Eastern South Dakota Soil and Water Research Farm

1996

Annual Report to the Board of Directors

March 19, 1997

USDA, ARS, Brookings, SD
USDA, ARS, Morris, MN
South Dakota State University

Research Partners

The Eastern South Dakota Soil and Water Farm is an outstanding example of cooperation between federal, state, and local organizations to accomplish a research mission. The North Central Soil Conservation Research Laboratory, ARS, Morris, MN, the Northern Grain Insects Research Laboratory, ARS, Brookings, SD, the South Dakota Agricultural Experiment Station, Brookings, SD, and South Dakota State University, Brookings, SD have developed cooperative research programs directed towards cropping systems. These programs provide needed answers to crop production and environmental problems producers in the Northern Great Plains, and eastern South Dakota in particular, face each year. The participants in these research activities, both scientists and support staff, are dedicated to finding solutions to these important problems.

Research participants during 1996 were:

North Central Soil Conservation Research Laboratory, ARS, Morris, MN

Dr. Ward B. Voorhees, Research Leader
Dr. Michael J. Lindstrom, Soil Scientist
Mr. Gary Amundson, Agricultural Research Technician
Mr. Steve Van Kempen, Agricultural Research Technician

Northern Grain Insects Research Laboratory, ARS, Brookings, SD

Dr. Laurence D. Chandler, Research Leader
Dr. Michael M. Ellsbury, Research Entomologist
Dr. Joseph L. Pikul, Jr., Soil Scientist
Dr. Walter E. Riedell, Research Plant Physiologist
Dr. W. David Woodson, Research Entomologist
Mr. Dave Beck, Biological Research Technician
Ms. Rae Jean Gee, Biological Research Technician
Ms. Jessica Gerwing, Research Apprentice
Mr. Dave Harris, Agricultural Research Technician
Ms. Deb Hartman, Biological Research Technician
Ms. Denise Hovland, Biological Research Technician
Mr. Bart Larson, Agricultural Research Technician
Mr. Chad Nielsen, Biological Research Technician
Mr. Max Pravecek, Biological Research Technician & Farm Manager
Mr. Dave Schneider, Biological ResearchTechnician
Mr. Tim Schlotterbeck, Agricultural Research Technician
Mr. Travis Trudeau, Agricultural Research Technician
Mr. Marcus White Bull, Agricultural Research Technician

South Dakota Agricultural Experiment Station, Brookings, SD

Dr. Fred Cholick, Director

South Dakota State University, Brookings, SD

Dr. Dale Gallenberg, Professor, Head of Plant Science
Dr. Thomas E. Schumacher, Professor, Plant Science
Dr. Sharon Clay, Assoc. Professor, Plant Science
Dr. David Clay, Assoc. Professor, Plant Science
Dr. Kevin Kephart, Assoc. Professor, Plant Science
Dr. Murt McLeod, Extension Entomologist, Plant Science
Dr. Steven Schiller, Assoc. Professor, Physics
Mr. Kevin Banken, Research Assoc., Plant Science
Mr. Dan Olson, Research Assoc., Plant Science
Ms. Susan Selman, Research Assoc., Plant Science

South Dakota State University, Brookings, SD (contract employees and/or students working at the Northern Grain Insects Research Laboratory)

Ms. Michelle Brunz, Agricultural Research Technician
Mr. Bill Clasen, Agricultural Research Technician
Ms. Sarah Gullickson, Agricultural Research Technician
Mr. Terry Hall, Biological Research Technician
Ms. Rae Ann Higbee, Agricultural Research Technician
Mr. Jesse Jenson, Agricultural Research Technician
Ms. Evelyn Kahler, Biological Research Technician
Mr. Josh Males, Agricultural Research Technician
Mr. Kurt Meister, Agricultural Research Technician
Ms. Sharon Nichols, Biological Research Technician
Ms. Lynelle Noisy Hawk, Agricultural Research Technician
Mr. Brian Norberg, Agricultural Research Technician
Mr. Caleb Shillander, Agricultural Research Technician
Mr. Caleb Watson, Agricultural Research Technician

A special thank you is extended to Shawn Rohloff (purchasing agent) at the North Central Soil Conservation Research Laboratory, Kathy Reese (secretary), Laurie Meier (administrative officer), Sharon Telkamp (purchasing agent), and Doug Nemitz (maintenance mechanic) at the Northern Grain Insects Research Laboratory, and Darwin Longieliere (SDSU-ABS Fiscal Officer) for providing the needed administrative and operational support for our research activities.

1996 FARM ACTIVITIES

Max Pravecek
USDA, ARS Northern Grain Insects Research Laboratory

The 1996 season at the ESDSW Farm was very successful. Research activities were expanded and conducted by researchers from SDSU and USDA labs from Morris, MN and Brookings, SD.

Activities included; effects of corn borer and corn rootworm on Bt corn; effect of foxtail on corn rootworm populations in corn; Bt corn demonstration; fertilizer placement in wheat, oats, and millet; soybean planting rates, rootworm effect on different corn cultivars, ground truthing of insect infestation for remote sensing.

The Input plots were revised in experimental design to emphasis soil fertility and crop rotation. These plots were sampled for organic carbon; plant biomass and yield; soil compaction; soil water use; corn rootworm population; soybean leaf beetle population; mineral nutrients in leaf samples; and water infiltration.

Rainfall from May to October was 16.8 inches, approximately 2 inches below normal, grain yields were excellent, especially corn

The second annual field day was held the 10th day of September at the farm. A roast hog supper was followed by a short talk by SDSU climatologist Al Bender and a short tour of the farm, where some of the research activities were highlighted. Approximately 135 people attended.

A weather station was set up at the farm where air temperature, wind speed and direction, and soil temperature are recorded and available to the public. More information on the weather station is elsewhere in this report.

1996 Rainfall

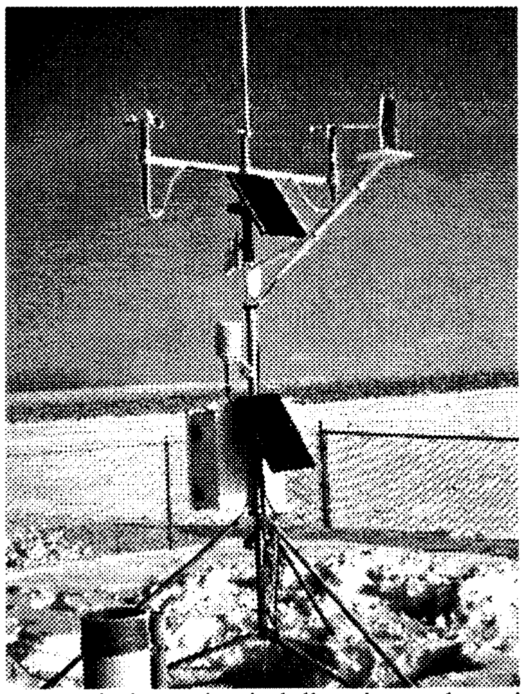
	May	June	July	Aug	Sept	Oct
Normal	2.02	3.06	4.42	2.85	1.96	1.33
Actual	.31	5.24	2.10	2.31	2.60	2.97

Automated Weather Station

Joseph L. Pikul Jr., Soil Scientist
USDA-ARS, Northern Grain Insects Research Laboratory

An automated weather station was installed on the Eastern South Dakota Soil and Water Research Farm in 1996. Many of our research projects rely on having a dependable source of weather data obtained at the location of the experiment. This weather station provides detailed measurements of wind speed, wind direction, air temperature, relative humidity, quantity of solar radiation, barometric pressure and soil temperature.

Current weather conditions can be obtained by calling the weather station on the telephone. The caller will hear a recorded greeting identifying the site and then be provided



with current air temperature, wind speed, wind direction and previous day soil temperature at 4". The recorded soil temperature at 4" is a daily average and as such will provide a good indicator of seed-depth temperature. Wind direction is given in degrees (East is 90°, south is 180°, and west is 270°) The entire system is battery operated. To reduce power drain, the station has been programmed to receive calls only during certain hours. On a trial basis we will provide service between the hours of **8 AM to 11 AM** and **5 PM to 6 PM** during the summer months. The station can be reached by calling:

695-2322

If you call at other times you will hear a COMMNET message indicating that the station is not available. Direct questions concerning this station to Joe Pikul at 605-693-5258.

YIELD IMPACT OF WESTERN CORN ROOTWORM AND EUROPEAN CORN BORER ON DIFFERENT MATURING VARIETIES OF FIELD CORN.

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INTRODUCTION:

European corn borer (*Ostrinia nubilalis* Hubner) and Western corn rootworm (*Diabrotica virgifera virgifera* Leconte), are two important corn pests found throughout the corn growing areas of the United States. Both pests are commonly found feeding on the same corn plants in a field. Individually, both of these pest species have received considerable attention from researchers. Little research has been conducted looking at the possible interactions that may exist between these two insects when feeding on the same host. The purpose of this study is to look at what, if any, interactions occur between the plant and these two pests, and to try and interpret the interaction.

METHODOLOGY:

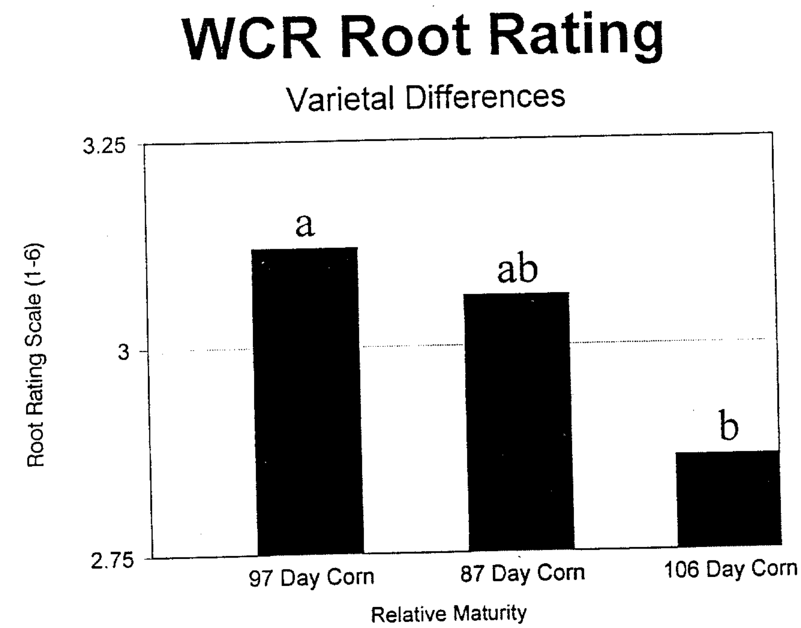
In 1996, an experiment was conducted at the USDA-ARS Northern Grain Insect Research Laboratory, Brookings, SD. This field study consisted of three Pioneer hybrid seed varieties with different relative maturities (87,97,106 day), three levels of Western corn rootworm infestations (0,600,1600 eggs/linear ft.) four levels of European corn borer infestations (0, 1st, 2nd, 1st and 2nd generation), in a strip-split-plot design. There were four replications with eleven treatments plus a control in each.

Throughout the growing year, damage assessments were made that consisted of the following; roots were extracted from the soil and were rated according to the amount of pruning done by Western corn rootworms (1-6 scale), stalks were split to observe tunneling caused by 1st and 2nd generation corn borers. Ear yields and ear lengths were recorded after harvest.

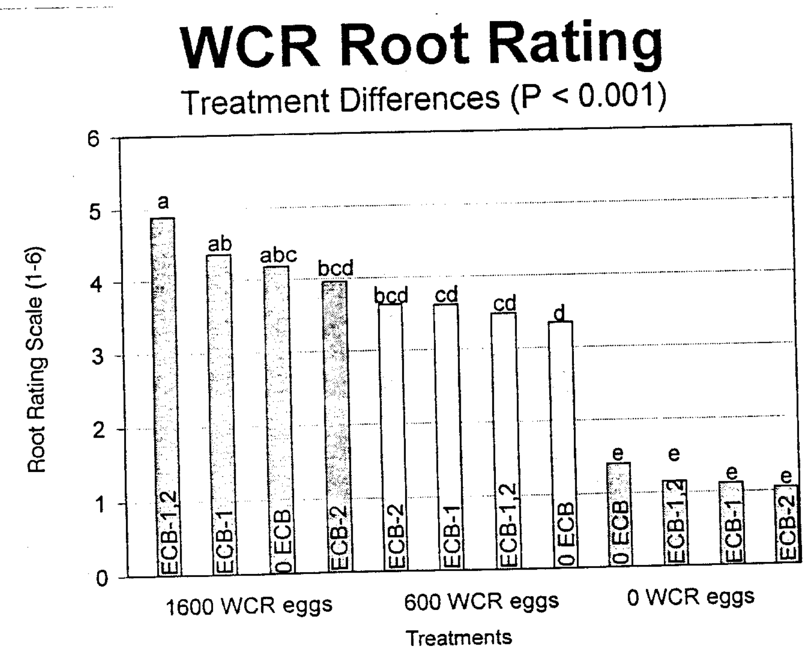
RESULTS:

When looking at the damage caused by the rootworms, the three varieties responded differently (Graph 1). There were also differences between infestation levels of rootworms (Graph 2).

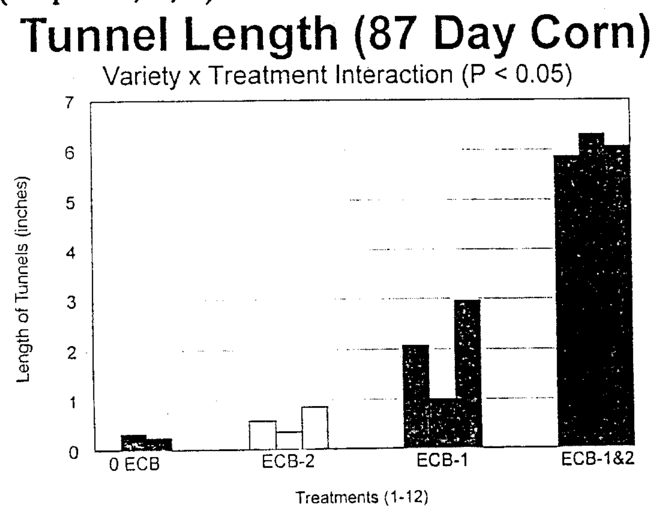
Graph 1



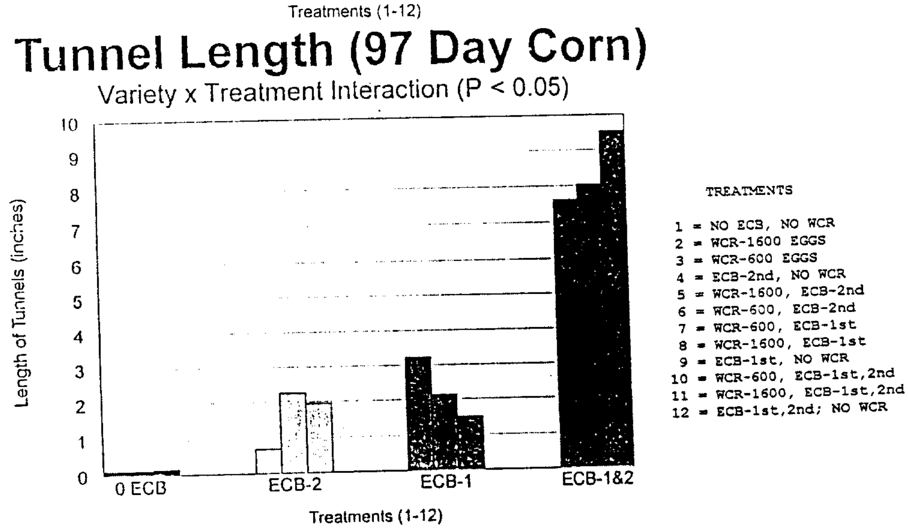
Graph 2



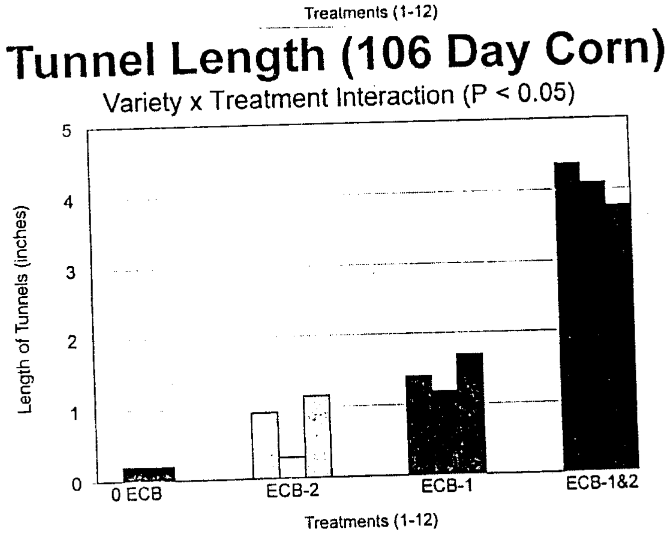
Differences were seen in the amount of tunneling caused by European corn borers. The three varieties did not perform in a similar manner to the different corn borer infestations (Graphs 3a,3b,3c).



Graph 3a



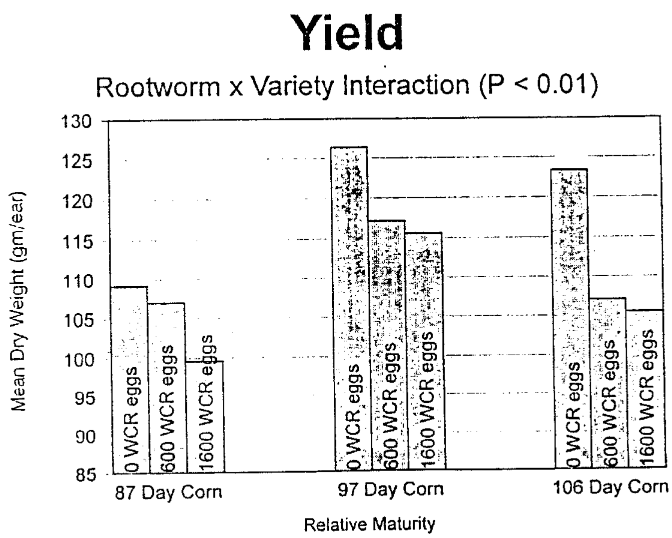
Graph 3b



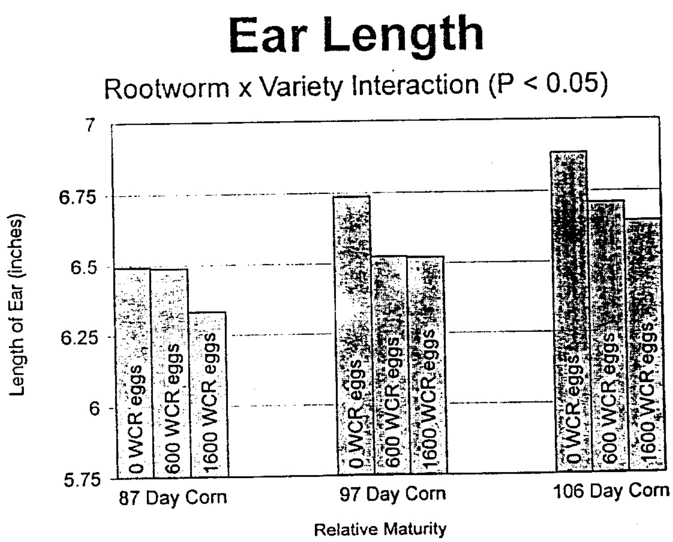
Graph 3c

The weight of the grain/ear and length of ears were measured in the fall to look at how feeding by the two insect larval forms would affect yield. The three varieties of corn responded differently to the same rootworm infestation (Graphs 4a,4b).

Graph 4a



Graph 4b



DISCUSSION:

The exact cause of the interactions observed in this experiment have yet to be determined. An explanation for why the corn borers had such little affect on yield may be because there was a poor take with the artificial infestation of first generation borers. This may be important do to the fact that previous work done by researchers has shown that 1st generation European corn borers have a greater impact on yield than 2nd generation borers. The data and conclusions presented here are representative of observations made from one growing season at one location. This experiment will be repeated in 1997, and we look forward to presenting those findings at an upcoming meeting or publication.

Corn yield and soil quality affected by nitrogen fertilizer and crop rotation

J.L. Pikul Jr., Soil Scientist
W.E. Riedell, Plant Physiologist
USDA-ARS, Northern Grain Insects Research Laboratory

Legumes grown in rotation with other crops have historically been an integral part of crop rotation strategies. In a symbiotic relationship of legume plant and soil microorganisms, atmospheric nitrogen (N_2) is converted to organic N combinations. Organic N is transformed through a soil microbiological process to inorganic N. These two process are part of the nitrogen cycle and are called N fixation and N mineralization. Crops grown after the legume benefit from the inorganic N fertilizer source.

There are additional benefits to rotating crops beyond the obvious N credit. Rotations break weed, disease, and insect cycles. Control of crop pests using rotational cropping can reduce the need for pesticide inputs. Rooting characteristics of various crops can have a beneficial effect on soil structure and improve soil quality. There is also another benefit of crop rotations that can be very difficult to quantify. Given the same inputs, crops will often perform at a superior level when grown in rotation with other crops. This effect is often called a crop rotation factor.

Objectives of this research are to identify the effect of crop rotation on physical, chemical, and biological properties of soils. This report focuses on corn yield and management of corn during 1996 on a crop rotation and nitrogen fertilizer experiment.

Methods

In 1990 a crop rotation study was started to investigate the effect of crop rotation on crop yield using three input levels. Input levels were related to the quantity of inputs and intensity of management. A high input level had high inputs of fertilizer, herbicide, and insecticide. In comparison, a low input level did not receive fertilizer, herbicide, and insecticide. These plots have been called the input plots.

In 1996, objectives of the input experiment were changed. The original experiment was a systems level experiment that was difficult to interpret using standard statistical analysis. In other words, we could not identify cause and effect. Variables that we could not isolate were tillage, weed control, insect control, fertilizer P and fertilizer K. Therefore, we reduced the number of input variables to be consistent with the physical layout of the field plots. Variables in the present study are rotation and fertilizer N. Crop rotations were not changed. Rotation and fertilizer N were part of the original design and in that respect we have continuity throughout the life of the experiment.

Design of the rotation/nitrogen field experiment was a randomized complete block with 3 replications. Plots were 100' by 100'. The experiment was designed so that each phase of each rotation were present every year. Soil is a Barnes loam (previously called Vienna loam).

Crop rotation treatments were:

1) Continuous corn (abbreviated CC)

2) Corn in rotation with soybean (CS)

3) Corn in rotation with soybean, ridge tilled (CS ridge)

4) 4-Year rotation of corn, soybean, spring wheat companion seeded with alfalfa, and alfalfa hay (4-year)

Fertilizer treatments for corn were:

1) Corn fertilized for 135 bu/acre yield. (N needed = 1.2lbs/bu*135bu - Soil nitrate N in top 2 feet of soil - Starter N) 100 lbs/acre 14-36-13 starter banded with seed. Remainder of N requirement supplied with 46-0-0 urea.

2) Corn fertilized for 85 bu/acre yield. (N needed = 1.2lbs/bu*85bu - Soil nitrate N in top 2 feet of soil - Starter N) 100 lbs/acre 14-36-13 starter banded with seed. Remainder of N requirement supplied with 46-0-0 urea.

3) No fertilizer

Soil samples for nitrate-N analysis and soil pH were taken each fall after harvest. Three cores to a depth of 4' were taken from each plot. Nitrate-N was measured for the 0-6", 6"-12", 12"-24", 24"-36", and 36"-48" depths.

Soil cores for organic carbon analysis were taken each spring from the 0-3" and 3"-6" depth. Soil carbon was determined by combustion.

Corn yield was measured on each plot using a plot combine. Yield was determined from eight rows 100' long. Grain moisture was determined at time of harvest. Yields were adjusted to a moisture content of 15.5% (56 lb/bu).

Total plant weight was measure on 3 rows, 3.3' long. From these samples grain and residue weights were determined. Samples of grain and residue were analyzed for total N and total P.

Primary tillage on all plots, except the ridge till system, was changed in 1996 from fall moldboard plow to fall chisel plow. Seedbeds on all plots, except ridge till, were prepared with a tandem disk and field cultivator. All corn plots were seeded on the same date with Pioneer 3769 at 30,000 seeds/acre. Population goal was 27,000 plants/acre. We overseeded to anticipate a 10% loss. Stand counts were taken at emergence. For weed control, Lasso (2.5 quarts/acre) and Bladex (2.5 quarts/acre) were applied prior to emergence.

Results

Phosphorus

After nitrogen (N), phosphorus (P) is likely to be the second most deficient nutrient in soils. We became concerned with fertilizer-P deficiency following extensive soil sampling in spring 1996 (Figure 1). For corn, an Olsen P test of 0-3 ppm is very low, 4-7 ppm is low, and 8-11 ppm is medium. Values shown in Fig. 1 are averages of all rotations. There were significant differences in Olsen P among fertilizer treatments (Figure 1). Our lowest test value was 1 ppm and the highest was 21 ppm.

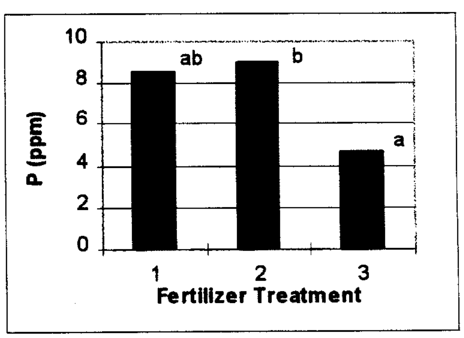


Figure 1. Soil P (Olsen) prior to broadcast application of P in 1996. Treatment 3 has had no P addition. Treatments 1 and 2 have had starter P.

History of the Eastern South Dakota
Soil and Water Research Farm

The Eastern South Dakota Soil and Water Research Farm, Inc. is a non-profit organization consisting of a Board of Directors elected from each of 15 Soil and Water Conservation Districts in eastern South Dakota: Brookings, Codington, Clark, Day, Deuel, Hamlin, Kingsbury, Lake, Lincoln, Marshall, McCook, Minnehaha, Minor, Moody, and Turner. The purpose of the corporation is to promote research of efficient farm production practices that conserve soil and water resources.

The corporation bought 100 acres of land in Lake County, South Dakota, near the town of Madison in 1959. This land was leased to the Agricultural Research Service, United States Department of Agriculture. The research performed at the Madison farm included evaluation of the erosion of different soil types, development of tillage practices to conserve soil and water, determination of efficient crop production methods, and modeling plant-insect interactions. Research was conducted by scientists from the North Central Soil and Water Conservation Laboratory, ARS, Morris, MN; the Northern Grain Insects Research Laboratory, ARS, Brookings, SD; and the South Dakota Agricultural Experiment Station.

The Board of Directors decided to relocate the research farm closer to the ARS and South Dakota State University primary facilities to improve program efficiency and facilitate productive cooperative research programs that would more effectively solve some of the production problems associated with agriculture in eastern South Dakota. The Madison research farm was sold in 1987, and the corporation bought another tract of land in Brookings County.

The Brookings research farm consists of 80 acres located approximately one mile north of the South Dakota State University campus. The soils on this farm are characteristic of those found in northeastern South Dakota and west central Minnesota and are similar to soils common to the northern corn belt.

Phosphorus is generally in low supply on our soils and even when present it may be in a form that is relatively unavailable to plants. The only satisfactory way of supplying plant needs is through addition of P fertilizer. In this experiment we are evaluating the effect of nitrogen fertilizer rate and crop rotation. To create uniformity in our trials we blanket applied 395 lbs/acre of 0-45-0 in April 1996. This rate provided 78 lbs/acre of elemental P (395 lbs/acre material * 0.45 = 178 lbs/acre P_2O_5; 178 lbs/acre P_2O_5 * 0.44 = 78 lbs/acre P). There is a rough rule-of-thumb that suggests it takes 5 lbs/acre elemental P to increase the soil test 1 ppm. Our application of P should bring all plots to a very high P soil test. However, annual soil testing for P will still be necessary to evaluate soil P nutrition.

Soil Quality

Soil quality is a term that has recently been coined to evaluate the effect of management on soil. Soil quality has been defined by the Natural Resources Conservation Service as: *"Soil quality is the fitness of a specific kind of soil to function within its surroundings, support plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation"*. As yet there is no single quantitative measure of soil quality. However, out of the many tests that can be used to judge soil quality, organic carbon may be the most important. Soil carbon can be thought of as soil organic matter and the presence of soil organic matter has a disproportionate effect on almost all soil properties including fertility and workability. In addition soil organic matter may be linked to the presence or absence of insect pests. Preliminary research reports from Ohio suggest lower numbers of European corn borer on plants from soils that had high levels of organic matter.

Soil organic matter is effected by tillage, crop rotation, and other management. Soil organic matter can be rapidly reduced with some farming practices, notably fallow. Rehabilitation of a degraded soil is difficult. Research has shown that primary tillage with the moldboard plow can result in lower levels of soil organic matter compared to tillage methods that do not invert the soil. Up until 1996 primary tillage on the rotation experiment has been with the the moldboard plow. There were no differences among rotations in soil organic carbon. Additional years will be required before conclusions can be drawn concerning the effect of rotation and fertilizer rate on soil organic matter.

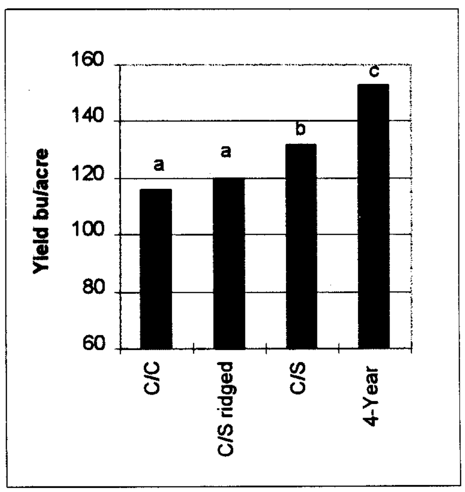


Figure 2. Corn yield for 1996

Nitrogen

Soil nitrate-N (NO_3-N) is the predominant test for nitrogen recommendations in our corn production area. South Dakota and Minnesota fertilizer guides provide for nitrogen credit from the previous crop and in practice these guides should be followed. To isolate cause and effect, we do not calculate our fertilizer needs using a nitrogen credit for the previous crop. Crop yield beyond that predicted by total NO_3-N (soil test plus added inorganic N) is a consequence of microbial conversion of organic N to inorganic N and an unknown factor called the crop rotation effect. Total NO_3-N in the top 2 feet of soil was not significantly different among rotation treatments for the 1996 growing season, however corn yield among the rotations was significantly different (Figure 2). Yields for each rotation are shown as an average of all fertilizer treatments. The 4-year rotation averaged 21 bu/acre more than the corn/soybean (C/S)and 37 bu/acre more than continuous corn (C/C).

Nitrogen Use Efficiency

The ratio of corn yield to soil NO_3-N at the start of the growing season provides an index to estimate efficiency of NO_3-N use. Earlier in the discussion of fertilizer treatments we presented a factor of 1.2 that was multiplied by our yield goal. This indicates that under ideal conditions it takes approximately 1.2 lbs of N to produce 1 bushel of grain. Fertilizer guides for corn in South Dakota and Minnesota use the same factor. Our corn yield to NO_3-N ratios for each of the crop rotations are shown in Figure 3. Average efficiency for the 4-year rotation was 1.72 bu/lb NO_3-N and this was significantly different from the continuous corn (C/C) and corn/soybean on ridges (C/Cridged) which averaged 1.42 and 1.38 bu/lb NO_3-N, respectively. There was no statistical difference between the 4-year rotation and corn/soybean rotation.

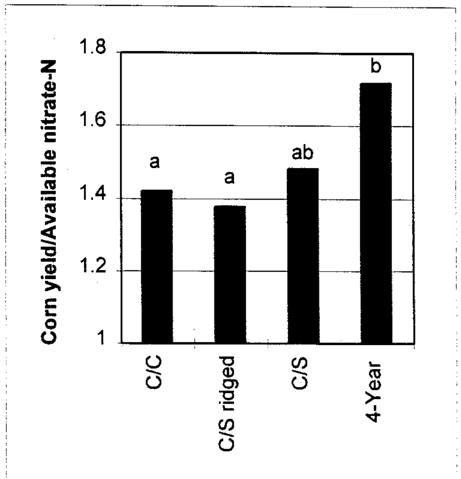


Figure 3. Ratio of corn grain yield to total NO_3-N in 1996.

Indirectly, these ratios can be used to infer differences in nitrogen mineralization rates during the growing season. Mineralization is a biological process whereby organic nitrogen is transformed to an inorganic form. We cannot be sure of the fate of this transformed N. The higher ratio on the 4-year rotation suggests that series of plots realized a yield benefit because of previous cropping history. Recall that there were no differences in total NO_3-N at the start of the growing season among rotations. For the 4-year rotation plot series, there have been two alfalfa crops, one in 1991 and another in 1995.

Conclusion

Crop and soil management effect soil nutrient cycling. With a given management we can anticipate a trend towards an equilibrium of soil physical and chemical state. Preferably we hope our management is taking the soil towards a more productive state. An important question in crop and soils research concerns this equilibrium and whether management is improving or degrading the soil resource. Is an equilibrium reached? How long does it take? These questions are fundamental to sustainable agriculture. Long term field trials provide a basis for understanding complex soil processes. The long term crop rotation and nitrogen experiments located on the Eastern South Dakota Soil and Water Research Farm are fast becoming an important resource with which to judge the effects of crop rotations in the northern corn belt. Our corn yield of 153 bu/acre on the 4-year rotation plots was respectable. This yield, when compared to 116 bu/acre on continuous corn, provides evidence that the longer rotation is out-performing the shorter rotations. In these rotation studies time is an essential element. We cannot draw casual conclusions based on one or two crop cycles.

Rootworm emergence in 1996 continuous corn with varying rates of nitrogen.

W. David Woodson
Northern Grain Insects Research Laboratory
USDA - ARS
Brookings, South Dakota

Introduction

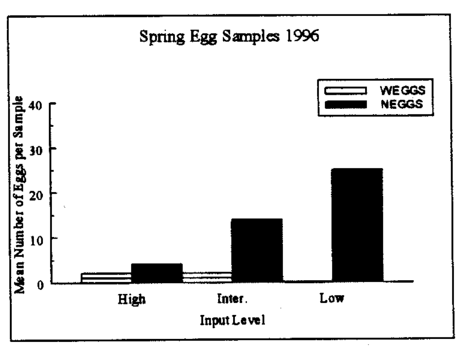
The effects of nitrogen on insect populations is poorly understood. Generally, increases in nitrogen are beneficial to insects such as aphids and leaf beetles. However, preliminary studies by scientist at the NGIRL indicate nitrogen may be detrimental to corn insects that feed on plant roots. Conversely, a plants greenness plays a significant role in determining its attractiveness to female rootworms preparing to lay their eggs. Late planted fields usually attract more beetles and consequently have more eggs deposited. The purpose of this study is to determine how different levels of nitrogen on field plots affect rootworm survival and its affect on corn rootworm egg laying.

Methods

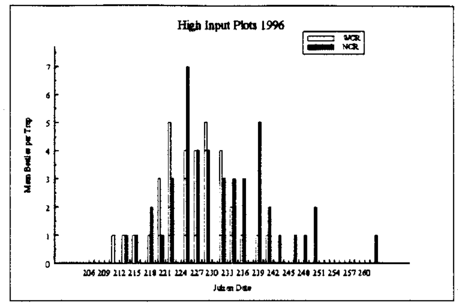
Plot areas were established that had either low, intermediate or high nitrogen levels. Low input plots had no additional nitrogen added. Intermediate plots had 13.5 actual N applied at planting on 16 May 1996 and an additional 38.7 lb. actual N applied as a side dress on 26 June 1996. High input plots had 13.5 actual N applied at planting on 16 May 1996 and an additional 91 lb. actual N applied as a side dress on 26 June 1996. Plots were sampled on 20 May 1996 to estimate the egg density of northern and western rootworms. Four soil samples per plot were taken, the eggs washed from the soil and eggs were identified. Adult emergence was monitored from 24 July till 18 September 1996 using four emergence traps per plot and emerging adults were counted twice per week. In the fall, 21 October 1996, eggs were sampled the same as in the spring.

Results

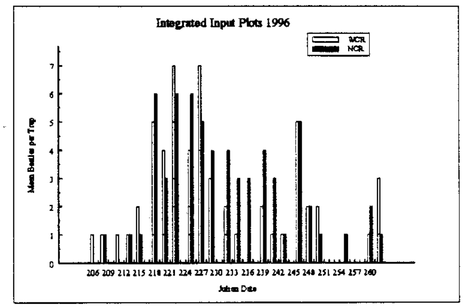
Spring egg samples indicated that western corn rootworm eggs were at their lowest level since monitoring began six years ago. No western corn rootworm eggs were detected in the low input plots, and less than one per sample was found in the integrated and high input plots. Large numbers of northern corn rootworm eggs were detected in low and integrated plots and a smaller number were found in the high input plots. In the past the high input plots have had the most corn rootworm eggs. This was due to large number of western corn rootworm eggs however, usually there have been more northern eggs in the integrated and low input plots.



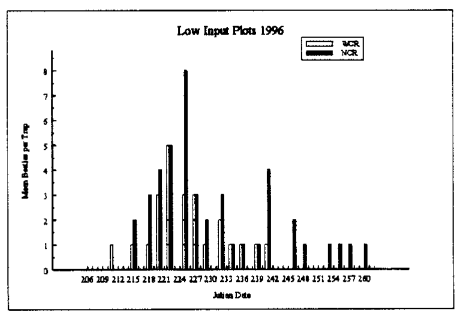
High input plots had large numbers of rootworms emerging for seven weeks. Western corn rootworms began the season, first emerging on 29 July and northern corn rootworms ended the season with the last emerging on 18 September. Emergence patterns between the two species differed markedly. Of the 92 western corn rootworms captured two thirds were male. In contrast, of the 135 northern corn rootworms captured from the high input plots, two thirds were female.



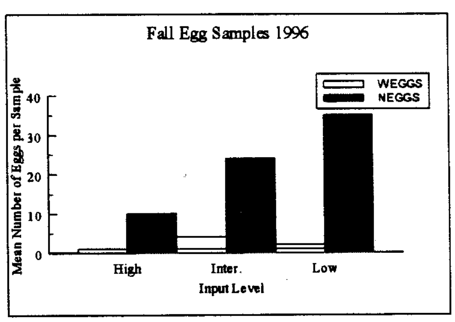
The integrated input continuous corn plots were prime rootworm producing field this year. Emergence began early in these fields, on 24 July continuing till 16 September and produced the greatest numbers of adults. The emergence pattern of the two rootworm species was similar to the other input plots with roughly two thirds of the western corn rootworms being male and two thirds of the northerns being female.



The low input fields produced few corn rootworm adults however, the emergence pattern was similar to the other input plot. This low emergence was not surprising with respect to the western corn rootworm because no eggs were detected in these plots. However, these plots had the largest number of northern eggs and still had few adults emerge. In past years similar occurrences have been attributed to the high weed populations in these plots. This year that argument won't work because the plots were almost weed free and the plots even had a yield, unlike past years..



Fall egg samples indicated that the low input plots were favored by the northern corn rootworm for oviposition followed by the integrated and high plots, respectively. Western corn rootworm eggs were in such low numbers that no valid conclusions can be made in relation to their preference for one input plot or the other. Why the low input plots were favored for oviposition is not clear



Conclusions

While it is still too early to make any broad conclusions about how the nitrogen levels are influencing rootworm population dynamics a couple of things are clear. Since weed control has been implemented on the low input plots they are much more attractive to the northern corn rootworms for egg laying sites when compared to past years. . Unlike western corn rootworms northern corn rootworms leave the field they emerge from and feed on pollen from other plants such as wild sunflower. After a period of feeding and maturing they mate and return to corn fields to lay their eggs. Currently little is known about factors that influence northern corn rootworm field selection for egg laying. In the case of the ESDSW Research Farm plots this may be due to the plants being more apparent in the landscape than in the past.

Bt Corn Hybrids: European Corn Borer Damage Protection and Yield in 1996

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Introduction

Western Minnesota and eastern South Dakota saw a major European corn borer outbreak during the 1995 growing season. In this region of the corn belt, corn borer populations generally pass through 2 generations. Plant damage caused by the first generation takes place in the leaf roll at about the crop's 6th leaf stage. This damage resembles shot-holes on the leaves. Second generation borers usually damage corn stalks and ear shanks near the time when the crop tassels.

Genetically-engineered Bt corn hybrids became available for growers in the 1996 season. To manufacture the Bt varieties, genetic information from the microbe *Bacillus thuringiensis* (Bt) was engineered into corn varieties. The microbe's genetic information allows the corn plant to manufacture a Bt protein that is toxic to the corn borer.

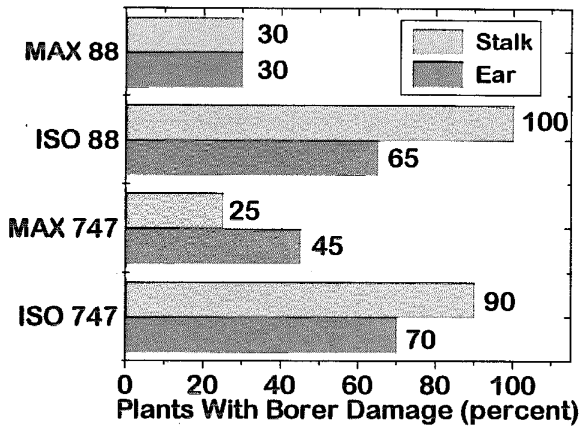
We were interested in evaluating the new Bt varieties for their ability to resist corn borer damage and for their yield. We obtained two Bt varieties from Ciba Seeds (MAX 88 and MAX 747) for our experiments. We also were able to obtain isolines (ISO) for each of these varieties that were exactly the same as the MAX lines except they did not contain the Bt gene.

Materials and Methods

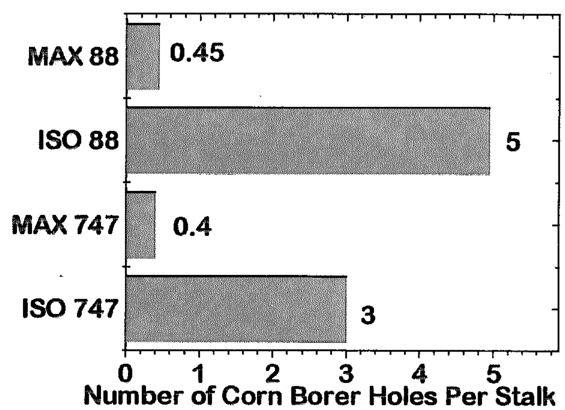
Research plots were established by planting each variety in rows that were 40 inches apart with 9 inch plant spacing (final plant stand of 17,000 seeds per acre). Plants were allowed to grow normally through the growing season. Towards the end of the season (just before the first frost), plants were harvested and corn borer damage in stalks and ears was measured. Leaves were stripped from the stalk, and the number of holes in the stalk was determined. The stalk of the plant was then split down the middle, and the length of the tunnel measured. The crop was harvested by hand at the end of the growing season.

Results and Discussion

The figure to the right shows the general appearance and size of one of the larval stages of the European corn borer. The larval form of the insect will burrow in corn stalks and leaf midveins, disrupting the movement of water and nutrients through these plant organs. The damage also can weaken stalks and ear shanks leading to stalk lodging or ear loss. Corn borers also aid in the development of stalk rots by creating wounds through which stalk-rot pathogens may enter.

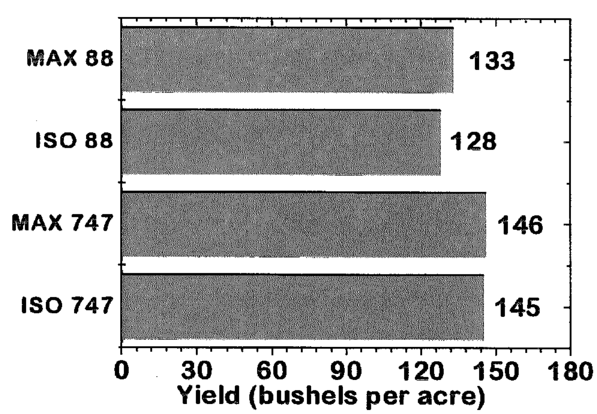


The percentage of plants damaged by corn borer in 1996 is presented on the left. These data suggest that between 25 to 30 percent of the plants that contained the Bt gene (MAX 88 and MAX 747) had stalk damage and 30 to 45 percent had ear damage. The percentage of plants that did not contain the Bt gene (ISO 88 and ISO 747) damaged by the corn borer was much larger (90 to 100 % had stalk damage; 65-70 % had ear damage).



The number of corn borer holes per stalk, which is a measure of the borer population size and hence the severity of the corn borer damage, is shown on the left. The varieties that did not have the Bt gene (ISO 88 and ISO 747) had an average of between 3 to 5 corn borer holes per stalk. The varieties that did have the Bt gene (MAX 88 and MAX 747) had a much lower average. The Bt gene reduced the severity of the corn borer damage.

The yield data, presented on the right, shows that all of the varieties tested had excellent yield. The yield of MAX 747 and ISO 747 was much greater than that of MAX 88 and ISO 88. The presence of the Bt gene in the MAX varieties was associated with a 5 bushel per acre yield increase in the MAX 88 variety, but only 1 bushel per acre yield increase for the MAX 747 variety.



Conclusions

The MAX genetic engineering technology does not protect 100 percent of the plants from corn borer infestation, but it does limit the severity of the corn borer damage. The 1996 corn borer population had only a small effect upon reducing yield in either of the ISO varieties tested. Additional studies with more varieties are planned for 1997.

Tillage, Row Spacing, and Soil Fertility for Optimal Soybean Yield

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Introduction

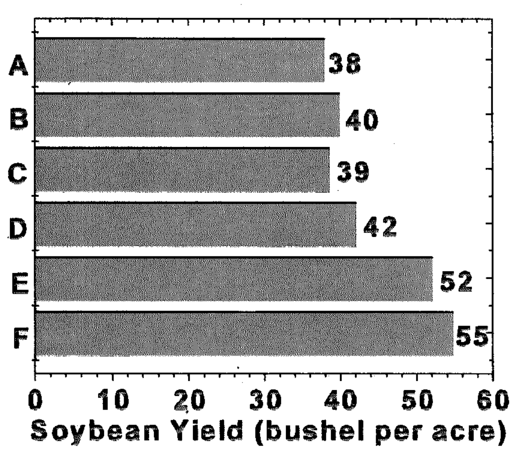
Soybeans use nitrogen (N) from the air to manufacture their own N fertilizer. Consequently, soybeans can be grown with no additional N fertilizer applied to the soil. Most farmers, however, apply a starter N-P-K fertilizer at soybean planting time. Our objective was to determine if soybean yield would increase if additional N fertilizer was used, and if this fertilization practice could cause problems with nitrate contamination of the ground water.

Materials and Methods

A plot at the Eastern South Dakota Soil and Water Research Farm was fertilized with 100 pounds of actual N (as 46-0-0, broadcast and incorporated) per acre and planted with 'Hendricks' soybeans (approximately 260,000 seeds per acre) drilled at 7.5 inch row spacing. We compared yield data obtained from this plot with yield data taken from other plots on the farm (Pioneer soybean with 30 inch row spacing and approximately 150,000 seeds per acre). Potential N contamination of ground water was estimated using the *NLEAP* computer simulation model.

Results and Discussion

When planted in 30 inch rows, soybean yields in 1996 ranged from 38 to 42 bushels per acre. Applying starter fertilizer (100 lbs product per acre of 13-33-13 in 2" by 2" band) improved yield by 2 to 3 bushels per acre. When planted in 7.5 inch rows (and given 100 lbs N per acre), soybean yields ranged from 52 to 55 bushels per acre.



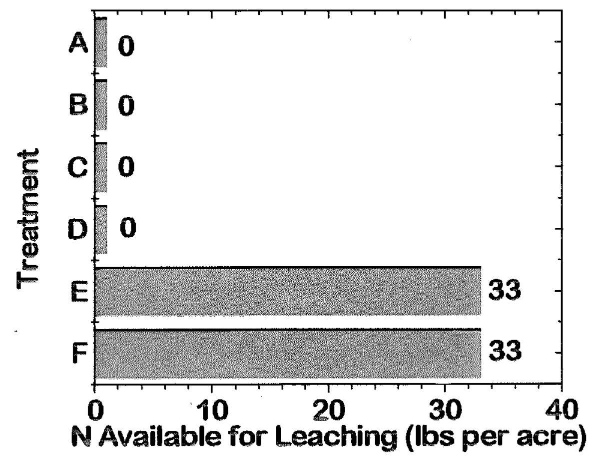
Explanation of Treatments:

A=30 inch row spacing under ridge tillage
B=30 inch row spacing under ridge tillage + starter fertilizer
C=30 inch row spacing under conventional tillage
D=30 inch row spacing under conventional tillage +starter fertilizer
E=7.5 inch row spacing under conventional tillage +N (plot previously under ridge tillage)
F=7.5 inch row spacing under conventional tillage +N (previously moldboard plow)

These results show about a 35% increase in soybean yield when the crop was fertilized with broadcast N and planted in 7.5 inch rows.

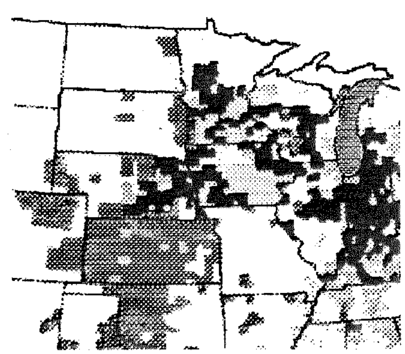
Are there any potential problems with this type of fertilizer practice for soybean production?

The Nitrogen Leaching and Economic Analysis Package (*NLEAP*) is a computer software program that predicts the amount of N available for leaching from the root zone. The results of an analysis of our soybean fertilizer program using this software is presented on the right. These data suggest that if only starter fertilizer was applied, there would be no N available for leaching from the root zone. If broadcast N fertilizer is applied (100 lbs actual N per acre applied at planting), then 33 lbs per acre N is potentially available for leaching from the root zone.



Is N leaching from the root zone a potential problem that soybean producers in eastern South Dakota and western Minnesota should be concerned about?

The map on the right shows the areas of the North Central U.S. that have the potential for nitrate and pesticide contamination of the groundwater. (Light gray is pesticide contamination potential, dark gray is nitrate contamination potential, and black is pesticide and nitrate contamination potential) The groundwater in eastern South Dakota and western Minnesota potentially could have contamination with nitrate. This potential is related to the shallowness of the aquifer in this region of the country. It seems that, if broadcast N fertilizer is used on soybean for increased yield, consideration must be given to the type, amount, and placement of that fertilizer for best yield response as well as reduced potential for N leaching from the root zone.



Conclusion

The results indicate that soybean planting methods that include additional broadcast N fertilizer, decreased row spacing, or increased crop population produced better yields. However, we do not know which component of these treatments (alone or in combination with each other) was the cause for this increase. Additional studies on this topic are planned for the 1997 growing season at the Soil and Water Research Farm. The objectives of these studies will be to identify soybean production practices that optimize yield yet reduce or eliminate the threat of N leaching from the root zone and into the groundwater.

Bean leaf beetle population dynamics in soybeans

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The bean leaf beetle, *Cerotoma trifurcata*, is a sporadically occurring pest of soybeans. Beetles are about 1/4 inch long and vary from reddish brown to pale yellow in color. They usually have black wing margins and two black spots on each wing cover. All have a black triangular-shaped spot just behind the head. Reports from other parts of the upper Midwest indicate that these insects spend the winter as adults in leaf litter or some other type of vegetation. They emerge from their winter hiding places over an extended period of time usually beginning sometime in May. The beetles can feed on a variety of legumes, including clover, alfalfa and soybean. In Iowa they are known to have two generations per year.

Bean leaf beetles can attack soybeans at any plant growth stage. Early season attacks on newly emerging leaves can be especially severe and could cause the greatest amounts of crop loss to growers. Growers should regularly look for early season infestations and treat their fields when greater than 5% of plants are affected. In South Dakota early season infestations do not appear to cause any significant problems. However, in 1995 many soybean fields in eastern South Dakota had significant late season defoliation attributed to this pest. During this part of the growing season beetles can feed on pod surfaces and pod petioles leading to yield loss. Additionally, leaf feeding by the adults can cause some defoliation and resulting plant stress. Based on the defoliation observations of 1995 and the possibility of soybeans being economically impacted by this pest a study was initiated in 1996 to track bean leaf beetle populations in soybeans grown in rotation with other crops and to determine if fertilizer level, tillage method, or crop rotation influence significantly affected the number of insects observed and their potential for inflicting damage.

Methods

Soybeans grown in a crop rotation/nitrogen fertilizer experiment were sampled weekly beginning on 11 July and continuing through 21 August. The soybeans were grown in a corn-soybean rotation using either ridge till or chisel plow methods or in a corn-soybean-alfalfa-wheat rotation using chisel plow ground preparation. In addition, three levels of fertilizer inputs were applied to the rotations. Two groups of soybean plots (high and intermediate fertilizer inputs) received starter fertilizer (13-33-13 at 104 lbs/ac) at planting while the low input plots received no fertilizer. No additional fertilizer applications were made during the growing season. All soybean plots were treated with Broadstrike and Dual herbicide. In previous years these plots received fertilizer and weed control that varied by input level. For example, in 1995 high input soybeans received 99 lbs/ac of 13-33-13 while intermediate soybeans received 47 lbs/ac of 13-33-13. Differences in the fertilizer amounts applied during the season to the corn and wheat crops in the rotations were much more dramatic. Bean leaf beetle numbers were sampled in each plot (27 total plots) using an insect sweep net. Sixty total sweeps per plot in two subsamples (30 sweeps/subsample) were made and the total number of beetles collected in the net counted.

Results

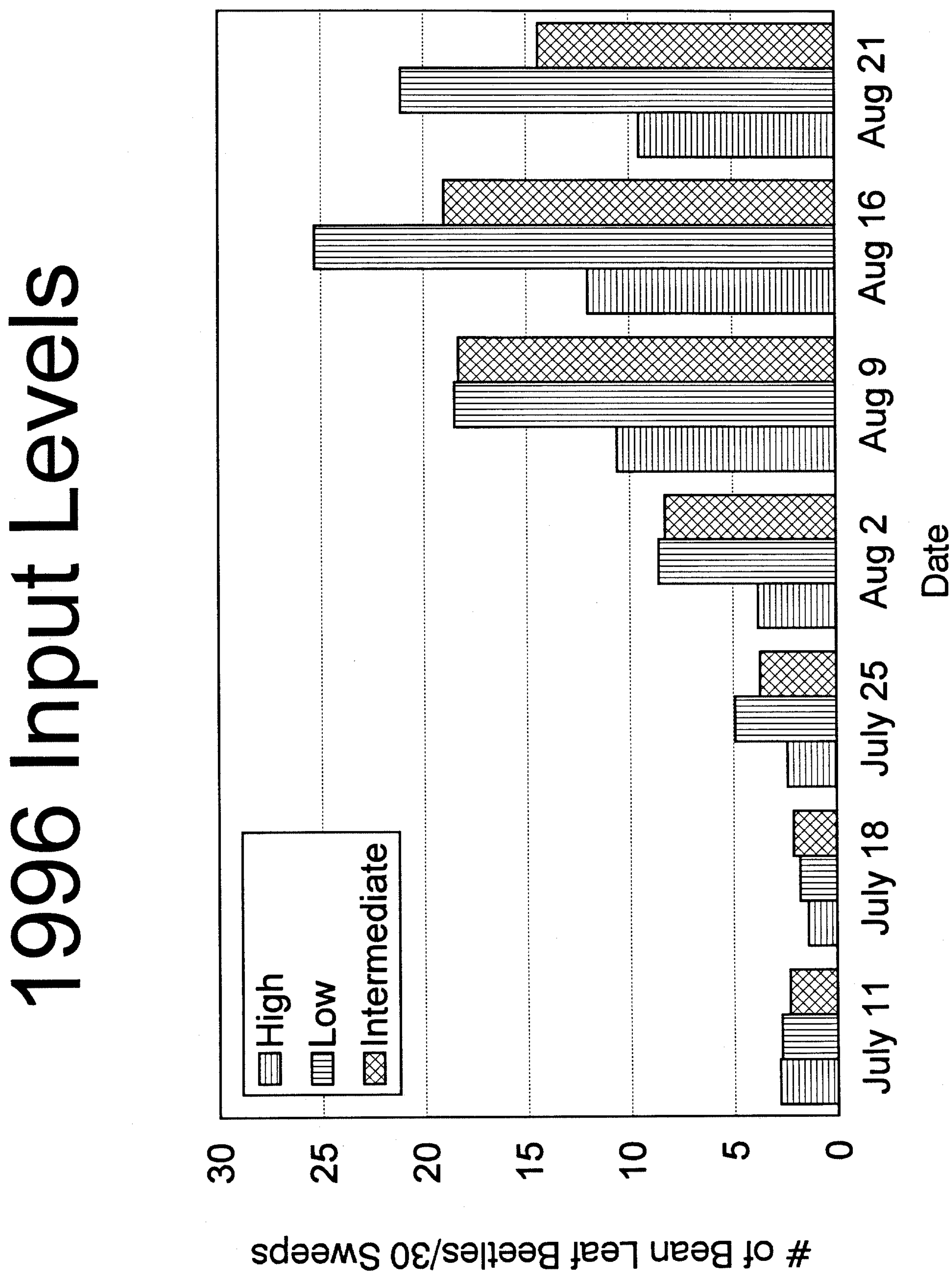
The number of bean leaf beetles collected remained low (<10/subsample) through 2 August in all plots. Beetle populations peaked from 9 August through 21 August. A comparison of input levels revealed that bean leaf beetle populations were highest in low and intermediate input plots during the time populations were peaking. Twenty-five beetles/subsample were collected from the low input plots on 16 Aug. The beetles were feeding primarily on foliage at this time and probably did little economic damage to the crop. Defoliation inflicted by the insects was less than 40% during this period which is below the threshold that requires treatment. Based on results only from the comparison of input levels you could speculate that beetle numbers were greatest in plots where nitrogen concentrations were least. Perhaps lower input levels influenced beetles to lay more eggs in these plots during the season, thus producing more beetles during August in these plots. However, during the 1996 growing season no additional nitrogen was applied to the crop after the starter fertilizer application and both the high and intermediate input plots received the same amount of starter. Obviously fertilizer applied during the 1996 growing season was not the only variable responsible for higher insect numbers in some of these plots.

A comparison of the number of bean leaf beetles collected from each of the three crop rotations provided a bit more insight into the differences observed. Again beetle populations increased dramatically after 2 August in each rotation. No differences in beetle numbers were observed among crop rotations until 16 and 21 August. At that time the corn/soybean chisel plow plots had the highest beetle numbers/subsample. Although the differences in beetle numbers per rotation are subtle (22 beetles/subsample in the chisel plow plots of the corn/soybean rotation vs.15 beetles/plot in the ridge till plots on 16 August) one could speculate that perhaps an interaction between chisel plow rotational plots and lower levels of nitrogen may account for plant growth that attracts more bean leaf beetles into the plots.

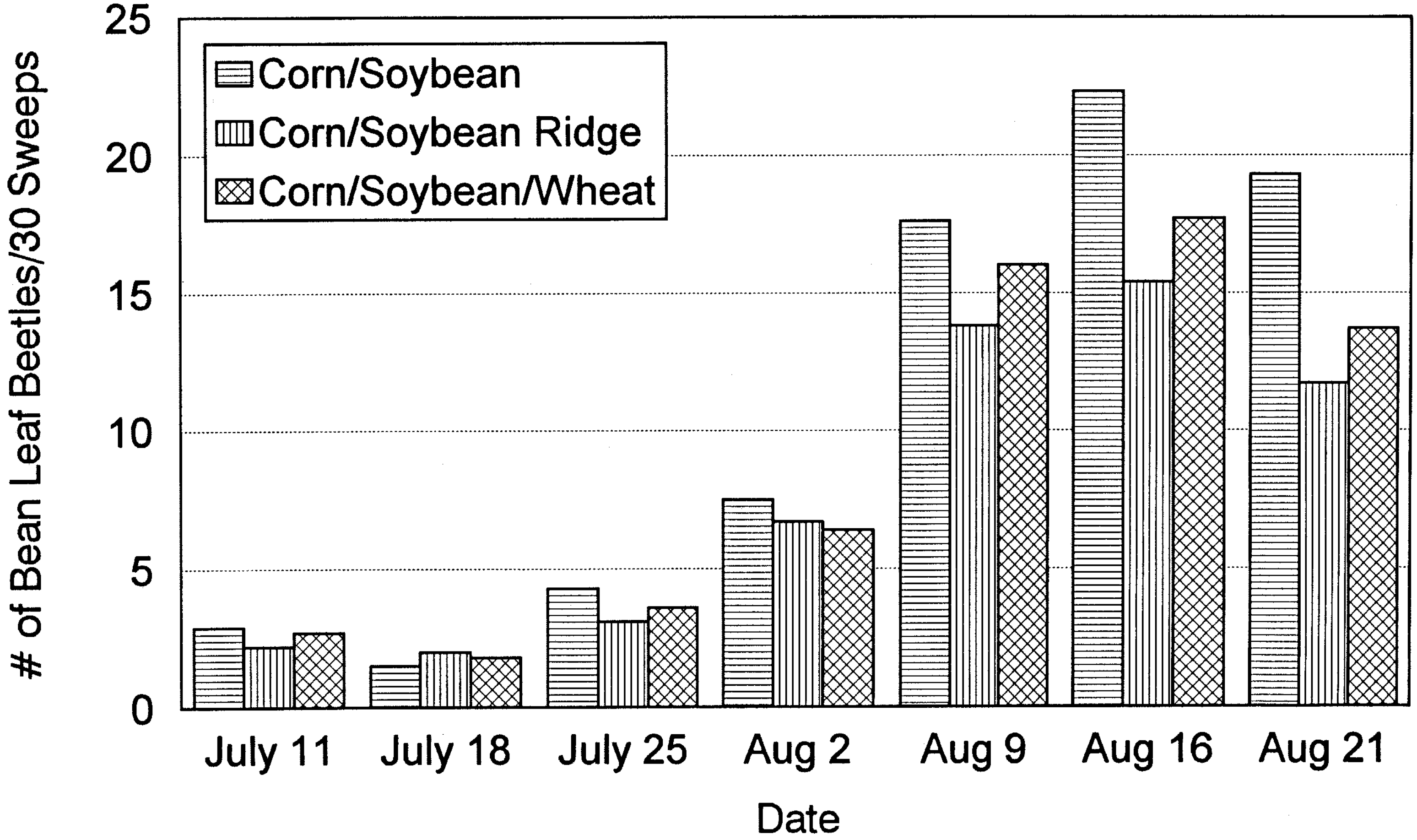
One additional reason for the differences in beetle numbers per input level could be related to fertilizer carry over from the previous year. Since the beetles are not known to overwinter as eggs in the field where they were most numerous and since adults probably move out of plots to find a winter home it is difficult to know for certain that the population differences seen in 1996 were the result of rotation and fertilizer influences from 1995. However, in 1995 the high input corn plots received 99 lbs of starter and 106 lbs of 46-0-0/ac, the intermediate plots 47 lbs of starter and 76 lbs of 46-0-0/ac, and the low input plots no fertilizer. The differences in nitrogen received and used by the corn crop preceding soybeans (which could provide varying amounts available for soybeans) may play an important role in soybean nutrition and could account for differences in plant attractiveness to the beetle.

Conclusion

Naturally one year of data is not enough to make any definitive conclusions on the influence of fertilizers and crop rotational patterns on bean leaf beetle populations. The study, which will be conducted again in 1997, did provide some important information that growers should be aware of. Bean leaf beetle populations appear to peak late in the season. However, there could be an early season threat (plant cotyledon stage) from these insects when they first move into a field. Growers should scout their fields for the insect on a regular basis and be aware of the damage potential large numbers of beetles can have. As in most crops, plant nutrition plays an important role, not only in the final yield obtained, but also in the pest pressure observed throughout the season. There is a likelihood that fertilizer availability can be a positive influence in limiting the problems associated with bean leaf beetle infestations.


1996 Input Levels
High
Low
Intermediate
# of Bean Leaf Beetles/30 Sweeps
0
5
10
15
20
25
30
July 11
July 18
July 25
Aug 2
Aug 9
Aug 16
Aug 21
Date

1996 Rotations



ANALYSIS OF PLANT CANOPIES USING REFLECTANCE SPECTRA

Susan Selman and Kevin D. Kephart, SDSU Plant Science Dept.
Steven Schiller, SDSU Physics Dept.

New technology has been developed to permit analysis of plant canopies in the field using a hand-held radiometer that collects reflectance spectra in the visible and near infrared regions. A field experiment was conducted at the ESD Soil and Water Research Farm near Brookings, SD. The objective of this research is to develop accurate calibration equations based on remotely-sensed reflectance spectra to measure crude protein and fiber concentrations, stable carbon isotope discrimination, and botanical composition of grass canopies.

Field plots of C_3, C_4, and a mixture of C_3 and C_4 grasses were established in 1990. The C_4 species included switchgrass (*Panicum virgatum*) and big bluestem (*Andropogon gerardii*), whereas the C_3 grasses were intermediate wheatgrass (*Elytrigia intermedium*), orchardgrass (*Dactylis glomerata*), and creeping foxtail (*Alopecurus arundinaceus*). All five species were used in the C_3/C_4 mixtures. The experimental design was a randomized complete block with three replicates.

Plots were burned on April 9, 1996, then on April 16,1996 each of the grass mixtures received four N fertility treatments (0, 42, 83, and 125 lb. N per acre). Plots were 400 ft^2 for each grass mixture - N treatment combinations within a replicate. Three sampling dates were 24 June 24, 31 July, and 4 September 1996. Reflectance spectra were collected from five 2 ft^2 quadrates randomly located with each plot. The spectra files were collected with a FieldSpec-FR instrument which is sensitive in the 350 to 2500 nm region in 1 nm segments. Forage samples were collected from each of the 2 ft^2 quadrates after reflectance spectra collection. Samples were split into 2 subsamples, one subsample was dried at 140 ^{0}F and later scanned whole with a laboratory based NIRS instrument equipped with a natural product transport mechanism. The other subsample was frozen for later separated into the different species components to determine botanical composition. Dry weights for the two subsamples were summed to determine forage yield on a dry matter basis. After drying and weighing, all samples were sequentially ground through a 2mm screen of a Wiley mill and a 1mm screen of a UD cyclone mill.

All ground samples were scanned with the NIRS instrument. Thus three types of reflectance spectra were collected for each quadrate; (1) filed based, (2) dried and not ground, and (3) dried and ground. The total herbage samples were analyzed for N, C, and stable C isotope discrimination with an isotope ratioing mass spectrometer. Field-based spectra collected with the FieldSpec-FR were converted to ISI software format in order to be consistent with the laboratory-based spectra.

Our research will permit a direct comparison of calibration equations of the FieldSpec-FR spectra with those from the NIRS, which is widely used as routine analysis of chemical composition of forages and other agricultural products.

Total forage yield increased with each increase in N fertility (Table 1). The relative increase in forage yield was 117% for the C_3 grasses, whereas the C_4 and C_3/C_4 mixtures had 68 and 76% increases, respectively. Averaged over N treatments, there was only a 3% difference in forage yield between the C_4 mixture and the C_3/C_4 mixture.

Table 1. Total forage yields of C_3, C_4, and C_3/C_4 grass mixtures for four N fertility levels.

N fertility	C_3	C_4	C_3/C_4
	lb. / acre		
0	1619	3655	3475
42	2805	5198	4917
83	3248	5957	5896
125	3509	6151	6119
LSD (P=0.05)		77.3	

Nitrogen fertilizer did not cause any changes in the proportion of C_4 (Table 2) or C_3 grasses (Table 3) for the C_3 or C_4 mixtures. There were significant shifts in botanical composition for the C_3/C_4 mixtures, however. As N fertilizer application rates increased, the proportion of C_4 grasses declined (Table 2) and the proportion of C_3 grasses increased. The results are consistent with other reports that conclude that C3 grasses have an ecological advantage in ecosystems that have relatively high N levels.

Table 2. Percent C_4 plants in C_3, C_4, and C_3/C_4 grass mixtures for four N fertility levels.

N fertility	C_3	C_4	C_3/C_4
lb N/acre		%	
0	0.4	100.0	92.7
42	1.0	99.3	71.7
83	0.4	98.5	64.4
125	0.5	97.0	68.1
LSD (P=0.05)		7.0	

Table 3. Percent C_3 plants in C_3, C_4, and C_3/C_4 grass mixtures for four N fertility levels.

N fertility	C_3	C_4	C_3/C_4
lb N/acre		%	
0	96.9	0.0	7.8
42	96.5	0.1	25.6
83	98.6	0.1	34.4
125	98.3	1.0	31.3
LSD (P=0.05)		6.0	

Analyses of forage quality and reflectance spectra are currently underway. These results will be presented next year.