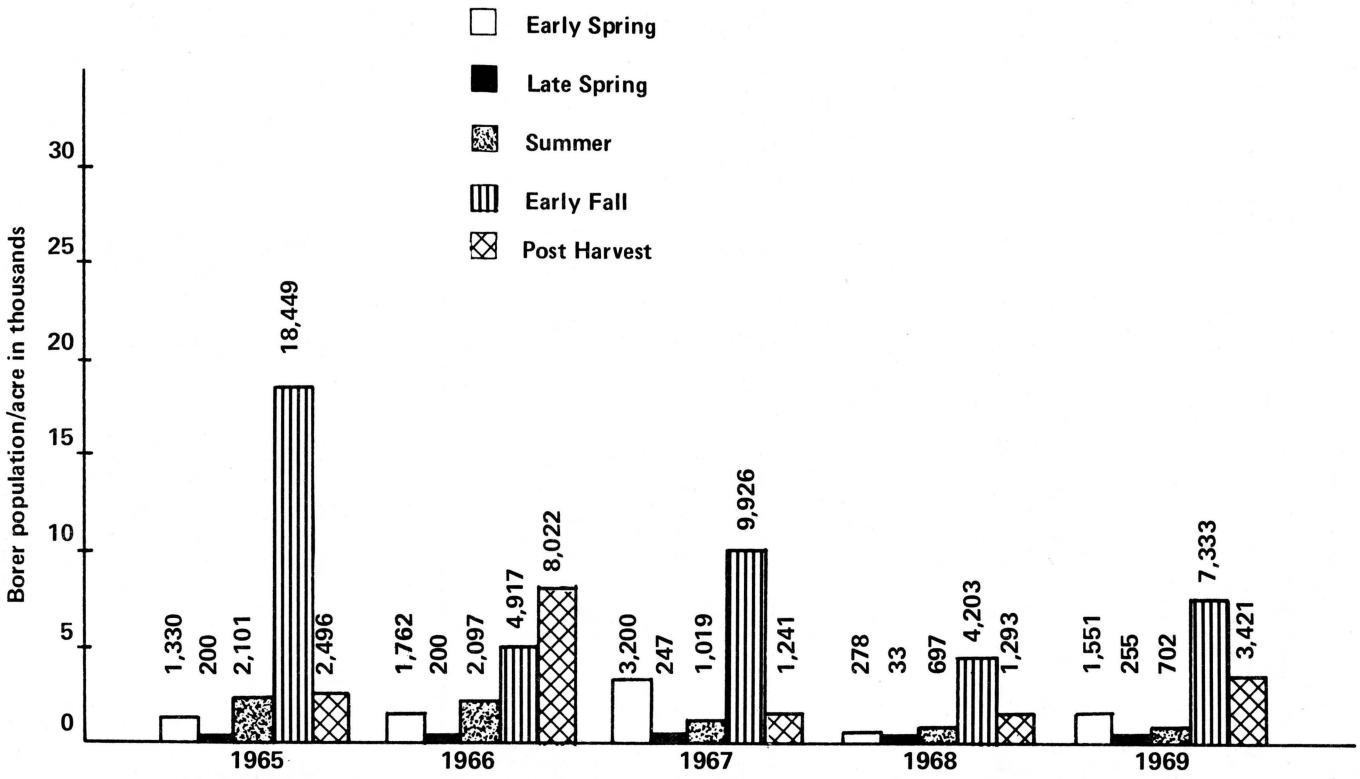

Fig. 6. Average number of borers per acre, New Madrid County, Missouri, 1965-69.

Table 22. Quantitative changes in borer population in New Madrid County, Missouri.

Multiple changes	1965	1966	1967	1968	1969	Average
Previous fall to early spring	–1.99	–1.42	–2.51	–4.46	1.20	–1.84
Early spring to late spring	–6.65	–8.81	–12.96	–8.42	–6.08	–8.58
Late spring to summer	10.51	10.49	4.13	2.11	2.75	6.00
Summer to early fall	8.78	2.34	9.74	6.03	10.45	8.06
Early fall to late fall	–7.39	–1.39	–8.00	–3.25	–2.14	–4.43

receives infestation from second and third generation borers. It is possible that some plantings can be infested by all three generations.

Changes in borer population and certain weather data are presented in Table 24. Since mid-season weather data are comparable for all five years, it is difficult to interpret the effect of weather on these borer populations.

Table 23. Summary of borer populations by planting date for New Madrid County, Missouri. Number per acre.

Date of planting	1965			1966			1967		
	Summer	Early fall	Late fall	Summer	Early fall	Late fall	Summer	Early fall	Late fall
Before March 31	.....	.....	.....	1,889	4,000	3,556	2,500	9,834	167
April 1–5	.....	.....	.....	778	5,556	4,778	1,200	4,733	535
April 6–10	1,667	1,100	1,667	5,667	5,000	1,222	500	2,667	2,167
April 11–15	1,833	14,500	2,167	4,333	8,000	667	.....	.....	.....
April 16–20	666	23,000	4,000	.....	.....	.....	555	14,055	1,333
April 21–25	1,666	10,555	778	.....	.....	.....	0	667	667
April 26–30	1,888	15,222	4,333	2,000	2,000	1,333	.....	.....	.....
May 1–5	1,916	24,833	4,333	5,444	1,889	1,400	.....	.....	.....
May 6–10	0	37,000	667	278	4,889	18,555	.....	.....	.....
May 11–15	.....	.....	.....	333	4,000	19,667	.....	.....	.....
May 16–20	.....	.....	.....	.....	.....	.....	.....	.....	.....
May 21–25	.....	.....	.....	.....	.....	.....	667	43,333	6,333
May 26–30	.....	.....	.....	.....	.....	.....	.....	.....	.....
After June 1	.....	.....	.....	0	7,834	19,167	.....	.....	.....

Date of planting	1968			1969		
	Summer	Early fall	Late fall	Summer	Early fall	Late fall
Before Mar 31	0	3,667	0	1,666	3,000	667
April 1–5	2,333	2,333	0	0	5,000	2,000
April 6–10	4,833	3,166	0	333	9,000	4,167
April 11–15	333	3,833	0	333	11,333	1,667
April 16–20	583	5,666	883	2,000	5,667	2,667
April 21–25	0	5,666	0	8,889	8,889	1,334
April 26–30	0	3,667	778	333	13,000	500
May 1–5	222	5,666	111	0	8,333	9,556
May 6–10	0	3,166	6,666	333	9,333	5,667
May 11–15	0	1,333	0	.....	.....	.....
May 16–20	.....	.....	.....	.....	.....	.....
May 21–35	.....	.....	.....	.....	.....	.....
May 26–30	0	2,667	3,000	.....	.....	.....
After June 1	.....	.....	.....	.....	.....	.....

Table 24. Changes in borer populations from spring to summer to fall in New Madrid County, Missouri, and certain weather data for June, July and August, 1965–69. (T—temperature; R—rainfall).

	1965	1966	1967	1968	1969
No. borers/A—spring (late)	200	200	247	33	255
—summer	2,101	2,097	1,019	697	702
Multiple change spring to summer[a]	10.51	10.49	4.13	2.11	2.75
No. borers/A—early fall	18,449	4,917	9,926	4,203	7,333
Multiple change summer to early fall[b]	8.78	2.34	9.74	6.03	10.45
June weather					
Departure of mean (T) from normal	–1.0	–1.6	–0.4	+0.4	–0.3
Departure of mean (R) from normal	–1.76	+0.22	–0.08	–1.41	–2.80
No. days 90° or more	11	14	15	17	18
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	1	4	5	2	1
July weather					
Departure of mean (T) from normal	–1.8	+2.3	–4.4	–0.5	+2.7
Departure of mean (R) from normal	+2.08	–0.61	–0.37	–1.02	+0.80
No. days 90° or more	12	24	11	22	25
No. days 100° or more	0	7	0	0	6
No. days with .50″ rainfall	5	3	3	2	2
August weather					
Departure of mean (T) from normal	–2.3	–4.2	–6.1	–0.1	–1.3
Departure of mean (R) from normal	–1.46	–0.04	–0.56	–1.03	–1.42
No. days 90° or more	16	4	4	18	18
No. days 100° or more	0	0	0	0	1
No. days with .50″ rainfall	1	3	2	1	0

[a] Overwintered generation to completion of first generation.
[b] First generation to completion of second generation.

CUMING AND HALL COUNTIES, NEBRASKA

Information included in this report has been gathered over the period from 1965 through 1969. All of the observations on corn borer populations were collected by members of the Department of Entomology of the University of Nebraska. Information on planting dates, crop rotations and fertilizer application was obtained through use of questionnaires sent to each of the cooperators soon after the completion of each fall survey. Spring populations were checked between May 16 and May 29, summer populations between July 20 and August 5 and fall populations between September 29 and October 27. Populations in 1965 and 1966 were estimated from three areas 1/1000 acre in size in each of 24 fields. During 1967, 1968 and 1969 populations were estimated from three areas 1/2000 acre in size from each of 30 fields.

CUMING COUNTY

Area Description

Cuming County is in the northeastern part of Nebraska in the

second tier of counties west of the Missouri River. This county is in a hilly region that was once smooth upland which has been thoroughly dissected by the drainage system of the Elkhorn River. Cuming County consists of 570 square miles, or 364,000 acres. The drainage of the county is toward the south by the Elkhorn River. Logan, Plum and Cuming creeks are the main tributaries in the county.

The topography of the county may be described as varying from steeply rolling along the more deeply entrenched waterways to nearly flat on the portions of the undissected prairie upland. Flood plains in the county are generally narrow but do expand to 1¼ miles along the streams. Terrace or bench lands form a considerable portion of tillable land and occur at several distinct levels, some as high as 60 feet above the adjoining floodplains.

Soils that make up Cuming County are divided among 18 different types which are all of glacial origin and are described as Nebraska loess. Marshall silt loam comprises 69.0% of the soil and Wabash silt loam 8.8%, with the remainder of the soils divided among silt and very fine sandy loams.

Corn is the major grain crop of the county and grain not fed to livestock is sold for cash. Irrigation plays only a minor role in the agriculture of the county.

Weather Conditions

The average monthly temperatures, total monthly rainfall for the 1965-69 growing seasons and borer degree-day accumulations at West Point, Nebraska are shown in Appendix V A. Deviations from long-term means are given in Appendix V B. In general, the weather conditions for Cuming County, Nebraska may be summarized as follows:

1965 – A cool and wet to dry season. The temperature was above normal for May but below during June, July and August. Total rainfall was above average for May and July but below during June and August.

1966 – A cool-wet season. May was cool and dry. June, July and August were all cooler and wetter than normal.

1967 – A cool season. May, June, July and August all were decidedly cooler than normal. June was very wet but the rest of the season was dryer than normal.

1968 – A cool year with precipitation averaging about normal. The average temperature for June was normal but May, July and August all were cooler. May and July were dryer than normal and June and August wetter.

1969 – A cool-dry season. May was slightly warmer, June exceptionally cooler and July and August cooler than normal. May, June and July were dryer and August wetter than normal.

Table 25. Five principal crops harvested, amount of land irrigated, and tons of fertilizer used in Cuming and Hall Counties, Nebraska, in 1968.[a]

Five principal crops:			
Cuming County		Hall County	
Crop	Acres harvested	Crop	Acres harvested
Corn (all purposes)	128,060	Corn (all purposes)	112,000
Hay (all)	42,380	Hay (all)	24,180
Soybeans	39,670	Sorghum (all)	13,970
Oats	19,670	Winter Wheat	13,960
Sorghum (all)	4,360	Soybeans	7,080

	Cuming County	Hall County
Extent of irrigation:	No. Acres	No. Acres
Total land irrigated	3,800	158,600
Irrigated corn (for grain)	1,620	98,810
Non-irrigated corn (for grain)	106,570	6,760
Fertilizer used:		
Tons fertilizer sold	8,159	34,620
Total acres fertilized	137,800	198,900

[a] Data from Nebraska Agricultural Statistics Annual Report for 1968.

Agronomic Practices

Cuming County farmers generally follow some form of rotation. During the past 5 years the acreage in oats has continued to drop and soybeans to increase (Table 25 and Appendix V C). Although many of the fields checked have corn following corn (49.8%) this does not necessarily mean continuous corn. Many growers plant corn for 2 or 3 years and then rotate with some other crop. Soybeans and oats have been the most popular crops to precede corn and recently soybeans have largely replaced oats in this respect (Appendix V C). Commercial fertilizers were used on an average of 72.0% of the cornfields checked in the county (Appendix V D). This represents a continued increase over the previous two 5-year periods when 15.3% and 60.3% of the growers, respectively, used commercial fertilizer. For the first time trace elements were also reported used during the past 5-year period. Drill planting was followed in 72.2% of the fields and 9.5% were lister planted (Appendix V E). A tendency for plant populations to increase was continued during the past 5 years with an average of 14,036 plants per acre contrasted to an average population of 11,930 for the 1960-64 period. A list of corn hybrids planted by the various cooperators is presented in Appendix V F.

Planting dates are now earlier with an average of 30.4% of the fields planted from May 1 to 10 (Table 26). The average date of planting during the third 5-year period was May 14, compared to May 17 to 18 and May 18 to 19, respectively, for the second and

Table 26. Planting dates in Cuming County, Nebraska.

Planting dates	Percent of fields					
	1965	1966	1967	1968	1969	Average
May 1–10	17.0	38.0	33.0	37.0[a]	27.0	30.4
May 11–20	37.0	38.0	50.0	43.0	43.0	42.2
May 21–31	21.0	8.0[b]	10.0[c]	3.0	7.0	9.8
Unknown	25.0	16.0	7.0	17.0	23.0	17.6
Average date of planting	May 17	May 13	May 14	May 13	May 13	May 14
Total fields observed	24	24	30	30	30	

[a] One field planted April 30, 1968.
[b] One field planted June 1, 1966.
[c] One field planted June 5, 1967.

first 5-year periods of the study. Hence there has been a definite trend toward earlier planting dates.

Borer Populations

Spring populations in Cuming County have averaged 1,042 borers per acre for the 1965-69 period. Summer and fall populations averaged 2,917 and 25,571 borers per acre, respectively (Table 27). Borer populations for each year are shown in Table 28 and graphically in Figure 7. The number of plants showing borer injury varied from year to year and at the time of the summer censuses ranged from 15.9% to 47.2% (Table 28). At the time of the fall censuses from 52.2% to 97.7% of the plants had been infested. The magnitude of the population changes during each of the five years is shown in Table 29. Populations increased from spring to summer and from summer to fall in each of the five years. For the 5-year period this multiple increase averaged 3.3 times for the first (summer) generation and 10.1 times for the second (fall) generation. Winter mortality of the corn borer has averaged 93.4%. A summary of the borer populations and certain weather data for the months of June, July and August is presented in Table 30.

A definite relationship is shown between planting date and borer populations in Table 31. The summer generation was markedly higher on early plantings and lower on late plantings. A reverse relationship for the fall generation was evident where later planted corn carried the larger populations. The relationship between the use of commercial fertilizers and borer populations was not as evident as in earlier observations (1960-64). The first generation was not affected but the second generation population was greater on corn growing in fertile soil compared to fields where commercial fertilizers were not used (Table 32). Several of the factors changed during the 15-year period. It is now possible to examine the effects on borer populations (Table 33).

Table 27. Population range and average number of borers per acre in Cuming and Hall Counties, Nebraska, 1965–69.

	Cuming County Number borers per acre		Hall County Number borers per acre	
	Range	Average	Range	Average
Spring	361– 2,408	1,042	477– 1,788	1,229
Summer	1,132– 5,395	2,917	244– 4,354	1,956
Fall	5,133–68,645	25,571	11,648–48,216	24,543

Table 28. Summary of plant and borer populations and injury at various times each year in Cuming County, Nebraska.

	Average number plants per acre	Total number plants checked	Percent plants with injury	Number of	
				Borers per 100 plants	Borers per acre
1965 Late spring	.....	.....	....	.....	.....
Summer	13,500	973	30.4	26.6	3,136
Fall	13,653	984	62.3	38.8	5,133
1966 Late spring	.....	.....	.....	.....	361
Summer	13,972	1,007	24.4	14.0	1,984
Fall	13,459	970	73.7	138.3	17,982
1967 Late spring	.....	.....	.....	.....	888
Summer	13,431	605	22.1	20.5	2,938
Fall	13,231	596	52.2	61.4	8,791
1968 Late spring	.....	.....	.....	.....	509
Summer	15,473	697	15.9	7.3	1,132
Fall	14,896	671	81.6	183.3	27,306
1969 Late spring	.....	.....	.....	.....	2,408
Summer	14,008	631	47.2	38.5	5,395
Fall	14,741	664	97.7	465.7	68,645

Table 29. Quantitative changes in borer population in Cuming County, Nebraska.

	1965	1966	1967	1968	1969	Average
Multiple changes						
Fall to spring	.....	–14.2	–20.2	–17.3	–11.3	–15.8
Spring to summer	.....	5.5	3.3	2.2	2.2	3.3
Summer to fall	1.6	9.1	3.0	24.1	12.7	10.1
Winter mortality (%)	.....	93.0	95.1	94.2	91.2	93.4

Table 30. Changes in borer population from spring to summer to fall in Cuming County, Nebraska, and certain weather data for June, July and August, 1965–69. (T—temperature; R—rainfall).

	1965	1966	1967	1968	1969
No. borers/A—spring	.....	361	888	509	2,408
—summer	3,136	1,984	2,938	1,132	5,395
Multiple change—spring to summer	.....	5.5	3.3	2.2	2.2
No. borers/A—fall	5,133	17,982	8,791	27,306	68,645
Multiple change—summer to fall	1.6	9.1	3.0	24.1	12.7
June weather					
Departure of mean (T) from normal	–2.3	–2.5	–3.4	0.0	–5.6
Departure of mean (R) from normal	–0.75	2.56	8.24	1.86	–1.70
No. days 90° or more	2	3	1	13	4
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	3	3	8	3	3
July weather					
Departure of mean (T) from normal	–4.0	–0.2	–4.7	–3.4	–1.2
Departure of mean (R) from normal	0.74	3.06	–2.62	–1.73	–0.55
No. days 90° or more	7	14	13	12	10
No. days 100° or more	0	2	0	0	2
No. days with .50″ rainfall	3	3	0	2	3
August weather					
Departure of mean (T) from normal	–3.7	–6.0	–4.6	–2.5	–0.9
Departure of mean (R) from normal	–1.07	0.16	–1.42	0.89	1.73
No. days 90° or more	8	3	4	9	15
No. days 100° or more	0	0	0	0	0
No. days with .50″ rainfall	2	2	1	3	3

Table 31. Relationship of corn borer population to date of planting in Cuming County, Nebraska, 1965–69.

Date	No. of fields	Average number borers per acre	
		Summer	Fall
May 1–10[a]	42	4,691	23,511
May 11–20	59	2,382	25,718
May 21–31[b]	12	1,665	31,942
Unknown	24	2,054	30,789

[a] One field planted April 30, 1968.

[b] One field planted June 1, 1966, another June 5, 1967.

Table 32. Relationship of corn borer populations to fertilizer applications in Cuming County, Nebraska, 1965–69.

Number years fertilizer applied	Summer		Fall	
	No. fields	No. borers/acre	No. fields	No. borers/acre
None	26	3,343	26	18,289
1	24	2,178	24	20,049
2	28	1,926	28	35,484
3 or more	35	4,611	35	30,649
Average, 1, 2 & 3 or more	87	3,076	87	29,281

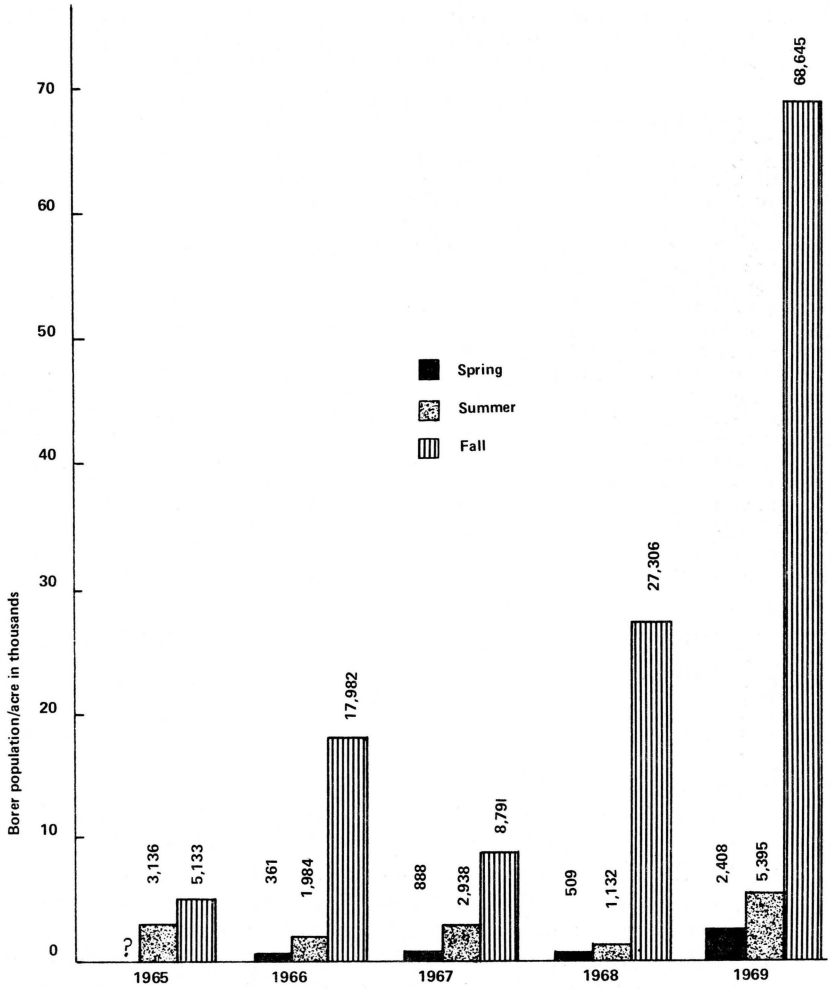

Fig. 7. Average number of borers per acre, Cuming County, Nebraska, 1965-69.

HALL COUNTY

Area Description

Hall County is in the central part of the state. The Platte River crosses the county in a northeasterly direction through a shallow valley 12 to 15 miles wide. Hall County is composed of 528 square miles or 337,920 acres. The drainage of the county is supplied by the Platte River except for an area of about 6 square miles in the

Table 33. Trend of changes of several ecological factors and of corn borer population in Cuming County, Nebraska 1955–69.

	1955–59	1960–64	1965–69	Overall effect
Plant population (Avg. no. plants/acre)	11,158	11,930	14,036	+
% corn fields sown to oats	43.3	25.8	23.2	–
No. acres oats harvested	57,250[a]	41,180[b]	19,670[c]	–
Total acres fertilized	8,700[a]	184,100[b]	137,800[c]	+
Avg date corn planted	May 19	May 18	May 14	+
Summation of monthly temperature departures from long-term normal	13.0	–43.5	–53.8	–
Avg % fall larvae parasitized:				
with *Lydella thompsoni*	2.2[d]	6.5	0.5	–
with *Horogenes punctorius*	0.0[d]	2.8	9.8	–
Avg % infected:				
with *Perezia pyraustae*	18.3[e]	52.2	19.2	–
Avg spring borer population/acre	2,581	1,375	1,042	
Avg summer borer population/acre	6,244	5,300	2,917	
Avg fall borer population/acre	36,957	21,414	25,571	
% cornstalks infested:				
Summer	45.3	42.8	28.0	
Fall	82.6	88.6	73.5	

[a] Chiang, *et al.* (1961).
[b] Hill, *et al.* (1967).
[c] Nebr. Agr. Statistics for 1968.
[d] Avg. for 1958 and 1959.
[e] Avg. for 1959.

northwestern corner, which is drained by the South Loup River. The Wood River and Prairie, Silver, Dry and Moore creeks, all flowing in a northeasterly direction, contribute to the drainage of the county.

The upland areas of the county lie 50 to 150 feet above the floor of the Platte Valley and the topography varies from nearly flat to slightly rolling. A small area along the northern border is covered with a layer of loosely piled sand in dunes or low irregular hills shaped by wind action.

The soils are all glacial in origin and are divided into 26 different types; 20.2% of the soils are Hall silt loam, 8.6% Hall very fine sandy loam, 8.5% Valentine sand, 7.0% Cass very fine sandy loam and 6.9% Grundy silt loam. The remainder of the soils are divided among various sand and silt loams.

Practically all of the soil types are under cultivation although some of the poorly drained low riverbottom areas are maintained as native grass meadows and pasture. Irrigation has had a tremendous effect upon the agriculture of the county in the past two decades and most of the areas level enough to permit efficient use of water are devoted to cash grain or crop farming with little or no crop rotation. Other

more poorly adapted areas are devoted to cattle raising and to some extent general farming.

Weather Conditions

The average monthly temperatures, total monthly rainfall for the five growing seasons (1965-69) and borer degree-day accumulations at Grand Island, Nebraska are shown in Appendix VI A. Deviations from long-term means are given in Appendix VI B. In general, the weather conditions for Hall County, Nebraska may be summarized as follows:

1965 – This was a cool-wet season. The temperature for May was above normal but below normal for June, July and August. Rainfall averaged above normal for May, June and August and slightly below for July.

1966 – This was a variable season. May was slightly warmer than normal but very dry, June was dry, July was the warmest of the 15-year period and wet, and August much cooler than normal and dry.

1967 – The entire season was cooler than normal and except for the exceptionally wet June the other months were each dryer than normal.

1968 – A cool-wet season. Except for the warmer June, the rest of the growing season was cooler than normal and except for the dry May, the season also was wetter than normal.

1969 – A variable season. May was warmer than normal and dryer, June exceptionally cooler and slightly dry. July temperatures were normal but the month somewhat wet. August was slightly warmer than normal but wetter.

Agronomic Practices

In Hall County nearly all of the commercially grown corn is raised under irrigation and this has led to the practice of corn season after season (Table 25 and Appendix VI C). Corn followed corn in 91.6% of the fields checked during the 1965-69 period.

This continuous cropping of corn has been followed by a wider use of commercial fertilizers than would be expected under normal Corn Belt conditions. Commercial fertilizers were used on 100% of the fields checked in Hall County (Appendix VI D). During the five years (1965-69), trace elements, principally zinc, iron and sulfur, were added to 15% of the fields.

Planting methods in Hall County are drilled or surface planting and lister planting. During the 1965-69 period the percentage of fields listed increased and surface planting decreased. Plant populations have continued to increase and have averaged yearly between

Table 34. Planting date in Hall County, Nebraska.

Planting dates	Percent of fields					
	1965	1966	1967	1968	1969	Average
Last week April	8.0	8.0	10.0	6.0	10.0	8.4
May 1–10	21.0	59.0	27.0	50.0	37.0	38.8
May 11–20	46.0	25.0	43.0	27.0	27.0	33.6
May 21–31	8.0[a]	0.0	3.0	0.0	3.0	2.8
Unknown	17.0	8.0	17.0	17.0	23.0	16.4
Average date of planting	May 13	May 7	May 8	May 8	May 9	May 9
Total fields observed	24	24	30	30	30	

[a] Two fields planted June 1, 1965.

16,213 and 19,402 plants for a 5-year average of 17,745 plants per acre (Appendix VI E). This increase represents almost 3,000 more plants per acre than that recorded for 1960-64.

Planting dates for Hall County also are earlier with the average date of planting during the 1965-69 period being May 9, compared to May 15 and May 21, respectively, for the second and first 5-year periods of the study (Table 34). There has been, therefore, a very striking trend toward earlier planting dates.

A list of corn hybrids planted by the various farmer cooperators is presented in Appendix VI F.

Borer Populations

During the 1965 through 1969 seasons, spring populations in Hall County have averaged 1,229 borers per acre. Summer and fall popu-

Table 35. Summary of plant and borer populations and injury at various times each year in Hall County, Nebraska.

	Average number plants per acre	Total number plants checked	Percent plants with injury	Number of	
				Borers per 100 plants	Borers per acre
1965 Late spring	.....	.....	....	.....	.....
Summer	15,956	1,150	21.6	15.2	2,484
Fall	16,470	1,187	83.3	133.4	21,871
1966 Late spring	.....	.....	.....	.....	1,027
Summer	17,150	1,236	16.5	13.3	2,276
Fall	17,191	1,239	96.4	298.5	48,216
1967 Late spring	.....	.....	.....	.....	1,623
Summer	16,606	748	24.7	25.8	4,354
Fall	17,516	789	61.8	65.7	11,648
1968 Late spring	.....	.....	.....	.....	477
Summer	18,692	842	2.7	1.3	244
Fall	19,070	859	69.2	97.8	18,648
1969 Late spring	.....	.....	.....	.....	1,788
Summer	18,803	847	8.6	2.2	422
Fall	20,002	901	74.4	111.6	22,331

lations averaged 1,956 and 24,543 borers per acre, respectively (Table 27). A summary of borer populations and percent of plants infested for the 5-year period appears in Table 35. The populations are also shown graphically in Figure 8. The number of plants showing borer injury varied from year to year and at the time of the summer censuses ranged from 2.7 to 24.7%. At the time of the fall censuses from 61.8 to 96.4% of the plants had been infested.

The magnitude of population changes from one census period to the next is compared in Tables 36 and 37. In 1968 and 1969 instead of an increase from spring to summer there was a recorded decrease in number of borers found. Fall populations were always greater than those of summer but increases varied considerably, from a low of 2.7 times in 1967 to 76.4 and 52.9 times in 1968 and 1969, respectively. The average summer to fall multiple increase is 32.4, indicating conditions for second generation establishment and survi-

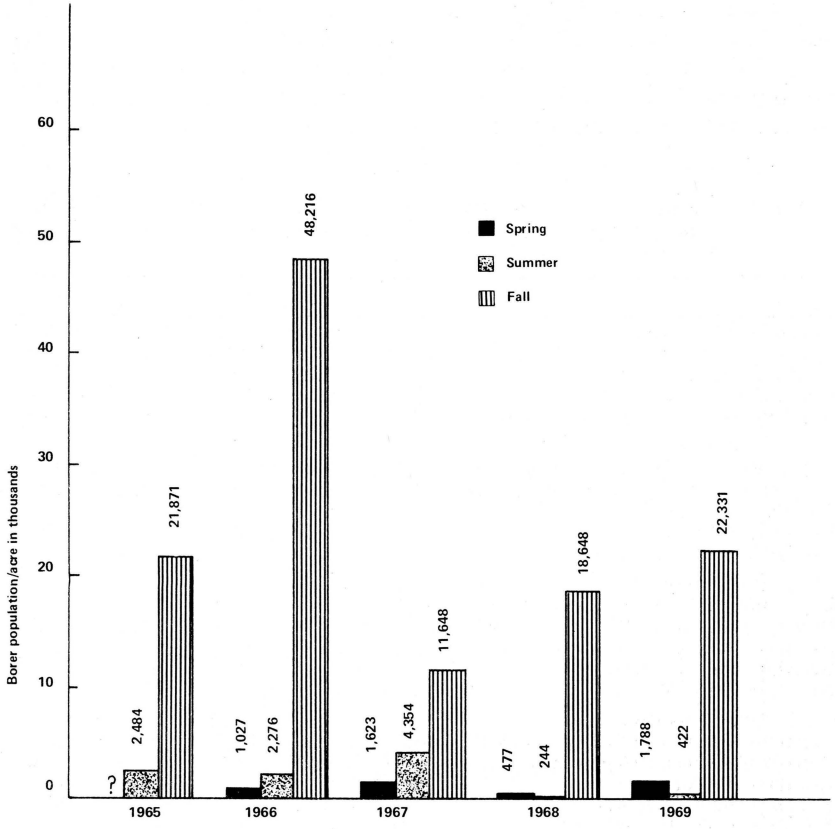

Fig. 8. Average number of borers per acre, Hall County, Nebraska, 1965-69.

Table 36. Quantitative changes in borer population in Hall County, Nebraska.

	1965	1966	1967	1968	1969	Average
Multiple changes						
Fall to spring	.....	-21.3	-29.7	-24.4	-12.5	-22.0
Spring to summer	.....	2.2	2.7	-2.0	-4.2	-0.3
Summer to fall	8.8	21.2	2.7	76.4	52.9	32.4
Winter mortality (%)	.....	95.3	96.6	95.9	90.4	94.6

val were favorable, especially during the 1968 and 1969 seasons. The average multiple change from spring to summer was -0.3, suggesting less than favorable conditions for first generation development. The average low summer population of 1,956 compared to 2,719 and 4,054 for the first and second 5-year periods, respectively.

Winter mortality, or a comparison of a fall population with the following spring population, averaged 94.6% over recent years.

A comparison of planting date and corn borer populations in Hall County (Table 38) illustrates a decrease in the summer population with lateness of planting. However, there appears to be less evidence of a relationship between date of planting and the average fall populations in Hall County except that the very earliest planted corn carries fewer second generation borers.

Table 37. Changes in borer populations from spring to summer to fall in Hall County, Nebraska, and certain weather data for June, July and August, 1965-69. (T—temperature; R—rainfall).

	1965	1966	1967	1968	1969
No. borers/A—spring	.....	1,027	1,623	477	1,788
—summer	2,484	2,276	4,354	244	422
Multiple change—spring to summer	.....	2.2	2.7	-2.0	-4.2
No. borers/A—fall	21,871	48,216	11,648	18,648	22,331
Multiple change—summer to fall	8.8	21.2	2.7	76.4	52.9
June weather					
Departure of mean (T) from normal	-1.3	0.0	-2.8	2.2	-4.9
Departure of mean (R) from normal	1.42	-0.81	10.17	3.34	-0.33
No. days 90° or more	2	9	2	14	5
No. days 100° or more	0	0	0	2	2
No. days with .50″ rainfall	5	2	9	5	2
July weather					
Departure of mean (T) from normal	-2.4	3.8	-2.4	-2.0	0.0
Departure of mean (R) from normal	-0.15	0.96	-1.53	2.31	0.59
No. days 90° or more	9	21	11	12	13
No. days 100° or more	1	9	3	0	3
No. days with .50″ rainfall	0	3	1	3	3
August weather					
Departure of mean (T) from normal	-1.7	-4.6	-3.1	-0.9	0.7
Departure of mean (R) from normal	1.00	-0.67	-1.05	2.06	1.40
No. days 90° or more	16	8	16	10	13
No. days 100° or more	1	0	0	2	0
No. days with .50″ rainfall	2	1	0	5	2

Table 38. Relationship of corn borer populations to date of planting in Hall County, Nebraska, 1965–69.

Date	No. of fields	Average number borers per acre	
		Summer	Fall
Late April	12	3,413	14,374
May 1–10	53	1,872	27,262
May 11–20	46	1,860	23,307
May 21–31[a]	4	583	43,207
Unknown	23	1,274	17,330

[a] Two fields planted June 1, 1965.

COMPARISON OF BORER POPULATIONS IN CUMING AND HALL COUNTIES

Cuming and Hall Counties are within 100 miles of one another in what could be considered the western Corn Belt. Farmers in Cuming County follow the more typical Corn Belt agronomic practices based on the maintenance of soil fertility through the use of crop rotations supplemented with commercial fertilizers. Farming in Hall County emphasizes irrigation from deep wells and the continuous cropping of corn has become the rule. Commercial fertilizers are used freely and short crop rotations are seldom seen.

Commercial fertilizers were used on all corn fields checked in Hall County during the 1965-69 period whereas in Cuming County 72.0% were so treated. This represents no change in Hall County over the previous 5-year period but is a 11.2% increase in fertilizer use in Cuming County.

A comparison of the two counties based on principal crops raised, fertilizer use and acres irrigated is shown in Table 25. The 1968 data compared with the 1963 figures (Hill *et al.*) show soybean acreages have increased in both counties and land in oats continues to decrease. In Cuming County the sorghum acreage increased but in Hall there was a reduction in the number of acres planted to sorghum and winter wheat.

Corn borer population ranges and averages over the 1965-69 period in the two counties are shown in Table 27. The spring population averaged slightly higher in Hall County but summer and fall populations were somewhat lower than for Cuming County. Spring, summer and fall populations are shown in Figures 7 and 8.

A noticeable difference in population trends in the two counties is that from summer to fall of 1965. The 1.6 times increase in the number of fall borers over the summer in Cuming County is considerably less than the 8.8 multiple increase from summer to fall in Hall County. Both June and August were dryer in Cuming County than in Hall and the incidence of *Perezia* infection was 88% in the 1965 fall larval population contrasted to 30% for Hall County borers.

Average spring, summer and fall populations for each of the 5-

Table 39. Trend of changes of several ecological factors and of corn borer populations in Hall County, Nebraska, 1955–69.

	1955–59	1960–64	1965–69	Overall effect
Plant population (Avg no. plants/acre)	13,768	14,677	17,745	+
% fields having moderate to heavy amount of cornstalks on surface in spring	30.3%	49.5%	64.8%	+
No. acres in oats	10,490[a]	1,920[b]	350[c]	–
Avg date planting	May 21	May 15	May 9	+
Summation of monthly temperature departures from long-term normal	–9.5	–29.4	–20.8	–
Avg % fall larvae parasitized:				
with *Lydella thompsoni*	0.0[d]	3.6	0.1	–
with *Horogenes punctorius*	0.0[d]	0.0	4.1	–
Avg % larvae infected:				
with *Perezia pyraustae*	1.0[d]	23.2	30.6	–
Avg spring borer population/acre	2,138	1,206	1,229	
Avg summer borer population/acre	2,719	4,054	1,956	
Avg fall borer population/acre	31,475	31,252	24,543	
% cornstalks infested:				
Summer	30.4	29.3	14.8	
Fall	89.3	93.3	77.0	

[a] Chiang *et al.* (1961).
[b] Hill, *et al.* (1967).
[c] Nebr. Agr. Statistics for 1968.
[d] Avg. for 1958 and 1959.

year periods from 1955 to 1969 are shown in Tables 33 and 39 for Cuming and Hall Counties, respectively. Spring populations have continued to decline in Cuming County and a most likely reason is the reduction in acreages planted to oats and the lower percentage of cornfields planted to oats which is a cultural practice favorable to the survival of overwintering corn borer larvae (Table 33). In Hall County average spring populations, following a reduction from 1955-59, have not changed much during the 1960-69 decade (Table 39). Here the oat acreage is minimal but an increase in minimum-tillage practices with its plant residues provides for successful overwintering of the borers and offsets any population disadvantages which might be caused by lack of oats.

Average summer populations have shown a decreasing trend in Cuming County which may be associated with the relatively cool growing seasons which have prevailed during much of the 1960-69 decade.

Except for the record high population of 68,645 borers per acre for 1969, the average fall populations in Cuming Conty showed a decreasing trend over the previous nine years.

In Hall County, the same decreasing population trend occurred for the summer and fall generations with the exception of the 1960-

Table 40. Average plant populations, percent infestation and number of borers per stalk in Cuming and Hall Counties, Nebraska, 1955–1969.

County	5-yr. period	Avg No. plants/acre	Summer		Fall	
			Avg % stalks infested	Avg No. borers per stalk	Avg % stalks infested	Avg No. borers per stalk
Cuming	1955–59	11,158	45.3	0.57	82.6	3.25
Cuming	1960–64	11,930	42.8	0.44	88.6	1.84
Cuming	1965–69	14,036	28.0	0.21	73.5	1.77
Hall	1955–59	13,768	30.4	0.18	89.3	2.31
Hall	1960–64	14,677	29.3	0.27	93.3	2.17
Hall	1965–69	17,745	14.8	0.11	77.0	1.41

64 summer populations which averaged higher than that for either the previous or following 5-year periods.

As the plant populations increased in both counties, the percent of stalks infested and average number of borers per stalk tended to decrease (Table 40). The implication of this relationship might be construed that under higher plant populations, the detrimental economic effect of borers would be lessened.

The comparison of the sequences of *Perezia* infection expressed in percentage of larvae infected in the field in the fall and the summer and fall borer populations in Hall and Cuming counties during the 1965-1969 period indicate *Perezia* was a limiting factor of considerable importance in Nebraska in different parts of the state. The complete absence of *Perezia* infection in fall-collected borers in Cuming County during 1967, 1968 and 1969, contrasted to the 35, 40 and 40% infections in Hall County for the same years, should partially explain the great average differences in borer populations in the two counties during the summer and fall of 1968 and 1969 (Tables 28 and 35 and Figures 7 and 8).

Of particular interest is the complete disappearnce of *Lydella*

Table 41. Borer population infected with *Perezia pyraustae*, parasitized by *Lydella thompsoni* or by *Horogenes punctorius* in Cuming and Hall Counties, Nebraska.

Affective agent	Percent borer parasitized or infected in the fall of year indicated.						
	1965	1966	1967	1968	1969	1970	1971
				Cuming County			
Lydella	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Horogenes	9.6	11.8	13.4	8.1	6.2	7.8	14.9
Perezia	88.0	8.0	0.0	0.0	0.0	48.0	100.0
				Hall County			
Lydella	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Horogenes	0.0	0.6	2.8	10.6	6.6	3.0	3.1
Perezia	30.0	8.0	35.0	40.0	40.0	20.0	0.0

thompsoni from both counties beginning in 1966 (Table 41). Whereas, *Horogenes punctorius* was first found in Hall County in 1966 and the fall collections from both counties have shown a certain percentage of the borer larvae to be parasitized by this species each year, reaching a peak of 13.4% in 1967 and 10.6% in 1968 for Cuming and Hall counties, respectively.

REGIONAL FLUCTUATIONS IN BORER POPULATIONS

The fluctuations in borer populations over the region during the three principal census seasons for the years studied will be discussed as follows:

1. Relation between the populations over the three seasons. The spring census dealt with the overwintering larvae, the summer census with the mature first generation larvae and the fall census with the larvae entering hibernation. It is to be expected that the population will show increases at each successive census during any given year. This relationship was generally true throughout the region. However, exceptions occurred when the population was lower in summer than in late spring (Boone, 1955, 1958, 1962 and 1969; Cuming, 1956 and 1959; Hall, 1956, 1963, 1968 and 1969), or lower in fall than in summer (Waseca, 1956, 1961, 1962, 1965 and 1967). That exceptional cases were found in different years and different locations suggests that they resulted from independent and varied causes.

The four lower summer populations of the 1950's in Nebraska occurred in the only four times that June was warmer and dryer than normal. In 1968 when the Hall County summer populations were lower than in the spring, June also was warmer though wetter than normal, but in 1969 when the summer population was again lower than the spring populations, June was the coolest recorded during the 1955-1969 period. Perhaps this very cool month plus the stress of a *Perezia* infection contributed to the low population of 1969 in Hall County. It was also cool and dry in Cuming County in 1969 but no *Perezia* was recorded in that county and "a normal" increase in borer numbers occurred from spring to summer.

July was always very cool in the years fall populations were lower than summer populations in Waseca County, Minnesota. July also was very cool in 1958 in Minnesota when fall and summer populations recorded were identical.

The fact fall borer populations are frequently lower than summer populations in Minnesota is an expression of the northern ecotype interacting with ecological conditions in this more northern location. Fall populations always have been greater than summer populations in the Iowa, Missouri and Nebraska counties.

2. Population peaks within a locality. One of the purposes of this study was to determine if the fluctuations of borer populations are

cyclic, *i.e.,* have regularity in the occurrence of population peaks. Chiang and Hodson (1959) studied the fluctuations of borer population in Waseca County on the basis of one field each year for a period of 10 years. They observed no cyclic fluctuations. Because of the multitude of factors which affected populations, these authors suggested that it is doubtful that population peaks will occur at any regular intervals more often than by chance. No definite cyclic fluctuations could be detected from the present study for any census locality.

3. Population peaks within the region. Another main objective was to determine if fluctuations in different parts of the region were synchronized. Chiang *et al.* (1961) showed that peaks for the three major yearly censuses in any given locality do not generally occur the same year. Results of the recent ten-year extension of this study further confirm that fact. However, an examination of the "peaks" and "lows" for the 15-year study does seem to indicate a *tendency* for the populations in certain parts of the region to be synchronized. If one considers the "peaks" for the six counties—Waseca, Boone, Cuming, Hall, Carroll and New Madrid—it will be noted that peak borer populations occurred in 50% or more of this region during the following periods:

Fall 1957, Spring 1958 and Summer 1958.
Fall 1960.
Summer 1961.
Fall 1963, Spring 1964 and Summer 1964.
Fall 1966, Spring 1967 and Summer 1967.

The three three-peak sequences began with the fall population (Table 42). This would indicate the growing seasons of 1957, 1963 and 1966 were favorable for corn borer development. In 1969 at the end of the third five-year census period, the borer entered "a period of prosperity" with its numbers on an unprecedented increase throughout the entire area. Record breaking fall populations occurred in 1970 or 1971 in all four states. This is illustrated in Figures 9, 10, 11, 12, 13 and 14.

Average borer populations over the entire study area were lower during the 1960-64 period than they were during the 1955-59 period. Only summer populations in Hall County and fall populations in Carroll and New Madrid Counties were higher during the second five-year period (Table 43). Average summer populations continued to decrease in Minnesota, Iowa and Nebraska but increased in the two Missouri counties during the third 5-year period. Except in Waseca and Hall Counties, average fall populations were greater in other counties during 1965-69 than in 1960-64. Over the 15-year period (1955-69) both summer and fall populations in Minnesota decreased. In Missouri average fall populations have continually increased (Table 43). Average quantitative changes in borer populations are shown in Table 44. The Waseca County average of 9.0

Table 42. Number of counties[a] showing "peak" populations at indicated seasons and the average multiple change for all populations during indicated season.

	No. counties with peaks	Average multiple change in populations
1955—Spring	1	.....
Summer	2	1.0 (spring to summer)
Fall	2	7.7 (summer to fall)
1956—Spring	3	.....
Summer	2	1.2
Fall	2	8.2
1957—Spring	0	.....
Summer	1	5.7
Fall	5	9.6
1958—Spring	4	.....
Summer	4	1.8
Fall	1	2.9
1959—Spring	1	.....
Summer	0	2.4
Fall	0	6.1
1960—Spring	0	.....
Summer	2	12.0
Fall	5	10.2
1961—Spring	2	.....
Summer	3	6.4
Fall	2	3.9
1962—Spring	2	.....
Summer	2	4.0
Fall	2	7.0
1963—Spring	2	.....
Summer	0	3.5
Fall	3	11.0
1964—Spring	3	.....
Summer	4	4.4
Fall	1	5.2
1965—Spring	0	.....
Summer	1	6.9
Fall	1	4.5
1966—Spring	0	.....
Summer	1	12.6
Fall	4	7.9
1967—Spring	5	.....
Summer	4	4.2
Fall	1	3.9
1968—Spring	0	.....
Summer	0	8.2
Fall	1	24.0
1969—Spring	6	.....
Summer	5	21.2
Fall	5	15.2

[a] Six counties involved; Waseca, Boone, Cuming, Hall, Carroll and New Madrid.

Table 43. Average corn borer populations for counties studied, 1955–1969.

		Corn borer populations in:		
		Late spring	Summer	Fall
		Average number borers per acre for 1955–59		
Minnesota	(W)	300	1,960	4,560
Iowa	(B)	4,911	4,695	13,504
Nebraska	(C)	2,581	6,244	36,957
	(H)	2,138	2,719	31,475
Missouri	(C)	952	2,167	7,871
	(NM)	356	730	2,474
		Average number borers per acre for 1960–64		
Minnesota	(W)	120	934	2,375
Iowa	(B)	2,112	2,581	10,446
Nebraska	(C)	1,375	5,300	21,414
	(H)	1,206	4,054	31,252
Missouri	(C)	304	1,143	10,307
	(NM)	101	518	4,867
		Average number borers per acre for 1965–69		
Minnesota	(W)	150	462	1,023
Iowa	(B)	1,614	2,424	13,996
Nebraska	(C)	1,042	2,917	25,571
	(H)	1,229	1,956	24,543
Missouri	(C)	148	2,454	14,073
	(NM)	187	1,323	8,966
		Average number borers per acre for 1955–69		
Minnesota	(W)	190	1,119	2,653
Iowa	(B)	2,879	3,233	12,649
Nebraska	(C)	1,666	4,820	27,981
	(H)	1,524	2,910	29,090
Missouri	(C)	468	1,921	10,750
	(NM)	215	857	5,436

for late spring to summer increases and the 2.6 for summer to fall populations might be expected for a northern area where first generation larvae diapause more readily than elsewhere in the region. Also, the relatively high average of 19.3 for summer to fall increases in Hall County may reflect the influence of irrigation on the borer ecology. It is not possible to account satisfactorily for high average increase of 12.4 (15-year average) and 21.6 (1965-69 average) from spring to summer in Carroll County, Missouri.

A geographical comparison of the average borer populations from north to south for the 15-year period (1955-1969) is evident in Table 43. On an average spring, summer and fall populations were low in the north (Waseca) and highest in the central part (Boone, Cuming and Hall) and decreasing again toward the south (Carroll and New Madrid). These population relationships were similar during all three census study periods.

A SUPPLEMENTARY STATEMENT

At the end of the third five-year census period, 1965-69, corn

Table 44. Average multiple changes in borer populations in four North Central states for three census periods (1950–59, 1960–64 and 1965–69).

	From late spring to summer				From summer to fall			
	1955–59	1960–64	1965–69	15-year Avg	1955–59	1960–64	1965–69	15-year Avg
Waseca	8.0	12.4 (3 yrs.)	7.8	9.0	4.1	2.0	1.7	2.6
Boone	1.5	1.4	1.8	1.4	2.7	5.7	7.7	5.4
Cuming	–0.2 (4 yrs.)	4.6	3.3	2.7	10.6	4.6	10.1	8.4
Hall	0.9 (4 yrs.)	5.5	–0.3	2.3	16.1	9.4	32.4	19.3
Carroll	1.8 (2 yrs.)	6.3 (4 yrs.)	21.6	12.4	2.7 (4 yrs.)	9.2	6.8	6.5
New Madrid	1.9 (2 yrs.)	8.0	6.0	6.2	3.4 (4 yrs.)	14.0	8.1	8.8

borer populations entered "a period of prosperity" and rose to record breaking numbers throughout the four-state area during 1970 and 1971. Then in 1972 the populations again dropped to low levels. This is illustrated in Figures 9, 10, 11, 12, 13 and 14. It is believed weather conditions became unusually favorable over the region permitting the borer to more nearly realize its biotic potential. This widespread upturn in borer populations also occurred when biological factors (i.e.., disease and parasites) were at a minimum over much of the area.

In 1970, Showers and Reed (1971) determined that 40% of the second generation borers pupated, emerged, mated and deposited egg masses that contributed to a third generation. Some of these third generation individuals attained the 5th instar and hibernated. Therefore, the borer population that entered the 1970-71 winter in Iowa was composed of 2nd and 3rd generations. The existence and high survival, respectively, of the third generation are directly attributable to long season corn hybrids and the favorable temperatures throughout July, August and September 1970.

In Minnesota field observations showed that all larvae of the first generation pupated in 1970 and the long warm fall season permitted a very high percent of the second generation to reach maturity. Thus under favorable weather conditions, this insect can still constitute an economic threat. The great reduction in population in 1972 resulted from a cool, backward and late season plus some pressure from a resurgence of biological factors (i.e., disease and parasites).

SUMMARY

This corn borer census study has been conducted in six counties in four states in the north central United States from 1955 to 1969 inclusive. Standardized procedures were followed in gathering the data. In some instances observations peculiar to individual states were also obtained. Nevertheless the study had several definite objectives. The main objectives and the results obtained under each are summarized in the following paragraphs.

1. *To follow the annual changes in corn borer populations in widely separated localities in the North Central Region for a period of many years.* In this report data are presented for the third five-year period (1965-69) from Minnesota, Iowa, Nebraska and Missouri. Thus borer fluctuations have been recorded for a period of 15 years over much of this region. This is a relatively short period of observation but certain patterns pertaining to the general borer distribution within the region, levels of abundance and seasonal activity have been recorded. It is evident the reasons for these patterns are quite complex and for the most part must await elucidation by further field and laboratory studies.

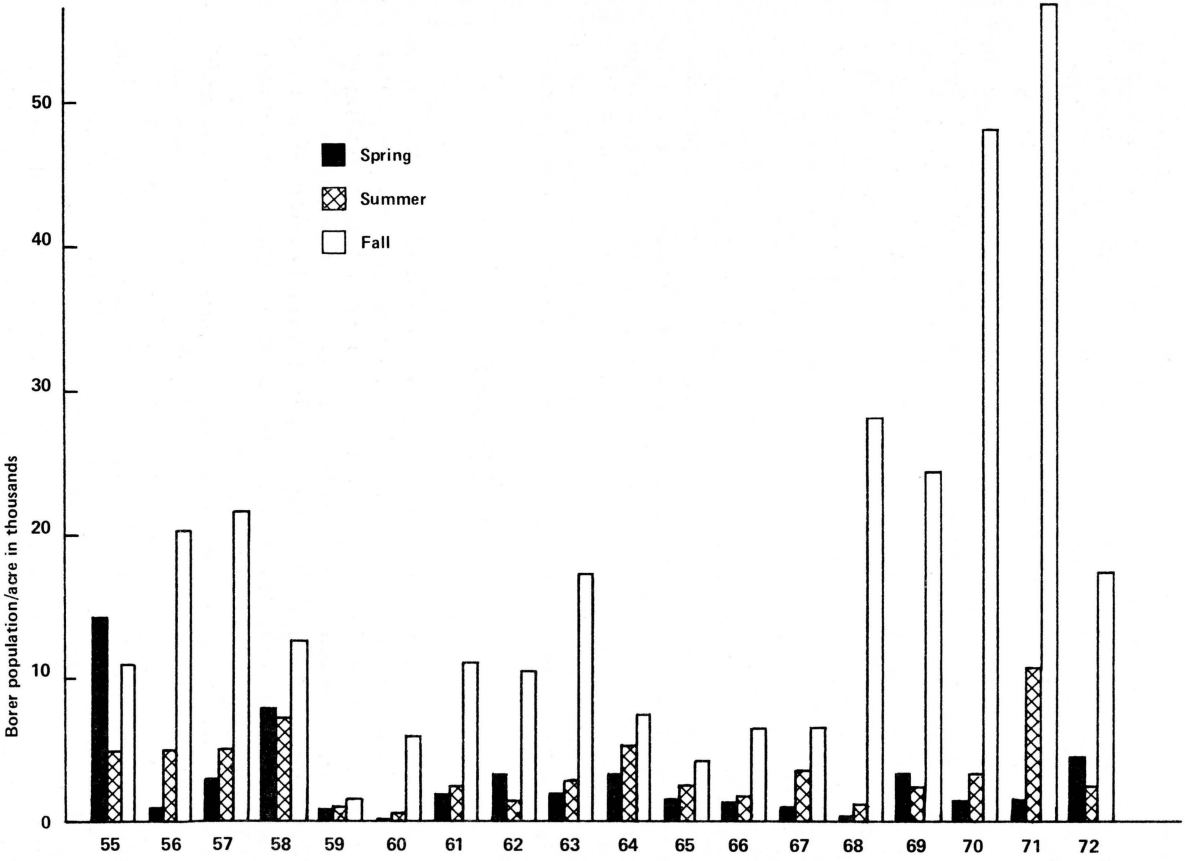

Fig. 9. Average number of borers per acre, Boone County, Iowa, 1955-72.

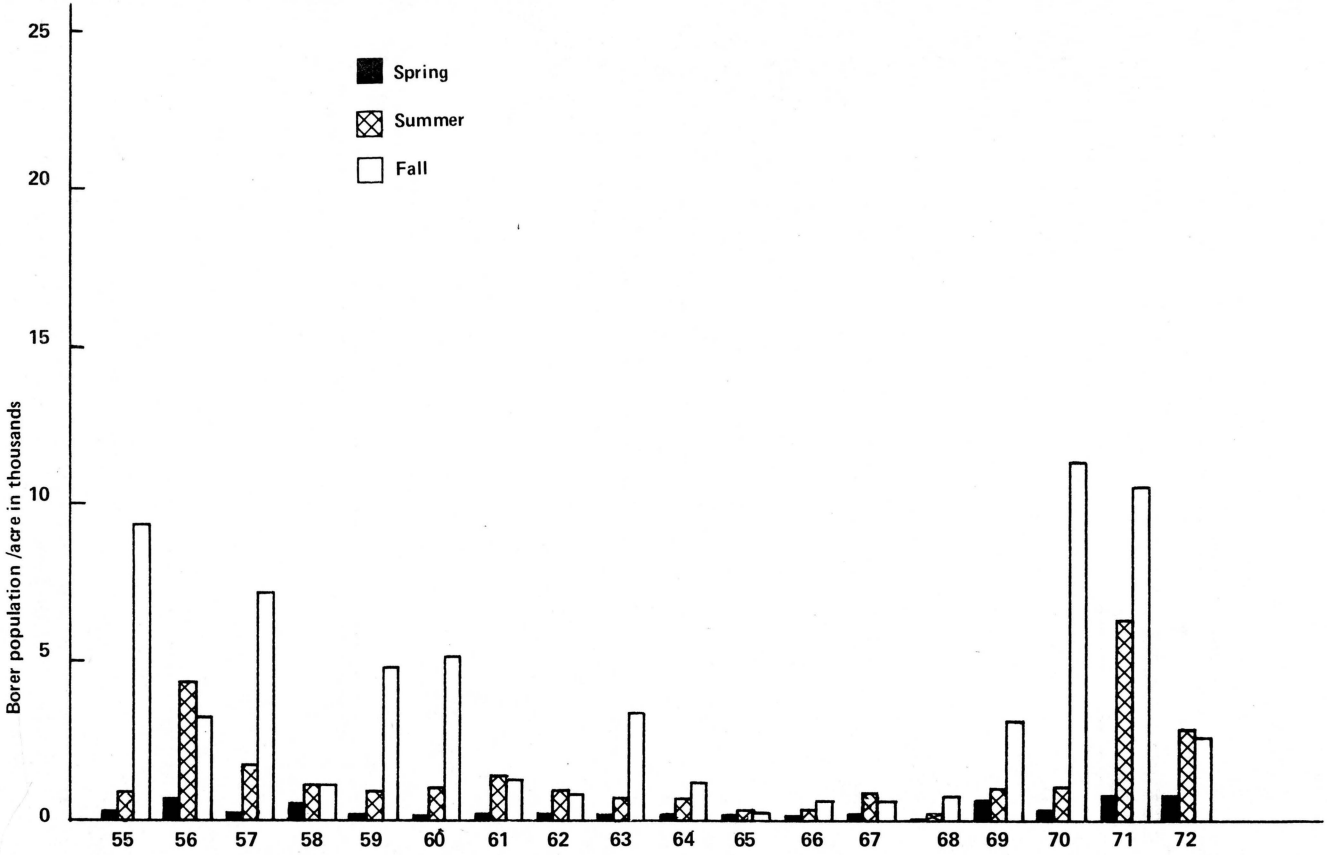

Fig. 10. Average number of borers per acre, Waseca County, Minnesota, 1955-72.

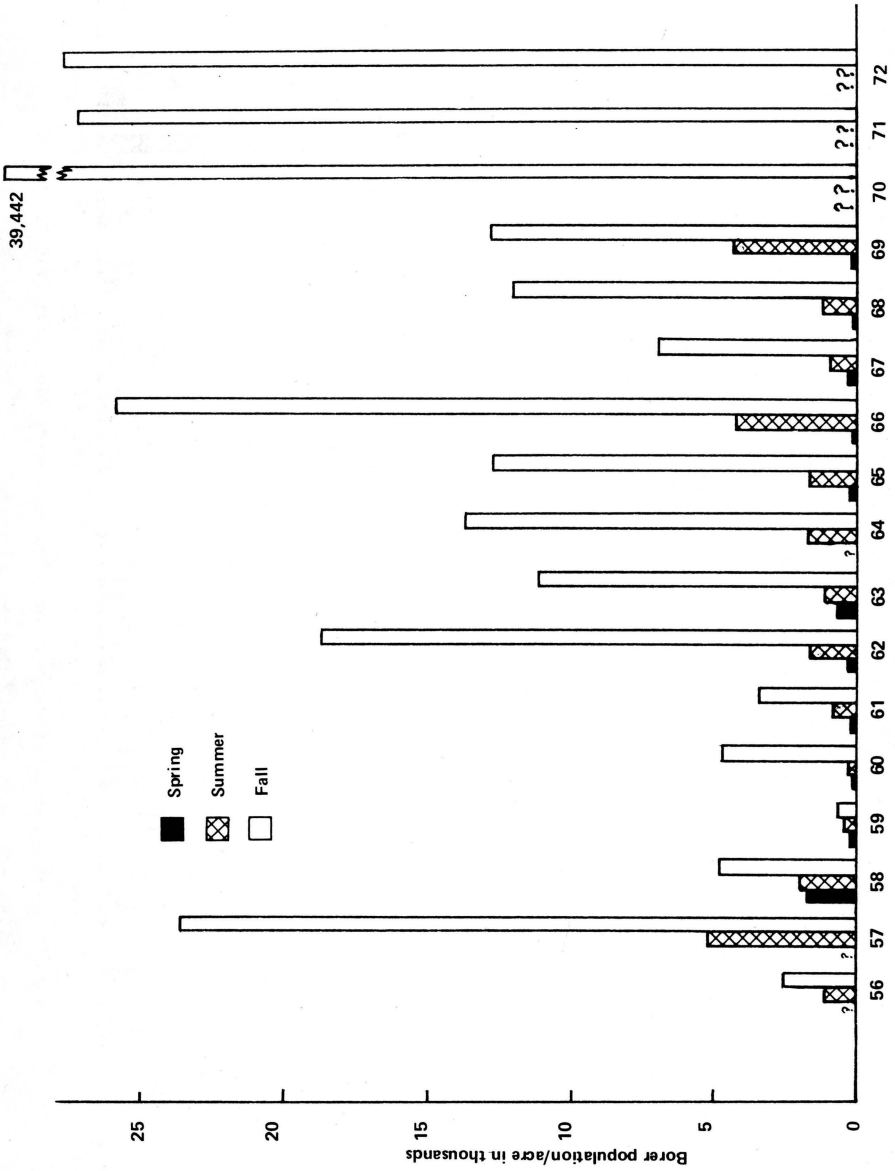

Fig. 11. Average number of borers per acre, Carroll County, Missouri, 1956-72. Data for 1970, 1971 and 1972 based partially on Extension Survey Entomologist's records.

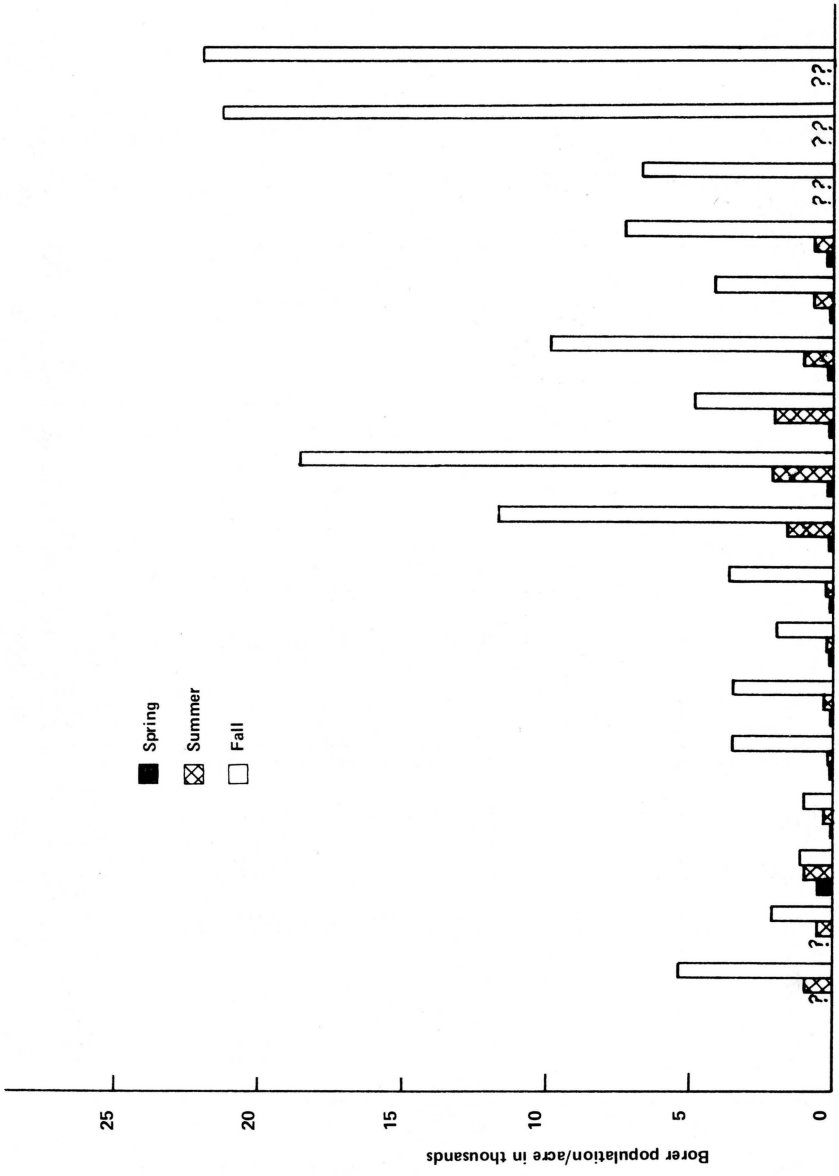

Fig. 12. Average number of borers per acre, New Madrid County, Missouri, 1956-72. Data for 1970, 1971 and 1972 based partially on Extension Survey Entomoligist's records.

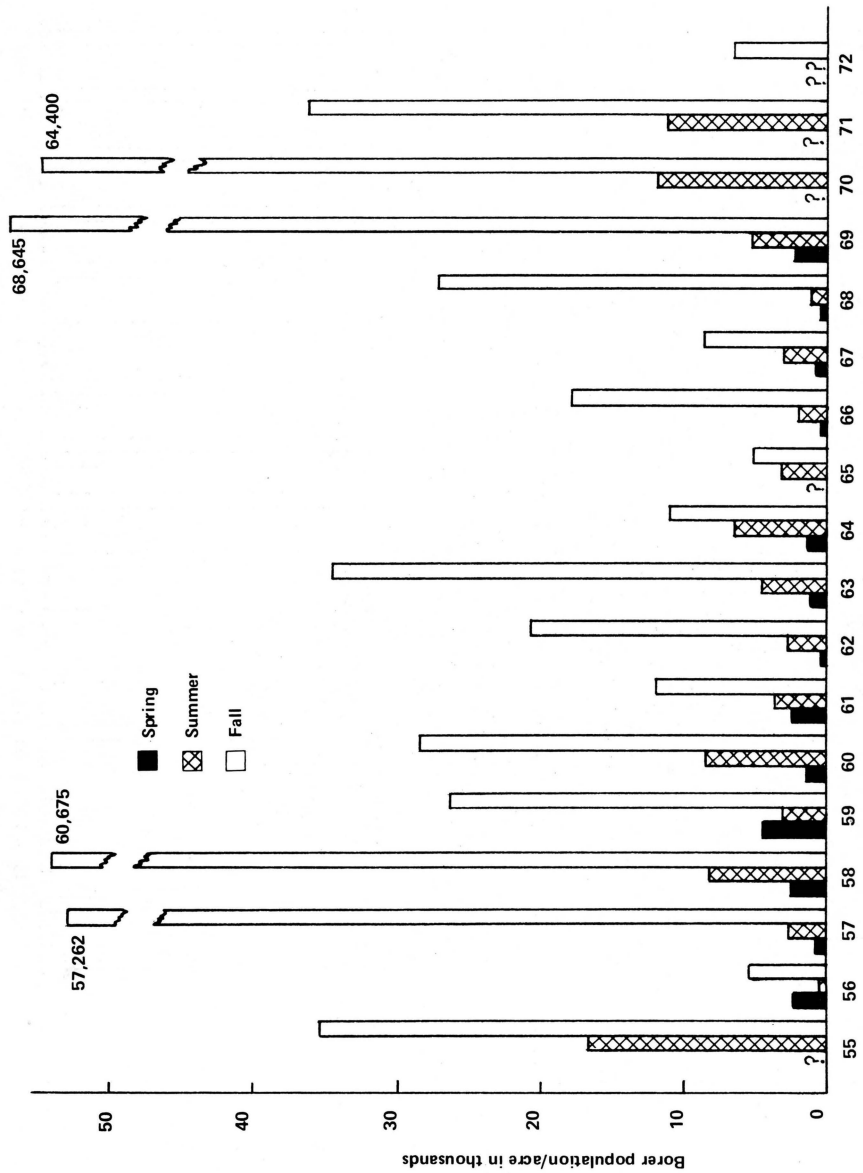

Fig. 13. Average number of borers per acre, Cuming County, Nebraska, 1955-72. Data for 1970, 1971 and 1972 based partially on Extension Survey Entomologist's records.

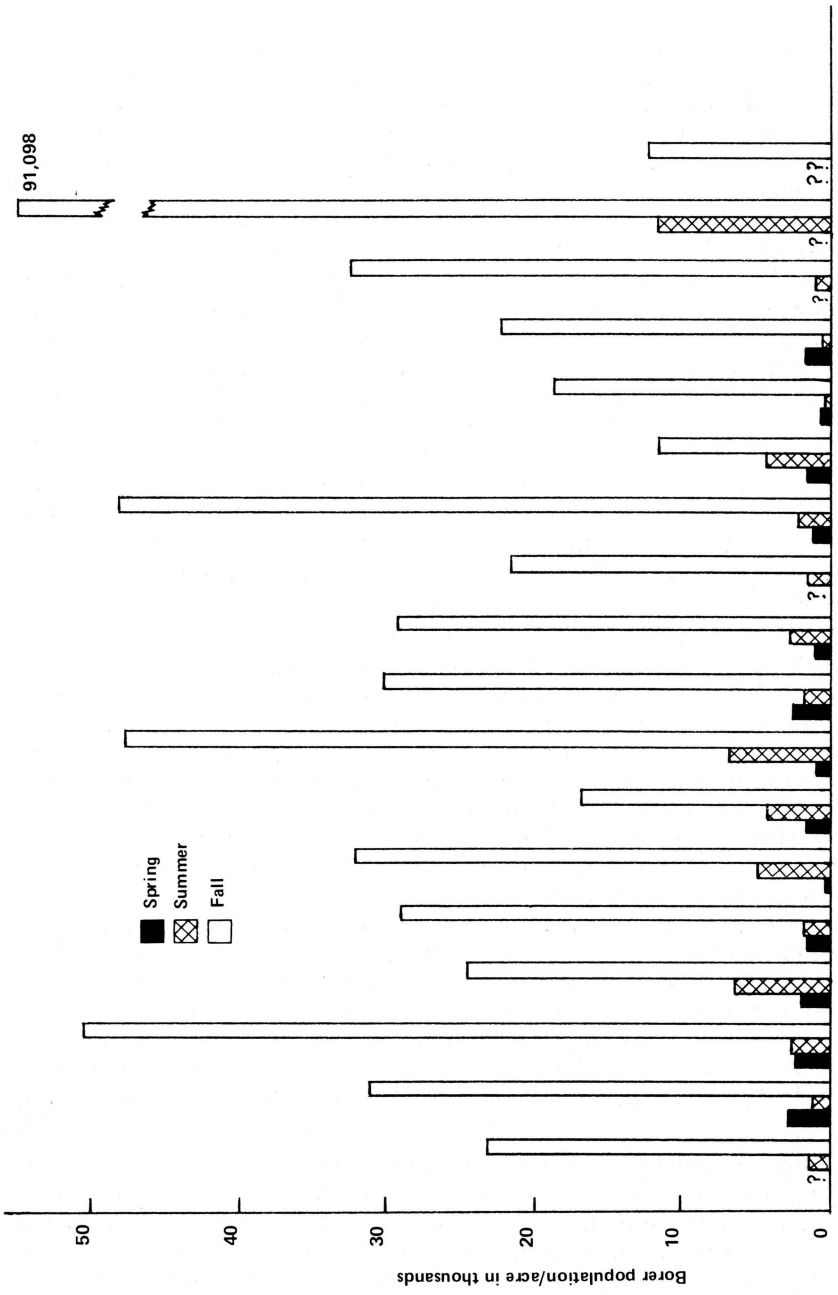

Fig. 14. Average number of borers per acre, Hall County, Nebraska, 1955-72. Data for 1970, 1971 and 1972 based partially on Extension Survey Entomolgist's records.

2. *To evaluate the effect of climatic factors on borer populations.* Weather conditions greatly influenced borer populations, both favorably and unfavorably. Isolated effects of rainfall and temperature on borer populations have been noted but the interactions of these factors probably are very important and if understood would explain the inconsistent temperature-rainfall-borer relationships reported from different localities and different years. In each of the four instances when and only when the summer population was lower than the spring population in Nebraska, June was warmer and dryer than normal. However, in 1968, when June was warmer but wetter than normal, borer populations in Hall County were lower in the summer than in the spring. In 1969, the same spring-summer population sequence occurred when June was dry but very cool—the coolest of the 15-year census period. In Iowa a reduction in population from spring to summer in 1955 was attributed to cool windy weather in June. June was dry, however. Second generation (fall) populations in Cuming County, Nebraska have been shown to be significantly and positively associated with total rainfall during June, July and August. Low fall populations in Waseca County Minnesota all were associated with cooler than normal Julys. Other weather-borer relationships are given in the various state reports.

3. *To analyze the effect of soil and crop management on the borer populations.* There is a relationship between date of planting corn and borer populations. In Iowa, Minnesota, Missouri and Nebraska, farmers have been planting corn increasingly earlier in the season. First-generation populations in all counties are greater on earlier planted corn, whereas the second generation is heavier on later plantings. During the 15 years (1955-69) more farmers have planted corn after corn. In Minnesota this continuous corn has been at the expense of fewer corn-oats sequences. This gradual decrease in corn-oats over the 15-year period may have contributed to a decrease in borer populations in that state. A similar situation may prevail in Iowa and Nebraska (Cuming County) where the acreage planted to oats is down and to soybeans up. Continuous corn planting is greatest in Hall County where 92% of the corn follows corn. The trend toward corn after corn also is evident in Missouri (Carroll County) but in New Madrid County there has been a recent decrease in corn after corn.

The planting of oats in the previous year's cornfield leads to higher spring populations than where more intensive cultivation practices destroy or bury old cornstalks. Minimum tillage practices, which are becoming more widely followed in Nebraska, are conducive to higher spring borer populations. In all states fall borer populations are reduced by mechanical picking operations each year. The increased use of picker-shellers may also reduce borer populations in some areas by eliminating the storage of corn-ears containing overwintering larvae.

In the Minnesota report it was noted the host resistance level of the recently planted corn hybrids is higher than for hybrids popular 10 years earlier. Thus the host factor has become less favorable to borers in recent years. In Iowa, researchers believe some of the greater multiple increases of fall populations over summer populations for the 1965-69 period compared to the 1960-64 period were due to host plant resistance to first-generation borers followed by a high percentage of pupation and emergence by the survivors and a lack of such resistance to the second brood.

All states report increased use of commercial fertilizers during recent years. Fertilizer use and borer populations were noted in Cuming County. Although previously (1960-64) a direct relationship was noted in the number of borers per acre and number of years fertilizers were applied, the first generation of the 1965-69 period was not affected. However, the second-generation population was greater on corn growing in fertile soil compared to corn in fields where commercial fertilizers were not used.

Irrigation was practiced in Nebraska. During the recent two cooler and wetter five-year census periods the influence of irrigation on borer populations was not so noticeable as during the dryer 1955-59 period. However, the highest 15-year average multiple borer increase (19.3) from summer to fall in Hall County indicates irrigation provides favorable conditions for borer development.

4. *To determine the presence, or the lack, of synchronization of the changes of borer populations.* Average borer populations over the entire study area were lower during the 1960-64 period than during the 1955-59 period. Only the populations for the first generation in Hall County and the second generation in Carroll and New Madrid Counties averaged higher during the second five-year period. For the 1965-69 period, average overwintering (spring) populations over the entire area remained lower than during the 1955-59 period; the same was true for the first generation except in Missouri where the populations averaged higher. The second generation averaged higher in Missouri and in Boone County but was below that recorded in 1955-59 from Waseca, Cuming and Hall Counties.

Data over the 15-year period show some correlation between borer numbers within counties from one census to the next. Fourteen three-season-peak sequences were recorded (two in Waseca, three in Boone, four in Cuming, three in Hall, and two in Carroll). Similarly seventeen three-season-low sequences were recorded (two in Waseca, two in Boone, five in Cuming, three in Hall, three in Carroll and two in New Madrid).

An examination of the "peaks" and "lows" for the 15-year study indicates a tendency for the populations in certain parts of the North Central Region to be synchronized. An examination of data from Waseca, Boone, Cuming, Hall, Carroll and New Madrid reveals that

peak borer populations occurred in 50% or more of this region during fall of 1957, spring and summer of 1958, fall of 1960, summer of 1961, fall of 1963, spring and summer of 1964, fall of 1966 and spring and summer of 1967.

5. *To develop a sampling method which may be adopted for routine borer surveys.* In the initial 5-year study (Chiang *et al.* 1961), the validity of the sampling method was discussed in some detail. The general conclusion reached was "the present scheme of two fields per township and three sites per field (five sites per field in the late spring census) appears to be adequate and no changes are recommended." It was further concluded that "if the sample size should be changed in the future, in no case should less than two fields per township and/or two sites per field be checked."

6. *To evaluate the effect of biological agents on borer populations.* The Iowa and Nebraska reports discuss the effects of parasites and disease on the borer populations. In Iowa a high *Perezia pyraustae* infection combined with the abnormally cool August and cool September of 1964 was suspected to have contributed to the greatest fall to post-harvest reduction in borer populations recorded in that state. The incidence of *Perezia* fell to a low level in 1966 and remained low and is considered one of the contributing factors for the increased fall borer populations of 1968 and 1969 in Iowa which were the highest since 1967. The complete absence of *Perezia* infection in the fall-collected borers in Cuming County during 1967, 1968 and 1969, contrasted to the 35, 40 and 40% infections in Hall County for the same years, should partially explain the great average differences in borer populations in these two Nebraska counties during the summer and fall of 1968 and 1969.

The parasites, *Lydella thompsoni* Herting and *Horogenes punctorius* (Roman) also have been factors of importance in Nebraska. Since 1966, *Lydella* has disappeared but *Horogenes* has been recovered from the fall borer collections each year, the percentage parasitized reaching 13.4% in 1967 and 10.6% in 1968 for Cuming and Hall Counties, respectively.

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ACKNOWLEDGMENTS

Data presented in this study were collected on many farms. The generous cooperation of the corn growers listed below is gratefully acknowledged.

Boone County, Iowa: Ronald Curry, Albert Doran, L. W. Ensley, A. K. Erickson, Tom Fisher, Donald Grimm, Richard Hoppe, Orval Hunter, Lyle Hurley, Dwayne Kammin, Roland Kruse, Norman Malcomb, Edward Larson, George Leonard, James Miller, Bob Morgan, Marion Mowrer, R. H. Murken, Eldon Olson, Burton Patterson, L. V. Patterson, James A. Poling, Jim Powers, Lorenzo Riech, Delmer Rietteur, Cleo A. Rinehart, Fred Rothfus, David Snyder, Donald Sturtz, C. M. Sundberg, Clarence Wisecup, Jr.

Waseca County, Minnesota: Loren Abraham, Otto Anderson, Quentin Bach, Edward Baarts, Ted Berndt, Herman Born, John Cawley, Mansfield Dahle, Henry Dimmel, Art Dobstein, Alvin Dumdie, Eldo Ewert, John Flintrop, Elmer Grossman, Marvel Hendrickson, Ernest Henkenseifken, David Hodgkins, Roger Keiser, Arnold Keller, Victor Kleunder, Clarence Korfe, Elmer Krause, Herman Krienke, Donald Kuhns, Leonard Miller, Louis Miller, Rubin Miller, Ralph Phillips, Vernon Pommerenz, Alfred Proechel, Keith Remund, Elmer Scheffert, Robert Schweer, John Sheldon, Willard Shollejegerdes, Loren Smith, Roland Steinhaus, Harold Sybilrud, Gordon Tollefson, Victor Trahms, Rodger Wilmes, David Zimmerman.

Carroll County, Missouri: Donald Amery, Homer P. Austin, Gary L. Baxter, Gerald Carr, Marvin Collier, Rudolph Drehle, Holton H. Eschenbach, Hugh I. Furry, R. G. Griffin, B. M. Grimpo, L. Dale Hinson, Roy Kelb, Mitchell Kincaid, Louis J. Kolster, Leo Martin, Ralph E. McBee, Oscar J. Miller, Marvin Moentmann, Charles Monk, Floyd Oglesbee, Aubrey Sherwood, Claude H. Stroud, Milton Tietjens, Lawman Wallace, Ivan J. West, Clinton Winfrey.

New Madrid County, Missouri: Joe Bader, K. H. Bell, Terrell Bennett, Jay Blankenship, A. P. Broom, Roland Byrd, Perry L. Clark, Harold Chartrau, Weldon Fortner, Charles Gardner, Jackson Haines, C. D. Heath, Henry Hulshof, E. V. Jewett, Harold Keaster, Cecil LaPlant, Everett Leirer, Collis Maltbia, Maxwell Brothers, Charles Penman, J. V. Robinson, Hugh Rogers, James Roth, Shannon Russell, Clyde Scott, Clyde Scott, Jr., O. A. Sisk, Glen Slusher, Jim Stoffer, W. P. Taylor, John Weeks, Robert Williams.

Cuming County, Nebraska: Delwin Anderson, Gail Anderson, Merlin Anderson, Rudy Bazata, Jr., Quentin Bleyhl, Willie Brockemeier, George Brester, Henry Buse, Duane Clatanoff, Arnold Daberkow, Herman Dinslage, Melvin Dislage, Gerald Ehler, William Galbraith, A. K. Glaubius, Leslie Glaubius, Gordon Gatzmeyer, Ira Grunke, Frank Hagedorn, Len Hagedorn, Lumir Hanzel, Ronald Hanzel, Clarence Heimann, Leo Knievel, August Leisy, Adrian Lofgren, Verne Lofgren, Fred Meyer, Virgil Nixon, Paul Repschlaeger, Edmund Schleuter, Arlie Schultz, Edward Stratman, Larry Ulrich, Martin Weiler, Leonard Wordekemper, Leonard Wortman.

Hall County, Nebraska: Clyde Batie, Loyd Boeka, Herbert Bredthauer, Leland Bredthauer, Loren Bruce, Alvin Denman, Robert Denman, Wayne Foster, Donald Frauen, Darrel Gloe, Edward Hartman, William Haskins, Doyle Hendrickson, Ronald Hervert, Vernon Heupel, Dean Hinkson, Dale Hongsermier, Orville Hulme, Robert Johnson, Louis Klintworth, Allen Losee, C. A. Lowry, George Mader, Charles McCullough, Paul Mecham, Orville L. Meyer, Everett Mieth, LaVern Moss, Lloyd Muller, Robert A. Neidfelt, Alfred Petzoldt, Harry Preisendorf, Elmer Rauert, Albert Sass, Donald Starr, Eli Thomssen.

APPENDIX I

I. A. Weather conditions in Boone County, Iowa, during growing season.

Month	1965	1966	1967	1968	1969
			Average temperature for month (°F.)		
May	64.6	58.6	58.2	58.3	61.8
June	68.8	69.7	69.2	72.7	66.5
July	74.5	78.3	72.1	73.7	75.5
August	72.9	69.1	70.4	73.4	73.7
			Total rainfall for month (inches)		
May	4.63	4.66	2.21	2.81	2.93
June	4.48	8.51	11.18	8.83	5.88
July	1.56	1.12	2.22	1.68	2.68
August	3.59	2.03	1.57	3.80	1.30
			Borer-degree day accumulations		
April 15	8.5	42.0	126.5	145.5	43.0
May 1	105.0	98.5	207.5	238.5	114.0
May 15	368.5	209.0	253.0	377.0	275.0
June 1	584.5	424.5	506.0	498.5	511.5
June 15	830.0	649.5	789.0	849.5	696.0
July 1	1155.5	1034.5	1096.5	1176.0	1006.5
July 15	1465.5	1464.5	1376.0	1508.0	1381.0
August 1	1874.0	1915.0	1813.5	1910.0	1795.5
August 15	2219.5	2193.5	2105.5	2254.5	2125.0
September 1	2511.0	2545.0	2427.0	2633.0	2527.5

I. B. Weather conditions in Boone County, Iowa; deviation from long-term normal.

Month	1965	1966	1967	1968	1969
			Monthly temperature		
May	+3.3	−2.7	−3.1	−3.0	+0.5
June	−2.2	−1.3	−1.8	+1.7	−4.5
July	−1.5	+2.3	−3.9	−2.3	−0.5
August	−0.8	−3.1	−3.3	−0.3	0.0
			Monthly rainfall		
May	+0.32	+0.35	−2.10	−1.50	−1.38
June	−0.80	+3.23	+5.90	+3.55	+0.60
July	−2.32	−2.76	−1.66	−2.20	+2.68
August	−0.32	−1.83	−2.34	−0.11	−2.61

I. C. Fertilizer treatments in fields used in Boone County, Iowa.

Fertilizer application	Percent of fields	
	1965	1966
NPK combinations	59	73
Anhydrous ammonia (side dress)	63	70
Starter fertilizer	53	50
Manure	13	10
None	6	10
Total fields checked	32	30

I. D. Previous year's crop in fields used in Boone County, Iowa.

Previous crop	Percent of fields	
	1965	1966
Corn	38	27
Clover	....	....
Soybeans	38	27
Oats	9	....
Alfalfa	6	13
Sod	6	13
Soil bank	3	20

I. E. Planting methods and plant population in fields used in Boone County, Iowa.

	Percent of fields	
	1965	1966
Type of planting		
Power checked	72	30
Drilled	28	70
Total fields observed	32	30
Plants per acre		
Less than 10,000	....	....
10,000–10,999	....	....
11,000–11,999	....	....
12,000–12,999	3	....
13,000–13,999	....	....
14,000–14,999	....	....
15,000–15,999	....	....
16,000–16,999	28	7
17,000–17,999	16	17
18,000–18,999	19	33
19,000–19,999	9	10
20,000 plus	25	33
Average	18,324	19,228
Total fields observed	32	30

I. F. Corn hybrids used in fields for study in Boone County, Iowa.

Hybrid	Percent of fields	
	1965	1966
Crows 408	3	0
Crows 428	3	6
Crows 722	3	0
DeKalb 341A	0	3
DeKalb 361	0	9
DeKalb 441	0	3
DeKalb 640	3	0
DeKalb XL45	0	12
DeKalb XL65	3	0
Funks 6	3	0
Funks 75	3	0
Funks G37	3	0
Funks G81	3	0
Funks G93	3	3
Funks G4582	6	6
Funks unknown	0	6
ISU C112	3	0
Iowa Wealthy	0	3
Moews 67A	0	3
Moews 530	6	0
Northrup King 598	3	0
Pfister 18	3	0
Pfister 58	0	3
Pfister 418	3	0
Pfister 440	0	3
Pioneer 329	6	0
Pioneer 3206	3	9
Pioneer 3280	9	3
Pioneer 3291	0	3
Pioneer 3304	3	3
Pioneer 3306	0	6
Pioneer 3414	3	0
Pioneer 3418	3	0
Pioneer 3484	3	0
Pioneer unknown	6	0
Tomco 612	3	0
Tomco 812	3	3

APPENDIX II

II. A. Weather conditions in Waseca County, Minnesota, during growing season 1965–69.

Month	1965	1966	1967	1968	1969
			Average temperature for month (°F.)		
May	58.5	51.3	51.7	53.2	58.7
June	66.3	66.3	65.7	66.8	59.8
July	69.3	73.2	68.3	69.5	70.4
August	66.3	65.4	65.2	68.5	69.3
			Total rainfall for month (inches)		
May	3.75	1.68	1.74	3.68	3.19
June	2.90	3.94	9.01	6.59	5.47
July	3.84	1.87	4.10	7.54	3.10
August	4.71	4.68	3.69	3.12	2.35

II. B. Weather conditions in Waseca County, Minnesota; deviation from long-term normal.

Month	1965	1966	1967	1968	1969
			Monthly temperature		
May	–0.2	–7.4	–7.0	–5.5	0
June	–1.8	–1.8	–2.4	–1.3	–8.3
July	–3.6	+0.3	–4.6	–3.4	–2.5
August	–4.6	–5.5	–5.7	–2.4	–1.6
			Monthly rainfall		
May	+0.07	–2.00	–1.94	0	–0.49
June	–1.68	–0.64	+4.43	+2.01	+0.89
July	+0.37	–1.39	+0.84	+4.28	–0.16
August	+1.24	+1.21	+0.22	–0.35	–1.12

II. C. Crop history in fields used in Waseca County, Minnesota, 1965–67.

	Percent of fields			
	1965	1966	1967	3 yr. average
Continuous corn	12.5	41.7	50.0	34.7
Two-crop rotations				
Corn-grain	4.2	.....	.....	1.4
Corn-pasture	20.8	8.3	9.1	12.7
Corn-oats	8.3	4.2	9.1	7.2
Corn-soybeans	37.5	29.2	22.7	29.8
Total	70.8	41.7	40.9	51.1
Three-crop rotations				
Corn-soybeans-oats	8.3	4.2	.....	4.2
Corn-grain-pasture	4.2	.....	.....	1.4
Corn-pasture-oats	4.2	4.2	4.5	4.3
Corn-bean-pasture	.....	8.2	.....	2.7
Corn-bean-peas	.....	.....	4.6	1.5
Total	16.7	16.6	9.1	14.1
Total number of fields checked	24	24	22	.....
Previous crop				
Corn	29.2	54.2	60.0	47.8
Sweet corn	.....	8.2	.....	2.7
Grain	4.2	.....	.....	1.4
Pasture	25.0	4.2	4.3	11.2
Oats	8.3	4.2	8.7	7.1
Soybeans	33.3	29.2	26.1	29.5
Total fields observed	24	24	23	.....

II. D. Fertilizer treatments in fields used in Waseca County, Minnesota, 1955–69.

	Percent of fields					
Fertilizer application	1965	1966	1967	1968	1969	Average
NPK combinations[a]	.....	4.2	8.8	4.8	4.2	4.4
NPK combinations + nitrogen	62.5	70.8	56.5	71.4	75.0	67.2
NPK combination + manure	.....	4.2	4.3	4.8	.....	2.7
NPK combination + anhydrous ammonia	.....	.....	.....	.....	12.5	2.5
NPK combination + nitrogen & manure	29.1	20.8	26.1	4.7	.....	16.1
Nitrogen only	4.2	.....	.....	.....	.....	0.8
Manure only	4.2	.....	.....	.....	.....	0.8
No treatment	.....	.....	4.3	.....	4.2	1.7
Unknown	.....	.....	4.3	.....	4.2	1.7
Total number of fields checked	24	24	23	21	24	.....

[a] The NPK combination included the following:

0/23/30	6/23/36	8/32/16
0/23/60	6/24/24	9/23/23
0/24/32	7/18/11	9/23/30
0/25/30	7/24/24	10/26/26
0/30/60	7/26/26	12/24/24
4/12/24	7/27/27	12.5/50/30
4/13/7	7/28/14	15/39/10
4/13/10	7/28/28	16/24/24
4/13/17	8/24/32	18/46/0
5/20/20	8/26/26	

II. E. Planting methods and plant population in fields used in Waseca County, Minnesota, 1965–69.

	Percent of fields					
	1965	1966	1967	1968	1969	Average
Type of planting						
Checked	.....	.....	4.8	.....	.....	1.0
Hilldrop	62.5	41.7	33.3	17.4	8.4	32.7
Drilled	37.5	58.3	61.9	82.6	91.6	66.4
Total fields observed	24	24	21	23	24	.....
Plants per acre, average	16,940	14,060	13,320	16,780	24,740	17,168
Total fields observed	24	24	24	24	24	.....

II. F. Corn hybrids used in fields for study in Waseca County, Minnesota, 1965–69.

	Percent of fields					
Hybrid	1965	1966	1967	1968	1969	Average
Blaneys B-500	.....	.....	.....	.....	.....	.....
Cargill 660	.....	.....	.....	.....	.....	.....
Cargill 840	.....	.....	.....	3.84	3.12	1.39
Cargill unknown	3.84	3.84	.....	.....	.....	1.54
Total	3.84	3.84	.....	3.84	3.12	2.93
DeKalb Ex26	.....	.....	.....	.....	3.12	0.62
DeKalb XL15-25	3.84	.....	.....	.....	.....	0.77
DeKalb XL45	3.84	7.69	3.84	7.69	3.12	5.24
DeKalb XL306	.....	3.84	.....	7.69	3.12	2.93
DeKalb XL325	.....	7.69	3.84	3.84	3.12	3.70
DeKalb XL409	3.84	.....	.....	.....	.....	0.77
DeKalb unknown	.....	7.69	7.69	3.84	6.25	5.09
Total	11.53	26.92	15.38	23.08	18.75	19.13
Farmers 4429XL	.....	.....	.....	.....	3.12	0.62
Foster 38	.....	.....	3.84	.....	.....	0.77
Foster unknown	3.84	3.84	3.84	.....	.....	2.30
Total	3.84	3.84	7.69	.....	.....	3.07
Funks G17	.....	.....	.....	3.84	.....	0.77
Funks G17A	.....	3.84	.....	.....	3.12	1.39
Funks 325	.....	3.84	.....	.....	.....	0.77
Funks 4444	.....	.....	.....	.....	.....	.....
Funks unknown	3.84	.....	7.69	3.84	3.12	3.70
Total	3.84	7.69	7.69	7.69	7.69	6.92
Hagues 9080	3.84	.....	.....	.....	.....	0.77
Jacques unknown	.....	.....	.....	3.84	3.12	1.39
Minhybrid 4301	3.84	.....	.....	.....	3.12	1.39
Minhybrid unknown	.....	3.84	.....	.....	.....	0.77
Total	3.84	3.84	.....	.....	3.12	2.16
Northrop King unknown	3.84	.....	3.84	.....	.....	1.54
PAG 5X52	.....	.....	.....	3.84	3.12	1.39
PAG 5X69	.....	.....	.....	.....	.....	.....
PAG unknown	3.84	.....	3.84	.....	.....	1.54
Total	3.84	.....	3.84	3.84	3.12	2.93
Pfister KX325	.....	.....	.....	.....	3.12	0.62
Pfister 3959	.....	.....	.....	.....	.....	.....
Pfister unknown	3.84	.....	.....	3.84	.....	1.54
Total	3.84	.....	.....	3.84	3.12	2.16

II. F. (continued)

Hybrid	Percent of fields					
	1965	1966	1967	1968	1969	Average
Pioneer 110	.....	.....	.....	3.84	.....	0.77
Pioneer 349	.....	3.84	.....	.....	.....	0.77
Pioneer 368A	.....	.....	.....	3.84	.....	0.77
Pioneer 371	3.84	.....	.....	.....	.....	0.77
Pioneer 3558	.....	3.84	.....	.....	.....	0.77
Pioneer 3579	.....	.....	.....	.....	.....	.....
Pioneer 3582	.....	.....	.....	3.84	3.12	1.39
Pioneer 3658	.....	3.84	.....	.....	.....	0.77
Pioneer 3680	3.84	.....	.....	.....	.....	0.77
Pioneer 3681	3.84	.....	.....	.....	.....	0.77
Pioneer 3715	.....	.....	3.84	.....	.....	0.77
Pioneer 3773	.....	.....	.....	.....	6.25	1.25
Pioneer 3775	3.84	.....	.....	.....	3.12	1.39
Pioneer unknown	26.92	19.23	19.23	7.69	6.25	15.86
Total	50.00	34.61	23.08	19.23	18.75	29.13
Trojan TXS98	.....	3.84	.....	.....	.....	0.77
Trojan TXS102	.....	.....	3.84	15.38	31.25	10.09
Trojan TXS105	.....	3.84	7.69	7.69	.....	3.84
Trojan unknown	3.84	3.84	15.38	3.84	.....	5.38
Total	3.84	11.53	26.92	26.92	31.25	20.09
Vinton 301	.....	.....	3.84	.....	3.12	1.39
Vinton 1.0	.....	.....	.....	3.84	.....	0.77
Vinton unknown	.....	3.84	3.84	3.84	.....	2.30
Total	.....	3.84	7.69	7.69	3.12	4.47
Weather Master	.....	.....	.....	.....	3.12	0.77
Unknown	3.84	3.84	3.84	.....	.....	2.30
Total number of fields observed	24	24	24	24	24	.....
Total number of varieties	26	26	26	26	32	.....

APPENDIX III

III. A. Weather conditions in Carroll County, Missouri during growing season.

Month	1965	1966	1967	1968	1969
	Average temperature for month (°F.)				
April	57.6	52.0	58.1	54.7	56.1
May	69.9	61.8	60.5	60.9	64.4
June	73.1	71.4	72.0	75.0	70.1
July	76.0	81.1	74.4	76.1	80.1
August	74.1	71.7	71.2	75.2	75.6
September	67.8	64.3	65.0	66.8	68.4
October	56.7	54.9	55.5	57.3	54.3
	Total rainfall for month (inches)				
April	2.08	2.97	5.69	4.25	5.29
May	1.16	1.26	6.10	8.10	4.68
June	4.89	7.45	8.32	2.83	12.29
July	7.92	1.65	2.28	3.15	10.08
August	5.25	3.42	1.92	3.42	4.88
September	5.85	2.78	7.86	3.42	5.08
October	1.87	2.73	8.38	2.64	8.60

III. B. Weather conditions in Carroll County, Missouri; deviation from long-term normal.[a]

Month	1965	1966	1967	1968	1969
			Monthly temperatures		
April	+2.9	-2.9	+4.9	+3.0	+3.4
May	+5.8	-2.6	-2.0	-1.7	+1.6
June	-9.9	-2.7	-1.3	+3.2	-3.3
July	-2.7	+2.7	-3.5	-0.2	+1.9
August	-2.6	-4.3	-3.6	+1.7	+0.7
September	- .8	-2.8	-2.3	- .3	+1.1
October	+ .1	- .8	-1.1	+1.6	+2.2
			Monthly rainfall		
April	-1.00	+0.31	+3.75	+2.08	+2.80
May	-2.88	-1.80	+0.35	-0.59	+0.64
June	-0.23	+0.58	+4.19	-2.59	+4.45
July	+2.10	-0.91	-1.38	+2.39	+6.70
August	-1.08	-1.30	-3.23	-0.41	+0.41
September	+5.86	-1.08	+2.67	-0.41	+7.43
October	-1.68	+1.06	+5.18	+0.17	+2.14

[a] Long-term normal temperature and rainfall are not available for Carrollton. The long-term normal reading for Chillicothe was used in calculation of deviations.

III. C. Fertilizer treatments in fields used in Carroll County, Missouri.

	Percent of fields					
Fertilizer application	1965	1966	1967	1968	1969	Average
NPK combinations	52.1	66.6	56.5	62.5	78.2	63.18
Anhydrous ammonia	69.5	66.6	69.5	75.0	82.6	72.64
Nitrogen	13.0	29.1	8.6	0	4.3	11.00
Starter fertilizer	8.6	12.5	0	0	4.3	5.08
Ammonium nitrate	4.3	16.6	17.3	20.8	8.6	13.52
No application	4.3	0	4.3	4.1	0	2.54
Lime	0	0	0	4.1	0	.82
Total number of fields checked	23	24	23	24	23	23.40

III. D. Crop history in fields used in Carroll County, Missouri.

	Percent of fields					
Previous crops	1965	1966	1967	1968	1969	Average
Corn	52.1	87.5	84.0	79.1	69.5	74.44
Soybeans	13.0	0	8.0	8.3	17.3	9.32
Wheat	8.6	0	0	4.1	4.3	3.40
Clover	21.7	12.5	8.0	8.3	8.6	11.82
Pasture	4.3	0	0	0	0	0.86
Total fields checked	24	24	24	24	23	.....

III. E. Plant populations in fields used in Carroll County, Missouri.

Plants per acre	Percent of fields					
	1965	1966	1967	1968	1969	Average
8,000– 8,999	0	4.1	0	0	0	.82
9,000– 9,999	0	0	0	0	0	0
10,000–10,999	0	8.3	0	0	0	1.66
11,000–11,999	12.5	4.1	8.3	0	4.5	5.88
12,000–12,999	4.1	4.1	4.1	0	4.5	3.36
13,000–13,999	16.6	12.5	12.5	8.3	9.0	11.78
14,000–14,999	20.8	16.6	20.8	8.3	27.2	18.74
15,000–15,999	8.3	12.5	25.0	16.6	9.0	14.28
16,000–16,999	12.5	0	4.1	4.1	4.5	5.04
17,000–17,999	8.3	4.1	8.3	20.8	18.1	11.90
18,000–18,999	8.3	8.3	8.3	16.6	4.5	9.20
19,000–19,999	4.1	12.5	8.3	12.5	0	7.48
20,000–20,999	4.1	4.1	0	8.3	13.6	6.02
Over 21,000	0	8.3	0	4.1	4.5	3.38
Average	15,153	15,638	14,735	17,277	16,242	15,809
Total fields observed	24	24	24	24	22	23.6

III. F. Corn hybrids used in fields for study in Carroll County, Missouri.

Hybrids	Percent of fields					
	1965	1966	1967	1968	1969	Average
Cargill 285	8.6	.....	.....	.....	.....	1.72
Cargill 340	.....	.....	.....	4.0	.....	.80
Cargill unknown	.....	.....	3.7	.....	.....	.74
DeKalb 165	4.3	.....	.....	.....	.....	.86
DeKalb 306	.....	3.7	.....	.....	.....	.74
DeKalb 361	.....	.....	.....	4.0	.....	.80
DeKalb 362	8.6	.....	.....	.....	.....	1.72
DeKalb 633	4.3	3.7	.....	4.0	.....	4.12
DeKalb 805	4.3	.....	.....	.....	.....	.86
DeKalb 824	4.3	.....	3.7	.....	.....	1.60
DeKalb XL45	.....	.....	3.7	4.0	4.3	2.40
DeKalb XL65	.....	3.7	.....	.....	.....	.74
DeKalb XS85	.....	.....	.....	.....	4.3	.86
DeKalb XL362	.....	11.1	3.7	4.0	.....	3.76
DeKalb 363	.....	.....	.....	.....	4.3	.86
DeKalb unknown	.....	.....	3.7	.....	4.3	1.60
Embro 48	4.3	.....	.....	.....	.....	.86
Funks unknown	.....	3.7	.....	.....	.....	.74
Maygold 58X	.....	.....	.....	4.0	.....	.80
Maygold 68	8.6	3.7	.....	.....	.....	2.46
Maygold 2036	.....	3.7	3.7	.....	.....	1.48
Maygold unknown	.....	.....	.....	.....	4.3	.86
MFA-K6	4.3	.....	.....	.....	.....	.86
MFA 2180	.....	3.7	.....	.....	.....	.74
Monior 702	4.3	.....	.....	.....	.....	.86
Pfisters 399	.....	.....	.....	4.0	4.3	1.66
Pfisters SX-29	.....	11.1	3.7	.....	.....	2.96
Pfisters 5X9B	.....	.....	.....	4.0	.....	.80
Pfisters unknown	.....	3.7	.....	.....	.....	.74
Pioneer 314	21.7	25.9	29.6	28.0	17.3	24.50
Pioneer 320	4.3	7.4	.....	.....	.....	2.34
Pioneer 321	8.6	3.7	3.7	.....	.....	3.20
Pioneer 328	.....	.....	.....	8.0	.....	1.60

III. F. (continued)

Hybrids	Percent of fields					
	1965	1966	1967	1968	1969	Average
Pioneer 368A	.....	.....	3.7	.....	.....	.74
Pioneer 3199	.....	.....	.....	.....	4.3	.86
Pioneer 3268	4.3	3.7	11.1	4.0	.....	4.62
Pioneer 3306	23.5	.....	3.7	20.0	34.7	21.00
Pioneer 3307	.....	.....	.....	8.0	.....	1.60
Pioneer 3305	.....	.....	.....	.....	8.6	1.72
Pioneer unknown	.....	.....	14.8	.....	4.3	3.82
United 50WW	.....	3.7	3.7	.... .	4.3	2.34

APPENDIX IV

IV. A. Weather conditions in New Madrid County, Missouri, during growing season.

Month	1965	1966	1967	1968	1969
	Average temperature for month (°F.)				
April	61.5	59.1	62.0	58.1	57.6
May	72.8	64.7	65.2	65.2	68.3
June	76.1	75.5	76.7	77.5	76.8
July	78.4	82.5	75.8	79.7	82.9
August	76.7	74.8	72.9	78.9	77.7
September	71.0	68.5	66.9	69.5	70.9
October	57.8	54.6	60.0	58.5	59.6
	Total rainfall for month (inches)				
April	3.37	9.90	2.59	5.48	6.18
May	6.03	9.62	9.27	7.68	2.20
June	2.40	4.38	4.08	2.75	1.36
July	5.20	2.51	3.49	2.10	3.92
August	1.46	2.88	2.36	1.89	1.50
September	12.29	6.96	2.60	6.01	2.73
October	0.59	2.33	5.12	2.29	2.40

IV. B. Weather conditions in New Madrid County, Missouri; deviations from long-term normal.

Month	1965	1966	1967	1968	1969
	Monthly temperatures				
April	+3.1	+0.7	+3.6	+0.3	−0.8
May	+4.9	−3.2	−2.7	−2.7	+0.4
June	−1.0	−1.6	−0.4	+0.4	−0.3
July	−1.8	+2.3	−4.4	−0.5	+2.7
August	−2.3	−4.2	−6.1	−0.1	−1.3
September	−0.8	−3.3	−4.9	−2.3	−0.9
October	−3.2	−6.4	−1.0	−2.5	−1.4
	Monthly rainfall				
April	−1.03	+5.50	−1.81	+1.08	+1.78
May	+1.59	+5.18	+4.83	+3.24	−2.24
June	−1.76	+0.22	−0.08	−1.41	−2.80
July	+2.08	−0.61	−0.37	−1.02	+0.80
August	−1.46	−0.04	−0.56	−1.03	−1.42
September	+8.50	+3.17	−1.19	+2.22	−1.06
October	−2.41	−0.67	+2.12	−0.71	−0.60

IV. C. Fertilizer treatments in fields used in New Madrid County, Missouri.

Fertilizer application	Percent of fields					
	1965	1966	1967	1968	1969	Average
NPK combinations	88.8	95.8	88.8	91.3	100	92.94
Ammonium nitrate	0.0	16.6	0.0	4.3	5.8	5.34
Anhydrous ammonia	77.7	83.3	83.3	73.9	94.1	82.46
Nitrogen	5.5	0.0	0.0	8.7	0.0	2.84
Starter fertilizer	88.8	95.8	88.8	91.3	100	92.94
Manure	0.0	0.0	0.0	0.0	0.0	0.00
No application	5.5	0.0	5.5	4.3	0.0	3.06
Total number of fields checked	18	24	18	23	17	20

IV. D. Crop history in fields used in New Madrid County, Missouri.

Previous crop	Percent of fields					
	1965	1966	1967	1968	1969	Average
Corn	35.0	34.6	31.8	21.4	38.0	32.16
Cotton	15.0	19.2	4.5	14.2	0	10.58
Soybeans	25.0	26.9	40.9	39.2	42.8	34.96
Wheat	15.0	11.5	18.1	21.4	19.0	17.00
Red clover	5.0	0	0	0	0	1.00
Pasture	5.0	7.6	0	0	0	2.52
Barley	0	0	4.5	0	0	0.90
Grain sorghum	0	0	0	3.5	0	0.70
Total fields checked	18	24	18	23	17	.....

IV. E. Plant populations in fields used in New Madrid County, Missouri.

Plants per acre	Percent of fields					
	1965	1966	1967	1968	1969	Average
Under 10,000	0	0	11.1	0	0	2.22
10,000–10,999	0	0	5.5	0	0	1.10
11,000–11,999	4.3	0	5.5	0	0	1.96
12,000–12,999	0	4.1	0	4.3	11.7	4.02
13,000–13,999	13.0	0	0	4.3	5.8	4.62
14,000–14,999	13.0	12.5	11.1	8.6	0	9.04
15,000–15,999	30.4	12.5	5.5	13.0	0	12.28
16,000–16,999	13.0	16.6	0	4.3	23.5	11.48
17,000–17,999	4.3	16.6	5.5	8.6	11.7	9.34
18,000–18,999	17.3	16.6	27.7	4.3	17.6	16.70
19,000–19,999	4.3	12.5	0	17.3	5.8	7.98
20,000–20,999	0	8.3	11.1	13.0	11.7	8.82
21,000–21,999	0	0	5.5	8.6	11.7	5.16
Over 22,000	0	0	11.1	13.0	0	4.82
Total fields observed	23	24	18	23	17	.....

IV. F. Corn hybrids used in fields for study in New Madrid County, Missouri.

Hybrids	Percent of fields					
	1965	1966	1967	1968	1969	Average
Acco 436	.....	.....	.....	.....	5.8	1.16
Cargill 880	.....	.....	5.8	.....	.....	1.16
DeKalb 624	5.0	.....	.....	.....	.....	1.00
DeKalb 834	.....	.....	.....	4.3	.....	.86
DeKalb PX66	.....	.....	.....	4.3	.....	.86
DeKalb PX85	.....	.....	.....	.....	5.8	1.16
DeKalb unknown	.....	4.1	.....	.....	.....	.82
Embro 44XE	5.0	8.3	.....	.....	.....	2.66
Funks 96	5.0	.....	.....	.....	.....	1.00
Funks 144	5.0	.....	.....	.....	.....	1.00
Funks 2749	.....	.....	.....	4.3	.....	.86
Funks 4003	.....	4.1	.....	.....	.....	.82
Funks G711A	.....	4.1	.....	.....	.....	.82
Funks mixed	.....	4.1	.....	.....	.....	.82
Gildersleeve SX52	.....	4.1	.....	.....	.....	.82
Griffith 125	5.0	.....	.....	.....	.....	1.00
Griffith 303	10.0	.....	.....	.....	.....	2.00
Griffith unknown	5.0	4.1	5.8	4.5	5.8	5.00
Indiana 592AW	.....	.....	.....	4.3	.....	.86
Northrup King PX72	.....	.....	.....	4.3	.....	.86
Northrup King PX78	.....	4.1	5.8	.....	.....	1.98
Northrup King PX674	.....	.....	5.8	.....	.....	1.16
Pfisters 18	5.0	.....	.....	.....	.....	1.00
Pfisters 47	5.0	.....	.....	.....	.....	1.00
Pfisters 434	5.0	8.3	5.8	4.3	.....	4.68
Pfisters 437	.....	4.1	5.8	....	.....	1.98
Pfisters SX29	15.0	20.8	23.5	26.0	29.4	22.94
Pfisters SX99	.....	.....	.....	4.3	.....	.86
Pioneer 312A	.....	4.1	.....	4.3	5.8	2.84
Pioneer 3304	.....	.....	5.8	4.3	17.6	5.54
Pioneer 3306	.....	.....	23.5	4.3	.....	5.56
Pioneer 3196	.....	.....	.....	4.3	.....	.86
Pioneer 3369A	.....	.....	.....	13.0	17.6	6.12
Princeton 8A	5.0	4.1	.....	.....	.....	1.82
US 13	5.0	4.1	5.8	4.3	5.8	5.00
Zimmerman Z82X	5.0	4.1	5.8	.....	5.8	4.14
Zimmerman Z90	.....	4.1	.....	.....	.....	.82
Zimmerman Z800	10.0	8.2	.....	.....	.....	3.66
Zimmerman Z911	5.0	.....	.....	. ....	.....	1.00
Zimmerman Tri-cross	.....	.....	.....	4.3	.....	.86

APPENDIX V

V. A. Weather conditions at West Point, Cuming County, Nebraska, during growing season.

Month	1965	1966	1967	1968	1969
			Average temperature for month (°F.)		
May	64.6	59.5	57.9	57.5	62.7
June	70.3	70.1	69.2	72.6	67.0
July	74.3	78.1	73.6	74.9	77.1
August	72.4	70.1	71.5	73.6	75.2
			Total rainfall for month (inches)		
May	7.41	2.70	3.15	2.58	2.33
June	3.73	7.04	12.72	6.34	2.78
July	4.01	6.33	0.65	1.54	2.72
August	2.02	3.43	1.85	4.16	3.00
			Borer degree-day accumulations		
April 15	17.5	49.5	159.5	139.5	49.5
May 1	92.0	103.5	250.0	227.0	117.5
May 15	249.0	225.0	300.0	351.5	288.0
June 1	498.5	464.0	549.0	458.0	508.5
June 15	760.5	685.0	830.0	806.0	707.5
July 1	1,116.5	1,073.5	1,148.5	1,136.0	1,022.5
July 15	1,456.0	1,512.0	1,417.0	1,476.5	1,427.5
Aug. 1	1,872.5	1,947.5	1,884.0	1,917.5	1,862.0
Aug. 15	2,228.0	2,219.5	2,184.5	2,272.0	2,222.0
Sept. 1	2,561.5	2,568.0	2,530.0	2,647.0	2,639.5
Sept. 15	2,759.5	2,789.0	2,743.5	2,851.0	2,901.5

V. B. Weather conditions at West Point, Cuming County, Nebraska; deviation from long-term normal.

Month	1965	1966	1967	1968	1969
			Monthly temperatures		
May	2.4	–2.7	–4.3	–4.7	0.5
June	–2.3	–2.5	–3.4	0.0	–5.6
July	–4.0	–0.2	–4.7	–3.4	–1.2
August	–3.7	–6.0	–4.6	–2.5	–0.9
			Monthly rainfall		
May	3.79	–0.92	–0.47	–1.04	–1.29
June	–0.75	2.56	8.24	1.86	–1.70
July	0.74	3.06	–2.62	–1.73	–0.55
August	–1.07	0.16	–1.42	0.89	1.73

V. C. Previous year's crops in fields used in Cuming County, Nebraska.

Previous crop	Percent of fields					
	1965	1966	1967	1968	1969	Average
Corn	42.8	28.6	55.2	63.0	59.3	49.8
Oats	23.8	23.8	13.8	7.4	3.7	14.5
Clover	0	9.5	7.0	3.4	0	4.0
Alfalfa	14.3	4.8	3.4	0	0	4.5
Soybeans	4.8	19.0	17.2	22.2	33.3	19.3
Sorghum	0	0	3.4	3.7	3.7	2.1
Wheat	9.5	4.8	0	0	0	2.9
Soil bank	4.8	9.5	0	0	0	2.9

V. D. Use of fertilizer in fields used in Cuming County, Nebraska.

	Percent of fields					
	1965	1966	1967	1968	1969	Average
Commercial fertilizer	53.0	60.0	82.1	79.2	83.3	72.0
Trace elements	0	5.0	0	8.3	8.3	4.3
Manure	0	0	7.2	8.3	4.2	4.0
None	47.0	40.0	10.7	16.7	12.5	25.4
Total fields checked	17	20	28	24	24	.....

V. E. Planting methods and plant populations in fields used in Cuming County, Nebraska.

	Percent of fields					
	1965	1966	1967	1968	1969	Average
Type of planting						
Checked	0	0	0	0	0	0
Hill drop	0	4.2	3.3	6.7	0	2.8
Drilled	66.7	70.8	80.0	70.0	73.3	72.2
Listed	8.3	12.5	10.0	6.7	10.0	9.5
Unknown	25.0	12.5	6.7	16.6	16.7	15.5
Total fields observed	24	24	30	30	30	.....
Plants per acre						
10,000 or less	0	0	6.7	0	0	1.3
10,000–10,999	8.3	4.2	3.3	3.3	0	3.8
11,000–11,999	16.7	16.7	13.3	10.0	16.7	14.7
12,000–12,999	16.7	12.5	20.0	10.0	10.0	13.9
13,000–13,999	16.7	29.2	26.7	23.3	23.3	23.9
14,000–14,999	20.8	25.0	20.0	16.7	20.0	20.5
15,000–15,999	12.5	8.3	3.3	6.7	10.0	8.2
16,000–16,999	8.3	0	3.3	10.0	10.0	6.3
17,000–17,999	0	0	0	6.7	10.0	3.3
18,000–18,999	0	0	0	3.3	0	0.7
19,000–19,999	0	0	3.3	3.3	0	1.3
20,000–20,999	0	0	0	0	0	0
21,000–21,999	0	4.2	0	0	0	0.8
22,000–22,999	0	0	0	0	0	0
23,000–23,999	0	0	0	6.7	0	1.3
Average plants/acre	13,576	13,716	13,331	15,184	14,374	14,036
Total fields observed	24	24	30	30	30	.....

V. F. Corn hybrids used in fields for study in Cuming County, Nebraska.

Hybrid	Percent of fields					
	1965	1966	1967	1968	1969	Average
Apco 619	0	0	0	0	3.3	.66
Cargill-Hi-Sugar	0	0	0	0	3.3	.66
Cargill unknown	4.1	0	0	0	0	.82
Total	4.1	0	0	0	6.6	2.14
DeKalb 3 x 0	4.1	4.1	3.3	0	0	2.3
DeKalb 3 x 1	12.5	12.5	3.3	0	0	5.66
DeKalb 3 x 2	4.1	4.1	0	0	0	1.64
DeKalb 3 x 3	0	0	3.3	0	0	.66
DeKalb XL	4.1	0	0	0	0	.82
DeKalb XL –25 +46	0	0	3.3	0	0	.66
DeKalb XL 45	0	0	3.3	3.3	10.0	3.32
DeKalb XL 66	0	0	0	3.3	0	.66
DeKalb XL 341	0	4.1	0	0	0	.82
DeKalb XL –346	0	4.1	6.6	10.0	0	4.14
DeKalb XL 361	8.3	8.3	23.3	6.6	16.6	12.62
DeKalb 661	0	0	3.3	0	0	.66
DeKalb 61	0	0	0	0	3.3	.66
DeKalb 342	0	0	6.6	3.3	0	1.98
DeKalb 344	0	0	3.3	6.6	0	1.98
DeKalb 362	4.1	8.3	3.3	3.3	3.3	4.46
DeKalb 363	0	0	0	3.3	0	.66
DeKalb 607	0	4.1	0	0	0	.82
DeKalb 660	0	0	3.3	0	0	.66
DeKalb unknown	4.1	0	0	3.3	0	1.48
Total	41.3	49.6	66.2	43.0	33.2	46.66
Farmer's 457	0	0	3.3	0	0	.66
Farmer's 3247	0	4.1	0	0	0	.82
Total	0	4.1	3.3	0	0	1.48
Federal 230	0	4.1	0	0	0	.82
Federal 267A	0	4.1	0	0	0	.82
Federal unknown	0	0	0	3.3	0	.66
Total	0	8.2	0	3.3	0	2.3
Fontanelle 109A	0	0	0	0	3.3	.66
Fontanelle 525	0	0	3.3	0	0	.66
Total	0	0	3.3	0	3.3	1.32
Frundt's #42	0	0	0	0	3.3	.66
Frundt's 38841	4.1	0	0	0	0	.82
Total	4.1	0	0	0	3.3	1.48
Funks 75A	0	0	3.3	0	0	.66
Funks G75A	4.1	8.3	0	3.3	0	3.14
Funks 83	0	4.1	0	0	0	.82
Funks 4476	0	0	0	0	3.3	.66
Funks 4582	0	0	0	3.3	0	.66
Funks G4582	0	0	3.3	0	0	.66
Funks 4588	0	0	3.3	3.3	3.3	1.98
Funks unknown	4.1	0	0	3.3	0	1.48
Total	8.2	12.4	9.9	13.2	6.6	10.06
Maygold 97	0	0	3.3	0	0	.66
Hulting 620	0	0	0	3.3	3.3	1.32
Lynks 44	0	0	3.3	3.3	0	1.32
McCurdy 3 x 5	0	0	0	0	3.3	.66
McCurdy 99	0	0	3.3	0	0	.66
McCurdy 100 day	4.1	0	0	0	0	.82
Total	4.1	0	3.3	0	3.3	2.14
Nebraska #801	0	4.1	0	0	0	.82
Nebraska Certified NC #42	0	0	0	3.3	0	.66

V. F. (continued)

Hybrid	Percent of fields					
	1965	1966	1967	1968	1969	Average
NC 51	0	0	0	3.3	0	.66
NC #52	0	0	3.3	3.3	0	1.32
NC 53	0	0	0	3.3	0	.66
NC +55	0	8.3	3.3	3.3	3.3	3.64
NC 60	0	0	0	3.3	0	.66
NC –605	0	0	0	3.3	0	.66
NC 705	0	4.1	0	0	0	.82
NC + unknown	0	0	3.3	3.3	3.3	1.98
Total	0	12.4	9.9	26.4	6.6	11.06
Northrup King						
NK PX 50	0	0	0	0	3.3	.66
NK 657	0	4.1	0	0	0	.82
NK 687	0	4.1	0	0	0	.82
NK unknown	0	4.1	3.3	3.3	3.3	2.8
Total	0	12.3	3.3	3.3	6.6	5.1
PAG 348	0	0	3.3	0	3.3	1.32
Pfister 272	0	0	0	3.3	0	.66
Pfister 380	0	0	3.3	0	0	.66
Pfister 391	0	0	0	3.3	3.3	1.32
Pfister 395	0	0	3.3	0	0	.66
Pfister 29 Single Cross	0	4.1	0	0	0	.82
Pfister unknown	0	0	3.3	0	0	.66
Total	0	4.1	6.6	6.6	3.3	4.12
Pioneer 318 A	0	4.1	3.3	0	0	1.48
Pioneer 314	0	0	3.3	0	0	.66
Pioneer 320	0	8.3	0	0	0	1.96
Pioneer 321	0	0	0	3.3	0	.66
Pioneer 328E	4.1	0	0	0	3.3	1.48
Pioneer 3077	0	0	3.3	0	0	.66
Pioneer 3261	4.1	0	0	0	0	.82
Pioneer 3268	0	0	3.3	0	3.3	1.32
Pioneer 3291	4.1	0	3.3	0	0	1.48
Pioneer 3303	0	4.1	0	0	0	.82
Pioneer 3307	0	0	0	3.3	0	.66
Pioneer 3390	0	0	0	3.3	3.3	1.32
Pioneer 3420	0	4.1	0	0	0	.82
Pioneer unknown	4.1	0	0	0	3.3	1.48
Total	16.4	20.6	16.5	9.9	13.2	15.32
Tekseed 75A	0	0	0	3.3	0	.66
Tekseed 92	0	0	3.3	0	0	.66
Tekseed unknown	4.1	0	0	0	3.3	1.48
Total	4.1	0	3.3	3.3	3.3	2.8
Trojans unknown	0	0	0	3.3	0	.66
United Hagie 1 x L-7	0	0	0	0	3.3	.66
United Hagie 52B	0	0	0	0	3.3	.66
United Hagie UH 155A	0	0	3.3	0	0	.66
Total	0	0	3.3	0	6.6	1.98
Wilson	0	4.1	0	0	0	.82

APPENDIX VI

VI. A. Weather conditions at Grand Island, Hall County, Nebraska, during growing season.

Month	1965	1966	1967	1968	1969
			Average temperature for month (°F.)		
May	64.0	61.1	56.5	58.2	61.8
June	69.7	71.0	68.2	73.2	66.1
July	74.8	81.0	74.8	75.2	77.2
August	73.6	70.7	72.2	74.4	76.0
			Total rainfall for month (inches)		
May	5.97	1.03	3.40	2.23	4.13
June	5.21	2.98	13.96	7.13	3.46
July	2.36	3.47	0.98	4.82	3.10
August	3.35	1.68	1.30	4.41	3.75
			Borer degree-day accumulations		
April 15	19.0	52.0	164.0	126.5	58.0
May 1	146.0	95.0	232.5	203.5	125.0
May 15	352.5	230.0	284.0	312.0	286.0
June 1	586.5	508.0	518.0	451.0	480.0
June 15	848.5	737.0	776.0	795.5	675.5
July 1	1,186.0	1,149.5	1,082.5	1,152.0	984.5
July 15	1,519.5	1,627.0	1,373.0	1,501.5	1,405.5
Aug. 1	1,949.5	2,104.0	1,858.0	1,934.0	1,826.5
Aug. 15	2,337.0	2,382.5	2,175.0	2,298.0	2,196.0
Sept. 1	2,671.0	2,741.0	2,526.5	2,739.0	2,624.5
Sept. 15	2,880.0	2,980.0	2,737.0	2,954.5	2,907.0

VI. B. Weather conditions at Grand Island, Hall County, Nebraska; deviation from long-term normal.

Month	1965	1966	1967	1968	1969
			Monthly temperatures		
May	3.4	0.5	–4.1	–2.4	1.2
June	–1.3	0.0	–2.8	2.2	–4.9
July	–2.4	3.8	–2.4	–2.0	0.0
August	–1.7	–4.6	–3.1	–0.9	0.7
			Monthly rainfall		
May	2.12	–2.82	–0.45	–1.62	0.28
June	1.42	–0.81	10.17	3.34	–0.33
July	–0.15	0.96	–1.53	2.31	0.59
August	1.00	–0.67	–1.05	2.06	1.40

VI. C. Previous year's crop in fields used in Hall County, Nebraska.

	Percent of fields					
Previous crop	1965	1966	1967	1968	1969	Average
Corn	91.3	87.0	96.6	96.7	86.2	91.6
Sorghum	8.7	8.7	3.4	0	0	4.2
Soil bank	0	4.3	0	3.3	6.9	2.9
Soybeans	0	0	0	0	6.9	1.3

VI. D. Use of fertilizer in fields in Hall County, Nebraska.

	Percent of fields					
	1965	1966	1967	1968	1969	Avg.
Commercial fertilizer	100.0	100.0	100.0	100.0	100.0	100.0
Trace elements	9.5	9.1	8.0	28.0	20.8	15.1
Total number farmers reporting	21	22	25	25	24	

VI. E. Planting methods and plant populations in fields used in Hall County, Nebraska.

	Percent of fields					
	1965	1966	1967	1968	1969	Average
Type of planting						
Checked	0	0	0	0	0	0
Hill drop	0	0	0	0	0	0
Drilled	21.0	29.2	20.0	10.0	10.0	18.0
Listed	58.0	62.5	63.0	73.0	73.0	65.9
Unknown	21.0	8.3	17.0	17.0	17.0	16.1
Total fields observed	24	24	30	30	30	
Plants per acre						
10,000 or less	4.2	4.2	0	3.3	0	2.3
10,000–10,999	0	0	0	0	3.3	0.7
11,000–11,999	0	0	0	0	0	0
12,000–12,999	0	0	6.7	0	0	1.3
13,000–13,999	16.7	8.3	6.7	0	0	6.3
14,000–14,999	12.5	8.3	13.3	0	3.3	7.5
15,000–15,999	8.3	12.5	3.3	3.3	6.7	6.8
16,000–16,999	16.7	16.7	20.0	16.7	10.0	16.0
17,000–17,999	16.7	16.7	13.3	13.3	3.3	12.7
18,000–18,999	16.7	8.3	20.0	13.3	13.3	14.3
19,000–19,999	4.2	4.2	10.0	16.7	20.0	11.0
20,000–20,999	4.2	12.5	3.3	10.0	16.7	9.3
21,000–21,999	0	0	0	16.7	10.0	5.3
22,000–22,999	0	8.3	3.3	3.3	6.7	4.3
23,000–23,999	0	0	0	3.3	0	0.7
24,000–24,999	0	0	0	0	0	0
25,000–25,999	0	0	0	0	6.7	1.3
Average plants/acre	16,213	17,170	17,061	18,881	19,402	17,745
Total fields observed	24	24	30	30	30	

VI. F. Corn hybrids used in fields for study in Hall County, Nebraska.

Hybrid	Percent of fields					
	1965	1966	1967	1968	1969	Average
Acco 12	0	0	0	3.33	0	.67
Acco UC 346	0	0	0	0	3.33	.67
Acco 619	0	0	0	0	3.33	.67
Acco 711	0	0	0	3.33	3.33	1.33
Acco 815	0	0	0	3.33	0	.67
Acco 956	0	0	0	3.33	0	.67
Acco 4600	0	0	0	0	3.33	.67
Total	0	0	0	13.4	13.4	5.36
Cargill 309	4.17	0	0	0	0	.83
Cargill 343	0	4.17	0	0	0	.83
Cargill 345	0	4.17	0	0	0	.83
Cargill 349	4.17	0	0	0	0	.83
Cargill 366	0	4.17	0	0	0	.83
Cargill 377	0	4.17	0	0	0	.83
Cargill 990	0	0	3.33	0	0	.67
Total	8.3	16.7	3.33	0	0	5.66
DeKalb 3 x 1	4.17	4.17	3.33	3.33	3.33	3.67
DeKalb 3 x 2	4.17	0	0	0	0	.83
DeKalb XL 44	4.17	0	0	0	0	.83
DeKalb XL 45	4.17	8.3	3.33	0	6.67	4.49
DeKalb XL 61	0	0	0	0	3.33	.67
DeKalb XL 66	0	0	0	3.33	6.67	2.0
DeKalb XL 70	0	4.17	0	0	0	.83
DeKalb XL 72	0	0	3.33	3.33	3.33	1.99
DeKalb XL 84	0	0	0	0	3.33	.67
DeKalb XL 342	0	0	0	3.33	0	.67
DeKalb XL 361	0	8.3	0	3.33	6.67	3.66
DeKalb XL 362	0	0	6.67	0	0	1.33
DeKalb XL 363	0	0	0	0	3.33	.67
DeKalb 666	4.17	0	0	0	0	.83
Total	20.8	25.0	16.67	16.67	36.67	23.16
Farmer's 426 XL	0	0	3.33	0	0	.67
Funks 693	4.17	4.17	3.33	0	0	2.33
Funks 695	0	4.17	0	0	0	.83
Funks 696	0	4.17	3.33	3.33	3.33	2.83
Funks 4401	4.17	0	0	0	0	.83
Funks 4588	0	0	6.67	0	0	1.34
Funks 4680	0	0	3.33	0	0	.67
Funks 4697	0	0	3.33	0	0	.67
Funks unknown	4.17	4.17	0	0	0	1.67
Total	12.5	1.67	20.	3.33	3.33	8.17
Hoegemeyer 901	0	0	0	0	3.33	.67
Hybrid popcorn	0	4.17	0	0	0	.83
Links 2588	0	0	0	3.33	0	.67
McCurdys 3 x 5	0	0	0	0	6.67	1.33
McCurdys 85	0	0	0	3.33	0	.67
Total	0	0	0	3.33	6.67	2.0
May's 2206	0	0	0	3.33	0	.67
May's unknown	0	0	0	0	3.33	.67
Total	0	0	0	3.33	3.33	1.33
Maygold 59A	0	4.17	0	0	0	.83
Maygold 67A	0	4.17	0	0	3.33	1.5
Maygold 68	0	0	0	3.33	0	.67
Total	0	8.3	0	3.33	3.33	2.99
Nebraska Certified						
NC 30s	4.17	4.17	3.33	0	0	2.33
NC 45	0	0	0	0	0	0

VI. F. (continued)

Hybrid	Percent of fields					
	1965	1966	1967	1968	1969	Average
NC 51	0	0	3.33	0	0	.67
NC 52	0	0	0	3.33	0	.67
NC 53	0	0	0	3.33	6.67	2.0
NC 55	0	8.3	6.67	0	3.33	3.66
NC 72	4.17	0	0	0	0	.83
NC 83	0	4.17	0	0	0	.83
NC 305	0	0	3.33	0	0	.67
NC 605	4.17	4.17	3.33	0	0	2.33
NC 705	8.3	4.17	3.33	0	0	3.16
NC 807	8.3	0	0	0	0	1.66
NC 3055	0	0	0	0	3.33	.67
NC unknown	0	0	0	3.33	0	.67
Total	29.17	25.0	23.33	10.0	13.33	20.16
Northrup-King						
NK 621	0	0	0	3.33	3.33	1.33
NK 623A	4.17	4.17	3.33	0	0	2.33
Total	4.17	4.17	3.33	3.33	3.33	3.67
PAQ 386	4.17	0	0	0	0	.83
Pfister 348	0	0	3.33	0	0	.67
Pfister 391	0	0	0	3.33	0	.67
Pfister 399	0	4.17	0	0	0	.83
Total	0	4.17	3.33	3.33	0	2.17
Pioneer 314	12.5	0	10.0	3.33	3.33	5.83
Pioneer 320	4.17	4.17	0	0	0	1.67
Pioneer 321	0	4.17	0	0	0	.83
Pioneer 328	4.17	4.17	0	0	0	1.67
Pioneer 3268	0	0	3.33	3.33	0	1.33
Pioneer 3300	0	4.17	3.33	0	0	1.5
Pioneer 3306	0	0	3.3	3.3	10.0	3.32
Pioneer 3307	0	0	6.7	3.3	0	2.0
Pioneer 3333	0	0	0	0	3.3	.67
Pioneer 3353	0	0	0	3.33	0	.67
Pioneer 3390	0	0	0	3.33	0	.67
Pioneer 3505	0	0	0	0	3.33	.67
Pioneer 3510	0	0	3.3	3.3	0	1.33
Pioneer unknown	0	0	0	3.3	3.3	1.33
Total	20.83	16.67	30.0	26.67	23.33	23.5
Prairie Valley 510	4.17	0	0	0	0	.83
Prairie Valley ccc	0	4.17	0	0	0	.83
Prairie Valley unknown	8.3	0	0	3.3	0	2.33
Total	12.5	4.17	0	3.3	0	3.99
Steckly 11MF	0	0	3.3	3.3	0	1.33
Steckly 12	0	0	3.3	0	0	.67
Steckly unknown	0	4.17	0	0	0	.83
Total	0	4.17	6.7	3.3	0	2.83
Tomco 12	0	0	6.7	3.3	0	2.0
Tomco 711	0	0	3.3	0	0	.67
Tomco 838	0	0	3.3	0	0	.67
Tomco 915	0	4.17	0	0	0	.83
Tomco 956	0	0	3.3	0	0	.67
Total	0	4.17	16.67	3.3	0	4.83