Eastern South Dakota Soil and Water Research Farm

1997

Annual Report to the Board of Directors

March 18, 1998

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

Annual Report

Eastern South Dakota Soil and Water Research Farm, Inc.

Volume 9, March 1998

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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 Experimentation, 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 1997 were:

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

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Dr. Thomas E. Schumacher, Professor, Plant Science
Dr. Sharon Clay, Assoc. Professor, Plant Science
Dr. David Clay, Assoc. Professor, Plant Science
Dr. Ron Gelderman, Assoc. Professor, Plant Science
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Mr. Joseph Schumacher, Research Assoc., Plant Science
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Bryon Van Ballegooyen

A special thank you is extended to Shawn Rohloff (purchasing agent) at the North Central Soil Conservation Research Laboratory, Kathy Reese (secretary), 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.

Eastern South Dakota Soil & Water Research Farm, Inc.

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March 18, 1998

As Chairman of the Board of Directors of the Eastern South Dakota Soil & Water Research Farm, Inc., I would like to make a few comments that come to mind pertaining to our partnership with those doing research on the Farm. Our interests in conserving and protecting the nation's soil and water resources and stabilizing rural economics prompts us to support USDA-ARS, SDSU, and any other group doing research in this or related areas. I believe the research programs now in place are directed toward finding solutions to national and regional concerns related to soil and water conservation and the efficiency and sustainability of agricultural production.

We strongly support research now being conducted by ARS at the Northern Grain Insects Research Laboratory in Brookings and the North Central Soil Conservation Research Laboratory in Morris, MN, and by South Dakota State University. I would also urge them to continue future research in areas that are directly or indirectly related to clean water, clean air, soil stewardship and sustainable agriculture.

After reviewing my comments from last year, I feel our goals and objectives have not changed that much. I would only say that our support and enthusiasm for the urgency of the research being done on the Farm is as high as ever. We see it as one way to help the economy of rural America.

Mark Stime

1997 FARM REPORT

Max Pravecek
USDA-ARS Northern Grain Insects Research Laboratory

Field day at the Eastern South Dakota Soil and Water Research Farm was held on September 11 with 136 people in attendance. The day was cool and windy but probably did not affect attendance. A supper of beef sandwiches, potato salad, baked beans and dessert was served. Following the supper, a riding field tour of some of the experiments on the farm was given.

Presenters and topics for the field tour were:

Dr. Larry Chandler - ARS Brookings - Bt Corn
Dr. Walt Riedell - ARS Brookings - Soybean row spacing and fertilization
Dr. Mike Lindstrom - ARS Morris MN. - Soil movement by tillage
Dr. Joe Pikul - ARS Brookings - Crop Rotations in Eastern South Dakota
Dr. Greg Carlson - SDSU - Finding a needle in a hay stack. GPS demonstration
Dan Olsen - SDSU Grad student - Corn root worm and Corn borer interaction
Susan Selman - SDSU Grad student - Analysis of grass canopies using reflectance spectra

A number of posters by SDSU and ARS researchers were set up in the farm shop for people to view.

Yields for 1997 were better than expected, although precipitation was 6.53 inches below normal for the growing season. The spring was especially dry with the months of April, May and June almost 5.5 inches below normal. Crop emergence was spotty and variable. Some corn and soybean plots had plants emerge two and three different times.

Rain fall amounts by month and normal rainfall for the growing season are listed in the table bellow.

	Actual	Normal
April	0.35	2.02
May	1.17	3.06
June	0.55	4.42
July	2.99	2.85
August	1.74	3.15
September	2.00	1.96
October	1.46	1.33

Corn yield varied from 50 bushels per acre on Continuos Corn - low input (no fertilizer) to 140 bushels per acre on the Four Year Rotation - high input (125 lb. nitrogen). The average corn yield for the farm was about 100 bushels per acre.

Soybean yield varied from 25 bushels per acre to 42 bushels per acre.

Wheat yield went 30 bushels per acre to 40 bushels per acre.

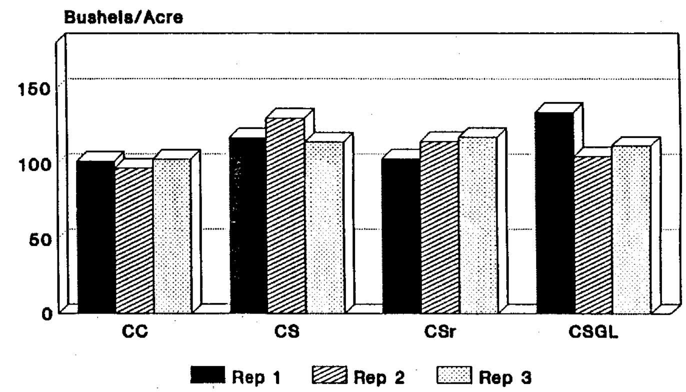
Alfalfa yield was between 3 to 4 ton per acre.

The following yield graphs are from the farm for all crops, rotations, and fertilizer rates.

Corn Fertilizer Rates on
Four Rotations

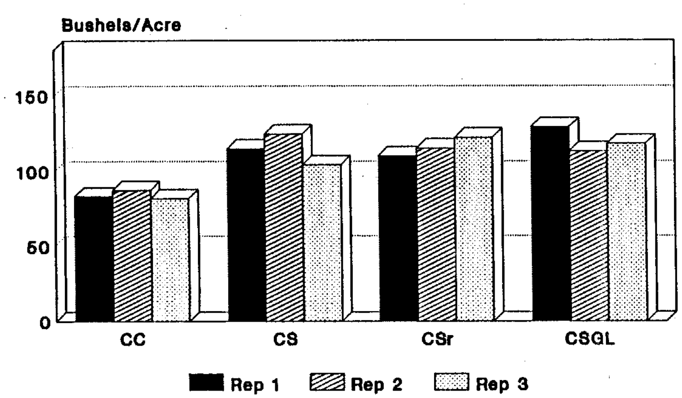
High Input 125 lb. Nitrogen
Integrated Input 75 lb. Nitrogen
Low Input 0 lb. Nitrogen

1997 Corn Yield
High Input



USDA Research Farm

1997 Corn Yield
Integrated Input



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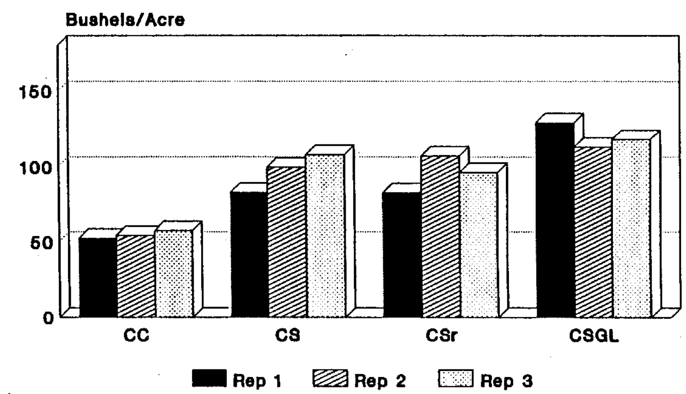
1997 Corn Yield
Low Input



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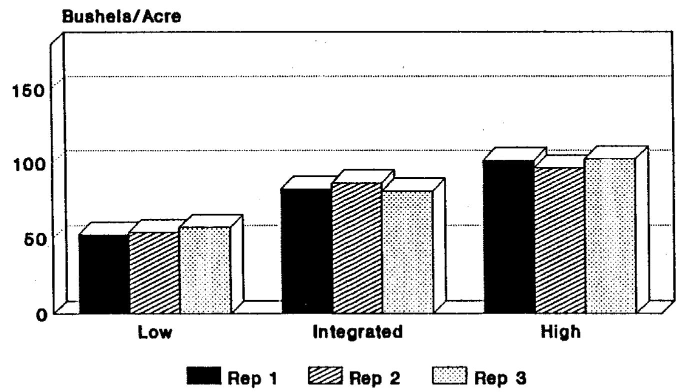
1997 Corn Yield
Continuous Corn



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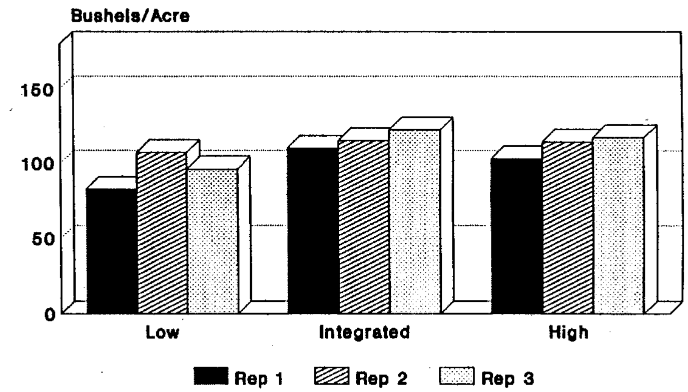
1997 Corn Yield
Corn Soybean Rotation on Ridges



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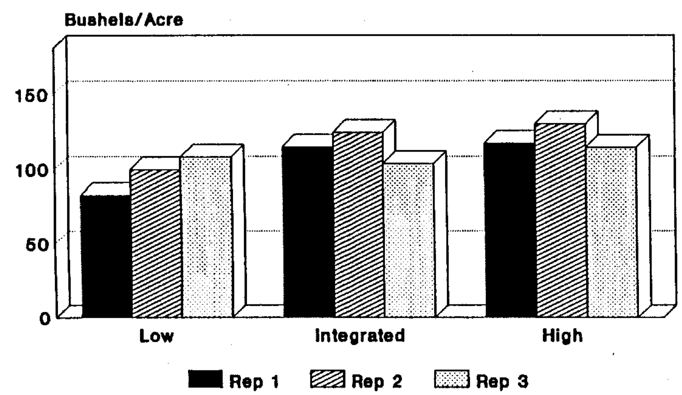
1997 Corn Yield
Corn Soybean Rotation



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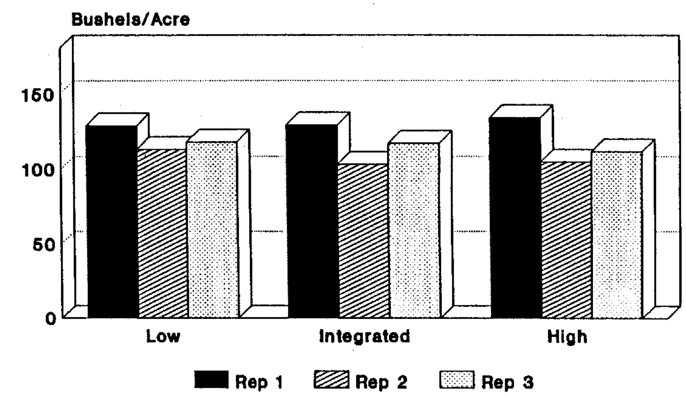
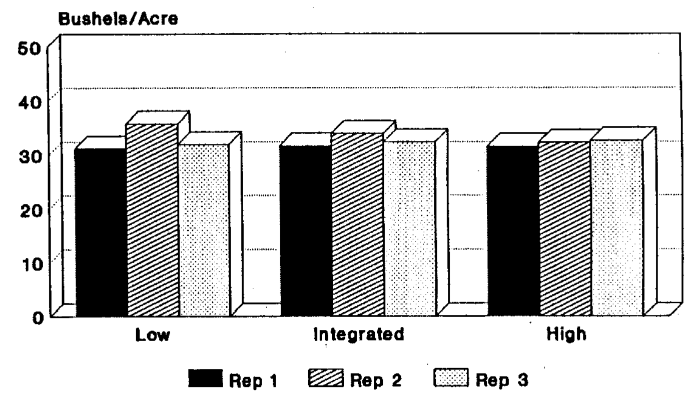
1997 Corn Yield
4 Year Rotation



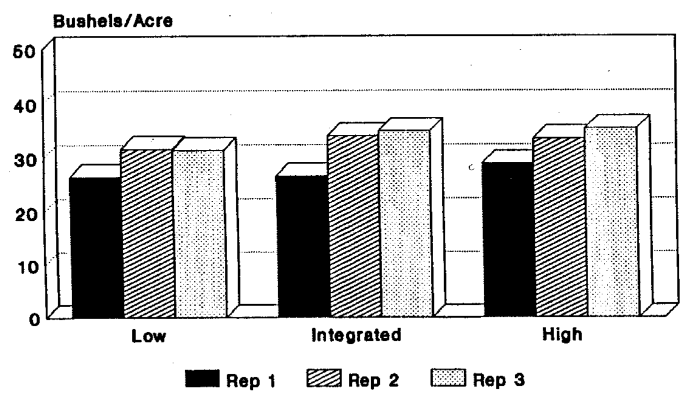
USDA Research Farm

1997 Soybean Yield
4 Year Rotation



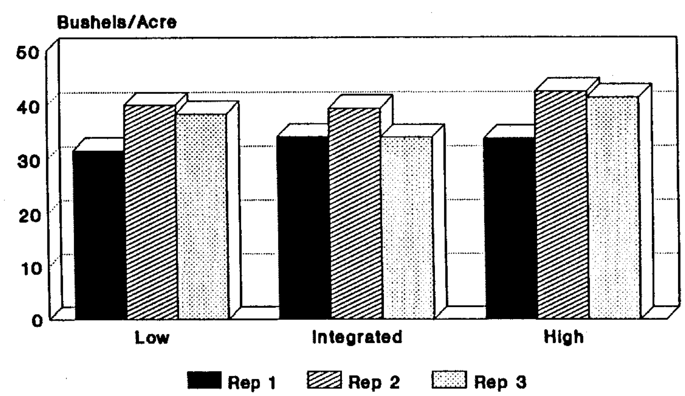
USDA Research Farm

1997 Soybean Yield
Corn Soybean Rotation



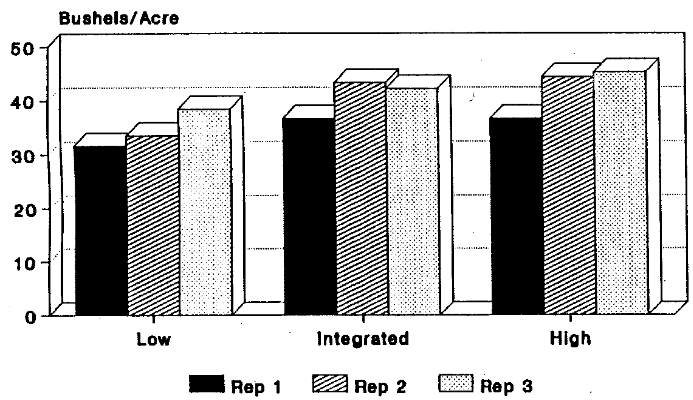
USDA Research Farm

1997 Soybean Yield
Corn Soybean Rotation on Ridges



USDA Research Farm

1997 Wheat Yield
4 Year Rotation



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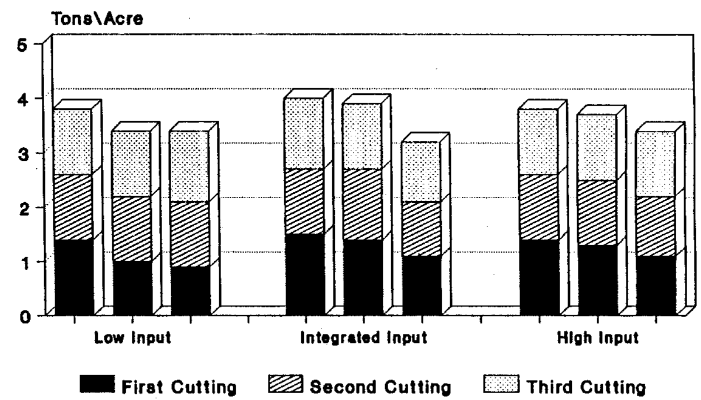
1997 Legume Yield
4 Year Rotation



USDA Research Farm

NITROGEN USE BY CORN GROWN IN ROTATION

Joseph L. Pikul Jr[1]., Walter E. Riedell, and Ron Gelderman

INTRODUCTION

Increased length of rotation and increased crop diversity have potential to improve efficiency of water and fertilizer use by corn. It is generally accepted that corn grown in rotation with other crops will out-yield corn that is grown in monoculture. Often, fertilizer guides provide for a N-fertilizer credit when grain crops follow legumes. 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. Studies have shown that given the same inputs, crops will often perform at a superior level when grown in rotation. This effect is often called a crop rotation factor. Objectives were to determine the effect of crop rotation and nitrogen fertility on N-fertilizer use efficiency of corn.

METHODS

The study was located on the Eastern SD Soil and Water Research Farm at Brookings, South Dakota on a Barnes (formerly Vienna loam) clay loam (fine-loamy, mixed Udic Haploboroll) with nearly level topography. Prior to the start of the experiment in 1990, the field was cropped to soybean in 1988 and spring wheat in 1989.

Samples for soil nitrate-N (STN) were collected in the fall or spring, depending on weather conditions (Table 1). Samples for 1991-1996 crops were taken from 0- to 6-in and 6- to 24-in depths. After 1996, samples were taken to a depth of 48 in at increments of 0 to 6 in, 6 to 12 in, 12 to 24 in, 24 to 36 in, and 36 to 48 in. Measurement of STN in samples collected in 1991-1995 was made using a nitrate electrode procedure (Gelderman et al., 1995). After 1995, STN was measured using a 2 M KCl extraction and automated copperized Cd reduction column procedure (Zellweger Analytics, 1992).

Whole plots (rotations) in the split plot experiment were arranged as a randomized complete block. All phases of each rotation were present every year. Crop rotations were: annually grown corn (C), corn grown in rotation with soybean (CS), and corn grown in rotation with soybean, spring wheat, and alfalfa (CSWA). In the CSWA rotation, spring wheat was used as a nurse crop to establish alfalfa. N treatments (sub plots) were: corn fertilized for a yield goal (YG) of 135 bu/acre (N1), corn fertilized for a YG of 85 bu/acre (N2), and corn not fertilized (N3). Plots were 100 ft by 100 ft.

Fertilizer N prescription (NP) for each N treatment was calculated as: NP = 1.2YG - STN. Adjustments (Gerwing and Gelderman, 1996) to NP for previous crop or sampling date were not made. NP for each rotation and N treatment, expressed as an average of three replications, was met by applying starter fertilizer with the seed and sidedressing appropriate amounts of urea (46-0-0). With the start of the 1996 crop year, 100 lb/acre of starter fertilizer as 14-36-13, 7-36-13, and 0-36-13 (N-P_2O_5-K_2O) have been used on N1, N2, and N3 treatments, respectively. Prior to 1996, starter was not used on N3. Available N (AN) for the crop was defined as the sum of NP and STN.

Apparent N credit attributed to the previous crop was expressed as a positive or negative deviation from expected N use by corn. For comparison of nitrogen use on the rotation and N treatments, we defined expected N use as 0.83 bu corn/lb N. This ratio is common to the fertilizer guides of SD (Gerwing and Gelderman, 1996) and western MN (Rehm et al., 1994). Apparent N credit was calculated as:

(Actual yield-Expected yield) X 1.2 lb N/bu corn

where expected yield was AN X 0.83 bu corn/lb N. Corn yield in excess of that predicted by AN results in a positive N credit (lb N/acre).

At the start of the experiment, sub plots N1, N2, and N3 were termed management sub plots and were called high, intermediate, and low, respectively. Management included tillage, herbicide, insecticide and fertilizer. N management has been consistent on the main and sub plots since 1990. Experimental objectives were narrowed at the end of 1995 to include only N as a variable on the sub plots. Riedell

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et al. (1998) describes previous management of sub-plots.

Soil phosphorous levels were rebuilt prior to spring field work in 1996 with an application of 395 lb/acre of triple super phosphate (0-45-0) on all plots.

Moldboard plow or chisel plow in the fall of the year has been the primary tillage, except in 1995 and 1996 when wet weather conditions precluded fall tillage. Primary tillage since 1996 has been chisel plow. Seed beds for corn on all plots and all years were prepared in spring using a tandem disk and field cultivator. Corn seeding date and rate were the same for all treatments in a given year. Depending on weather, seeding has been as early as 5 May (Table 1). Row spacing was 30 in. All plots were cultivated twice during the early growing season and urea-N was broadcast immediately before the 2nd cultivation. Corn yield was determined from 8 rows 100 ft long.

Statistical comparisons were made using analysis of variance and multiple factor analysis of variance (MSUSTAT, ver. 5.02). Least significant differences (LSD) were used to compare means. The split plot arrangement within randomized blocks was such that factor 1 was rotation (whole plot).

RESULTS AND DISCUSSION

In the first year of the study (1990) there were no significant differences in corn yield among rotations, however there was a significant response to N fertilizer (Table 2). Corn without fertilizer yielded 118 bu/acre, while corn fertilized for 135 bu/ace yielded 143 bu/acre. These results were important because they showed that our test site was responsive to N fertilizer and that prior to imposing our crop rotation scheme there were no differences in corn yield among the test plots that were in corn.

At the end of 5 years, soil phosphorous (P) was lowest in the CSWA rotation compared with C and CS rotations (Data not shown). P and K have been supplied with starter fertilizer to N1 and N2 sub plots on all rotations since 1990 and N3 sub plots since 1996. Soil P in 1989 (Maursetter, 1992. MS Thesis South Dakota State University, Brookings, SD) in the top 6 in averaged 11 PPM (n=154, CV=38%). Before P levels were rebuilt in 1996, P averaged 10, 6, and 5 PPM on the C, CS, CSWA rotations, respectively. Lowest P level was 2 PPM on N3 sub plots in CSWA rotation. An Olsen P test of 2 PPM is considered very low. However, even with low P levels, the CSWA rotation with N3 fertilizer treatment still out-yielded other rotations in 6 of 7 years (Fig. 1c). Soil K in 1989 (grid sample) averaged 155 PPM (n=154, CV=17%). In 1996, K averaged 154, 134, and 141 PPM on the C, CS, CSWA rotations, respectively. These K levels are considered high.

Corn yield was generally less on plots with a short rotation (C) compared with plots having longer rotations (CSWA). In 3 of 7 years (Table 2, excluding 1990 yields) corn yield was significantly greater on CSWA compared with CS and C. Data in Table 2 were pooled to include all N treatments within rotations and all rotations within N treatments. Average corn yield (1991-1997) has been 109 bu/acre on CSWA, 95 bu/acre on CS, and 75 bu/acre on C treatments (Table 2).

Greatest N benefits of rotation were realized in plots that had no additional inorganic N fertilizer. Corn yield data for each rotation for each N treatment (non-pooled) are shown in Figs. 1a, 1b, and 1c for N1, N2, and N3 treatments, respectively. Rotation benefited corn yield in only 1 out of 7 years when corn was fertilized for a production goal of 135 bu/acre (N1 treatment, Fig 1a). In contrast, corn yield was significantly greater on CSWA rotation in 6 out of 7 years when corn was not fertilized (Fig. 1c).

These field trials cover some of the wettest and coolest periods in the South Dakota climate record (Table 1). Precipitation totals from 1991-1995 were the greatest in more than 100 years of South Dakota climate records and the 1992 and 1993 summers were the coolest consecutive summer seasons in the South Dakota climate record beginning 1890 (Alan Bender, South Dakota State Climatologist, Brookings, SD). Corn yields were least in 1992 and 1993 compared with other years in the study (Table 2), but even during these adverse growing seasons corn yields were greater on CSWA compared to CS or C.

Soil nitrate-N (STN) is a key management tool for corn producers in SD. In most years STN was greatest on the CSWA rotation compared with C and CS rotations for the N1 and N3 fertilizer treatments, however they were most pronounced on the N2 fertilizer treatment. Average STN for 1991-1997 was 43, 46, and 62 lb-N/acre on C, CS, and CSWA rotations respectively (data not shown).

The ratio of corn yield to AN was used to estimate N use efficiency (NUE) of corn grown in rotation. The fertilizer recommendation guides for South Dakota and Minnesota indicate that it normally takes 1.2 lb of N to produce 1 bu of corn (or 0.83 bu of corn/ lb N). Our average NUE's (1991-1997) for C, CS, CSWA rotations were 1.01, 1.16, and 1.44 bu corn/lb N (Data not shown).

We estimated N-benefits of crop rotation to corn yield and expressed this yield-benefit as an apparent N credit. For simplicity, we associated benefits of crop rotation to only AN. There may be other factors responsible for improved yields beyond available N and we use the term "apparent nitrogen credit" to acknowledge this. Apparent N credit for each of the rotations and N treatments are shown in Figs. 2a, 2b, and 2c. Positive deviations suggest that significant amounts of nitrogen were transformed (mineralized) from organic to inorganic forms during the growing season. Negative deviations show that N was not used. We do not know the fate of N not used during the growing season. However, we can assume a potential hazard to ground water quality exists when N is not utilized.

Inspection of Figs. 2a, 2b, and 2c show that beneficial effects of crop rotation diminished as production goals increased. Greatest benefits of rotation (measured as positive N credit) were realized in plots that had no additional inorganic N fertilizer. In plots that were not fertilized with N, the average positive N credit (excluding 1990) for continuous corn was 45 lb/acre, 76 lb/acre for corn following soybean, and 99 lb/acre for corn following alfalfa. In plots fertilized to achieve a 135 bu/acre corn yield positive N credit (excluding 1990) for continuous corn was 19 lb/acre, 23 lb/acre for corn following soybean, and 31 lb/acre for corn following alfalfa.

CONCLUSION

In 5 of 7 years, including adverse growing seasons of 1992 and 1993, increased rotation length increased corn yield and NUE. Greater NUE on 4 and 2-year rotations compared with annually grown corn suggest that the timing and availability of N, presumably from microbial decomposition of organic material during the growing season, on 4 and 2-year rotations was superior to that of annually grown corn. Soil WUE increased with increased rotation length in years with ample growing season precipitation (data not shown). However, we suspect that in drought years, excessive soil water use by alfalfa in the CSWA rotation may be a liability to subsequent corn yield. Greatest benefits of rotation were realized in plots that had no additional inorganic N fertilizer. These results show the necessity of tailoring nitrogen application rates to specific production levels when employing crop rotations. Research is in progress to further quantify N cycling and water use characteristics of these crop rotations.

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ACKNOWLEDGMENTS

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Table 1. Corn planting date, variety (Pioneer), seeding rate, date of soil sample for nitrate-N, harvest date, growing season and yearly precipitation, and growing degree days (base 50 °F) for 1990 through 1997. (Weather data courtesy of Alan Bender, South Dakota State Climatologist, Brookings, SD).

	1990	1991	1992	1993	1994	1995	1996	1997	Average 1961-1990
Planting date	17-May	8-May	7-May	17-May	10-May	5-May	16-May	8-May	
Variety	3737	3737	3737	3737	3737	3769	3769	3769	
Seeds/acre	24503	26300	26300	26300	26300	26300	29620	30500	
Sample date for soil nitrate-N	none	23 May 1991	21 May 1992	7 May 1993	7 April 1994	30 Nov. 1994	1 May 1996	30 Oct. 1996	
Harvest date	23-Oct	3-Oct	19-Oct	27-Oct	25-Oct	30-Oct	23-Oct	10-Oct	
				-----Precipitation (inches)-----					
April	0.89	3.59	1.79	1.96	2.99	2.71	0.26	1.98	2.07
May	4.95	3.66	1.19	4.32	1.52	4.52	4.92	1.17	2.93
June	6.08	3.92	7.98	8.69	10.21	2.73	2.84	2.55	4.34
July	3.67	2.44	3.69	5.18	2.08	6.85	0.86	2.99	3.32
August	2.78	2.10	4.67	2.27	3.57	4.46	3.02	1.74	2.81
September	0.49	2.27	1.87	2.12	2.75	3.93	2.61	2.00	2.64
October	2.45	0.72	1.09	0.28	1.64	3.20	2.75	1.46	1.66
Total (June-Sept.)	13.02	10.73	18.21	18.26	18.61	17.97	9.33	9.28	13.11
Total (April-Oct)	21.31	18.70	22.28	24.82	24.76	28.40	17.26	13.89	19.77
Year total	25.14	21.30	26.72	28.59	26.52	32.37	20.12		22.89
				-----Growing degree days (base 50 °F)-----					
April	167	156	53	67	106	36	120	100	123
May	242	358	369	243	367	187	247	205	302
June	490	606	406	375	483	508	552	542	479
July	545	592	383	551	516	602	601	625	620
August	560	584	423	561	480	656	657	543	558
September	430	349	312	217	383	326	380	401	336
October	127	162	184	136	157	108	195	208	162
Total	2561	2807	2130	2150	2492	2423	2752	2624	2580

Table 2. Mean corn yield (15.5% grain moisture) for crop rotations of continuous corn (C), corn/soybean (CS), and corn/soybean/wheat-alfalfa/alfalfa (CSWA). Nitrogen fertilizer treatments include corn that was fertilized for a yield goal of 135 bu/acre (N1), corn that was fertilized for a yield goal of 85 bu/acre (N2), and corn not fertilized (N3).

	1990	1991	1992	1993	1994	1995	1996	1997	Average 1991-1997
				-----corn yield (bu/acre)-----					
Rotation (R)									
C	133a	114a	53a	26a	68a	68a	116a	79a	75
CS	128a	132a	67a	36ab	97b	92a	132b	110b	95
CSWA	131a	142a	88b	54b	115c	91a	153c	118b	109
LSD (0.05)	ns	ns	13.6	20.7	15.5	ns	10	21.5	
Fertilizer (N)									
N1	143a	156a	98a	60a	139a	110a	152a	113a	118
N2	132b	146a	75b	44b	100b	77b	131b	105b	97
N3	118c	86b	35c	11c	41c	65c	117c	90c	64
LSD (0.05)	7.2	11.0	6.6	5.2	7.5	9.4	4.6	6.8	
p value R	ns	ns	.005	.045	.003	ns	.001	.020	
p value N	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	
p value RxN	ns	<.001	<.001	ns	<.001	ns	<.001	<.001	

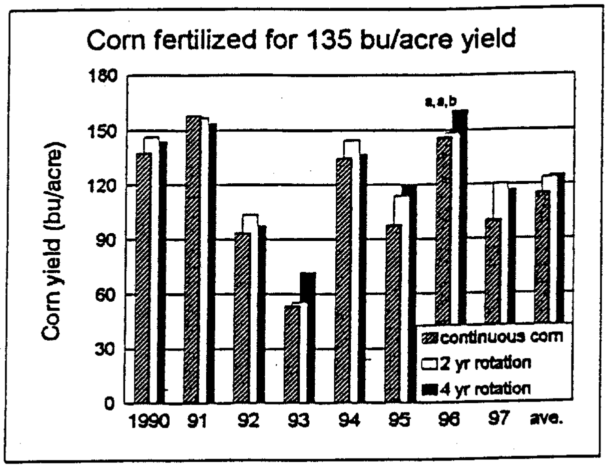


Figure 1a. Corn yield on continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were fertilized with N to achieve a 135 bu/acre yield goal. Values followed by different lowercase letters within years are significantly different (p=0.05).

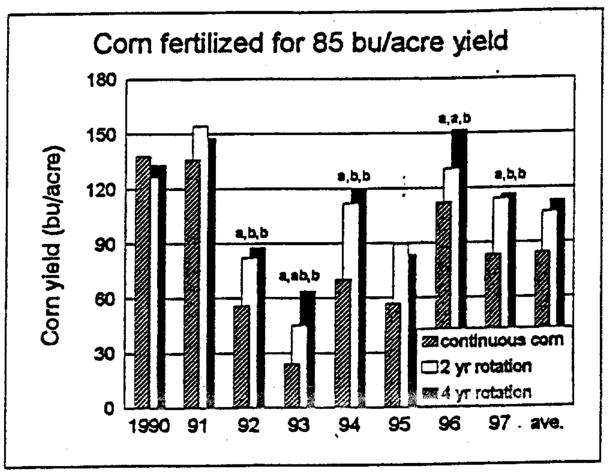


Figure 1b. Corn yield on continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were fertilized with N to achieve a 85 bu/acre yield goal. Values followed by different lowercase letters within years are significantly different (p=0.05).

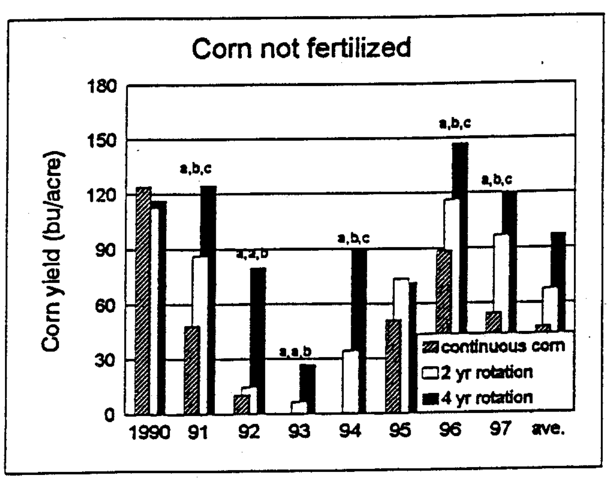


Figure 1c. Corn yield on continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were not fertilized with N. Values followed by different lowercase letters within years are significantly different (p=0.05).

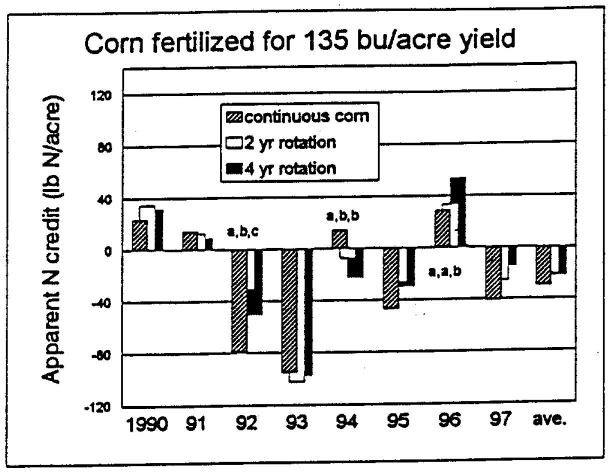


Figure 2a. Apparent N credit attributed to the previous crop in continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were fertilized with N to achieve a 135 bu/acre yield goal. Positive deviations reflect corn yield in excess of the expected 0.83 bu corn/lb N. Values followed by different lowercase letters within years are significantly different (p=0.05).

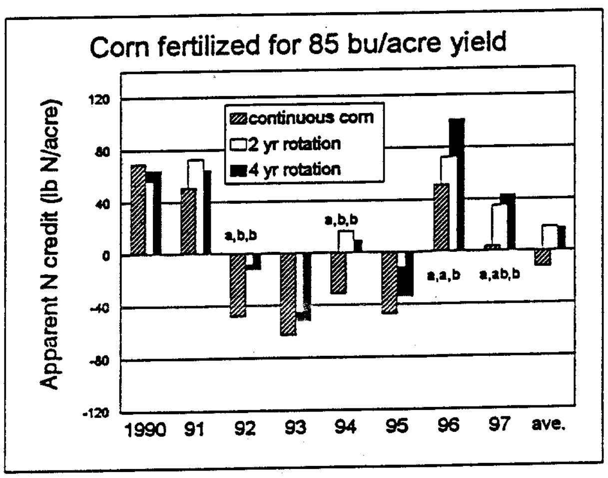


Figure 2b. Apparent N credit attributed to the previous crop in continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were fertilized with N to achieve a 85 bu/acre yield goal. Positive deviations reflect corn yield in excess of the expected 0.83 bu corn/lb available N. Values followed by different lowercase letters within years are significantly different (p=0.05).

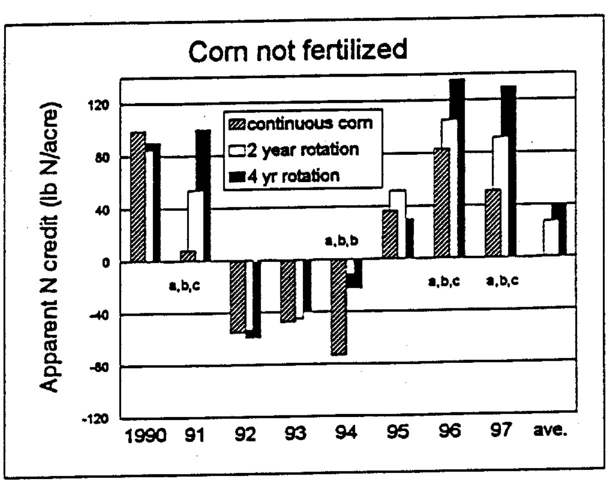


Figure 2c. Apparent N credit attributed to the previous crop in continuous corn, corn/soybean (2 yr rotation), and corn/soybean/wheat, interseeded with alfalfa/alfalfa (4 yr rotation) rotations that were not fertilized with N. Positive deviations reflect corn yield in excess of the expected 0.83 bu corn/lb available N. Values followed by different lowercase letters within years are significantly different (p=0.05).

ROOTWORM EMERGENCE IN CONTINUOUS CORN WITH VARYING RATES OF NITROGEN

David Woodson
USDA – ARS Northern Grain Insects Research Laboratory

INTRODUCTION

The effect 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. Soil nitrogen levels influence plant greenness and leaf greenness plays a significant role in determining its attractiveness to female rootworms. 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 effect rootworm survival and if there are any differences in the amount of eggs laid in relation to nitrogen applications.

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. In 1997 intermediate plots had 7.5 actual N applied at planting on 8 May 1997 and an additional 72.5 lb. actual N applied as a side dress on 13 June 1997. High input plots had 14.5 actual N applied at planting on 8 May 1997 and an additional 72.5 lb. actual N applied as a side dress on 13 June 1997. Plots where sampled in early May and middle October of each year for rootworm eggs. Each time four-soil samples per plot were taken, the eggs washed from the soil and the eggs were identified. Adult emergence was monitored from early July till about the end of September each year. Four adult emergence traps covering about a square yard were used per plot and emerging adult were collected and counted each week.

RESULTS

Spring egg samples in 1996 indicated that western corn rootworm eggs were at their lowest level since monitoring began. No western corn rootworm eggs were detected in the low input plots, and less than one per sample was found in the intermediate and high input plots (Figure 1). In 1997 western levels were quite low with just a few eggs found in the input plots. Large numbers of northern corn rootworm eggs were detected in 1996 in the low and intermediate plots and a smaller number were found in the high input plots. In 1997 numbers of northern eggs were about half their number in 1996, with approximately equal numbers occurring at each input level.

High input plots had large numbers of rootworms emerging for seven weeks in 1996 and in 1997. Western corn rootworms emerged slightly ahead of the northern corn rootworm each year and the northern corn rootworms ended each season (Figures 2 and 3). Despite a slow start in 1997, rootworm emergence occurred about a week earlier than in 1996 for both species and the number emerging was almost double that emerging in 1996. Emergence between the two species was quite different with two thirds of the western corn rootworms trapped being male. In contrast, two thirds of the northern corn rootworms captured from the high input plots were female.

The intermediate input plots in continuous corn were the best rootworm producing fields in 1996 but came in second in 1997. 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 male and two thirds being female. Northern corn rootworm number increased from 1996 to 1997 but western numbers fell by about 40%.

The low input fields produced few corn rootworm adults but the emergence pattern was similar to the other input plots. This low emergence was not surprising with respect to the western corn rootworm because we were unable to detect any eggs in the soil at the beginning of the season in these plots. What was surprising was that we found the highest number of northern corn rootworm eggs and had very low numbers of these insects surviving to emergence. 1996 marked the first year that these plots were kept free of weeds, and in that year we had very few adults emerge. In 1997 they had twice as many northerns than in 1996 and western increased by about 30%.

Fall egg samples in 1996 and 1997 showed the low input plots were favored by the northern corn rootworm for oviposition followed by the intermediate and high input plots (Figure 1). The northern eggs in the high input plots in 1997 doubled over 1996 numbers, going from about 6 eggs per liter of soil to over 12. For the intermediate plots in 1997 there were almost eight times more eggs than in 1996 per liter of soil. Low input plots had a tripling of egg population going from less than 10 in 1996 to about 30 per liter of soil in 1997. Western corn rootworm eggs were at very low numbers in 1996 but rebounded in 1997. Only the low input plots reached an economic level, 10 eggs per liter of soil. However, all the western populations increased by 5 to 10 times the levels seen in 1996, indicating that 1997 was a very good year for corn rootworm reproduction.

Figure 1. Oviposition in 1996 and 1997.

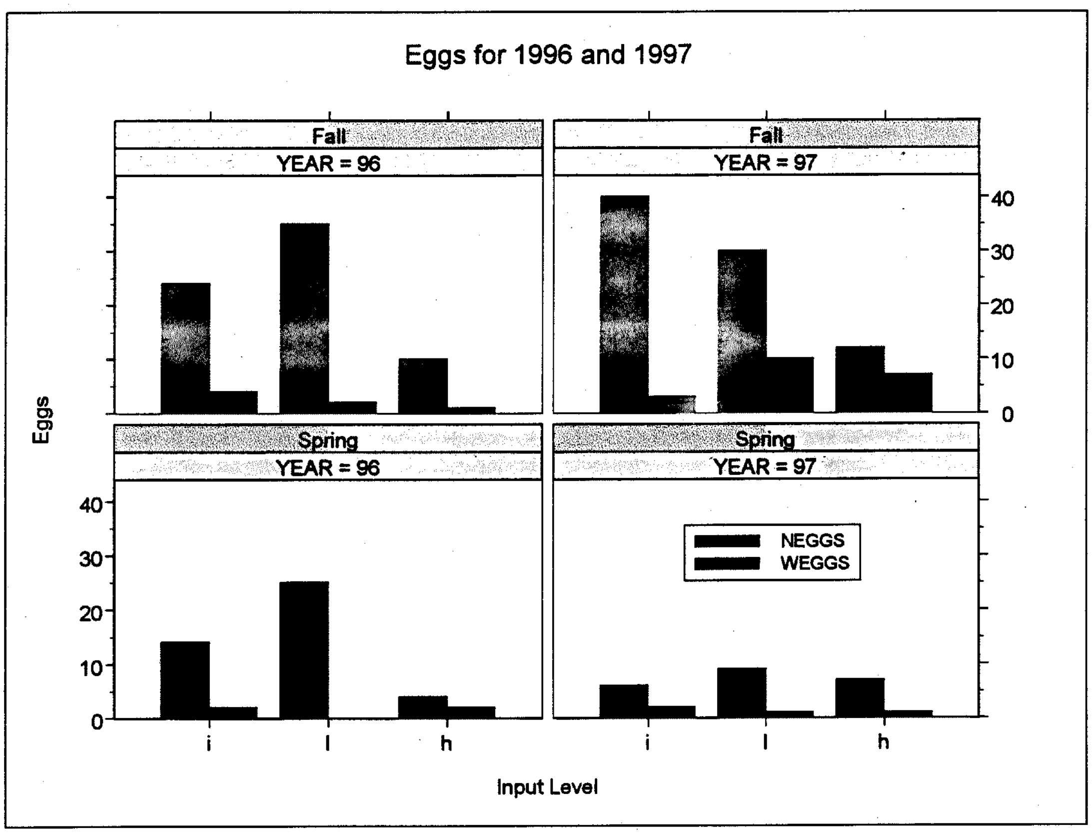


Figure 2. Northern corn rootworm emergence.

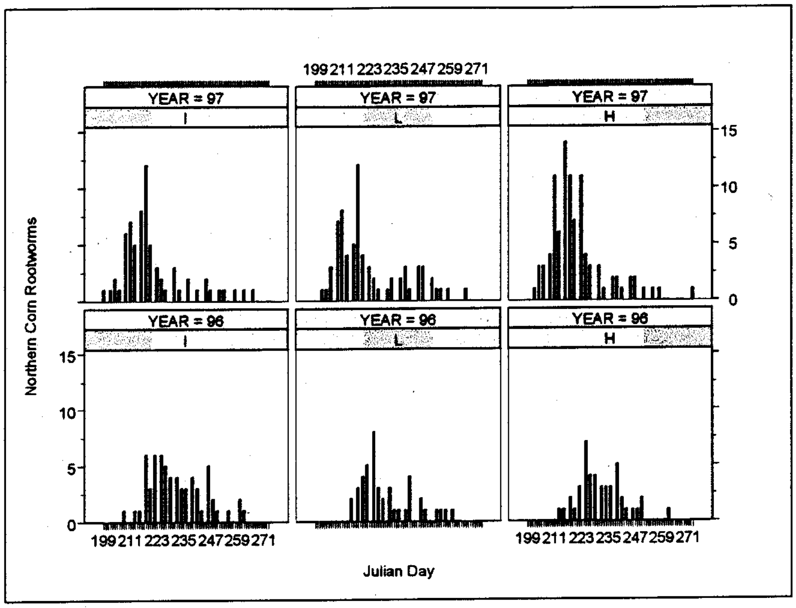
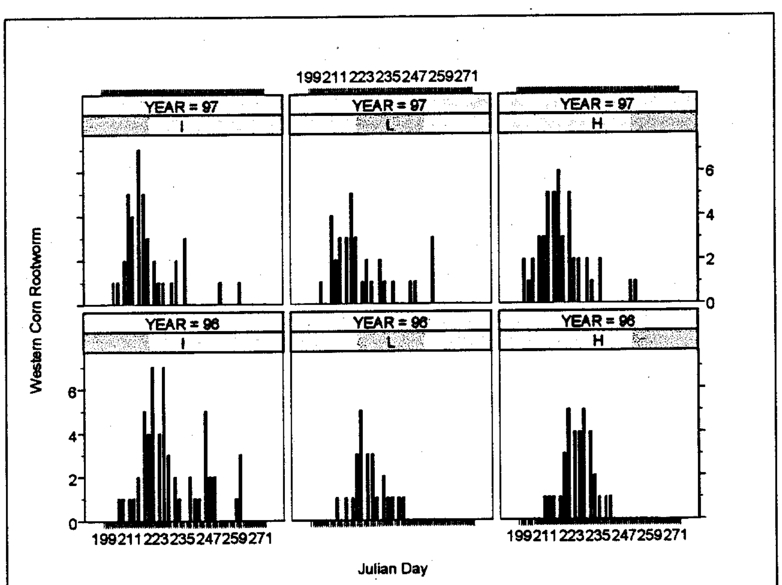


Figure 3. Western corn rootworm emergence.



EUROPEAN CORN BORER AND CORN ROOTWORM DAMAGE TO CORN GROWN UNDER VARIOUS ROTATIONAL SCHEMES

Larry Chandler, Research Entomologist
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European corn borer, *Ostrinia nubilalis*, western corn rootworm, *Diabrotica virgifera virgifera*, and northern corn rootworm, *Diabrotica barberi*, are important pests of field corn throughout the United States corn belt. These insects account for millions of dollars in yield loss and control costs each year. Many pest managers recommend various cultural practices to limit the severity of infestations from both insects. For example, corn/soybean rotations are widely used to limit corn rootworm infestation severity. By alternating crops growers can break corn rootworm life cycles by eliminating their feeding source every other year. Since corn rootworms cannot develop on soybeans, eggs that are laid in corn in one year will hatch and have no food source if soybeans are planted the following year. However, certain proportions of corn rootworm populations have adapted to these rotations by developing a mechanism where their eggs can survive in the soil for two or more years. Thus, they can again hatch when corn is planted after soybeans. Obviously, both groups of insects have developed abilities to seek preferential locations for feeding and reproduction. These insects will continue to adapt to changes crop managers impose on the corn/soybean system. To more thoroughly understand the biology/ecology of these pests continual field observations are needed to determine if insect infestational patterns exist that are based on rotational schemes, tillage methods, and fertilizer use. Therefore, the observations reported here were made to investigate the occurrence of physical damage symptoms inflicted by these pests and the effects of various cultural practices on the occurrence of pest infestations.

METHODS

Corn grown in a crop rotation/nitrogen fertilizer experiment was sampled for visual signs of European corn borer and corn rootworm (both species combined) damage on 16 September. The corn was grown in four rotational schemes: 1) soybean/wheat/alfalfa/corn using chisel plow ground preparation; 2) soybean/corn using ridge till ground preparation; 3) soybean/corn using chisel plow ground preparation; and 4) corn following corn using chisel plow ground preparation. Three levels of fertilizer inputs were applied to the rotations. Starter fertilizer was placed on all plots at planting as follows: 100 lbs/ac 14-36-13 for high input; 100 lbs/ac 7-36-13 for intermediate input; and 100 lbs/ac 0-36-13 for low input; A side dress fertilizer application was applied at 125, 75, and 0 lbs/ac 46-0-0 for high, intermediate, and low input plots, respectively. All plots received herbicide treatments consisting of 3 qts/ac Lasso and Bladex, 2 pts/ac Buctril and 1.33 oz/ac Accent. In the center two rows of each plot (12 treatments replicated 3 times) 25 plants/row were evaluated for signs of corn borer and corn rootworm damage. Corn borer damage consisted of signs of stalk breakage (with tunneling apparent) and larval exit holes. Corn rootworm damage was evaluated as goosenecked or lodged plants. Several roots were examined from each area to verify rootworm feeding although no root ratings were taken. All data were subjected to appropriate statistical analyses.

RESULTS

European corn borer damage was observed in each plot and ranged from 38 to 59% and from 43 to 59% depending on crop rotational pattern and fertilizer input level, respectively (Table 1). Damage was significantly less in the continual corn rotational plots and in the low fertilizer input plots. Reasons for the decreased damage in the continual corn plots are unclear. However, plants in the low fertilizer plots were slower to develop than plants in other treatments and were probably less attractive to corn borer moths.

Corn rootworm damaged plants were also observed in all plots. This would indicate that a portion of the rootworm population infesting corn in this experiment had survived longer than a single winter. No attempt was made to separate western and northern corn rootworm damage. However, both species were observed feeding as adults on plants within the experiment. The percent of goosenecked plants ranged from 12 to 39% and from 20 to 33% depending on crop rotational pattern and fertilizer input level, respectively (Table 2). The number of goosenecked plants observed in the soybean/wheat/alfalfa/corn rotations were significantly fewer in number than those noted in the continual corn rotation. No differences in the number of corn

Table 1. Average number of European corn borer damaged plants (out of 50) per rotation or fertilizer level.

	Avg. number/plot	%
Soybean/wheat/alfalfa/corn	29.7 A	59.4
Soybean/corn/ridge till	28.9 A	57.8
Soybean/corn/chisel plow	27.1 A	54.2
Corn on corn	19.1 B	38.2
High fertilizer input	29.3 A	58.6
Intermediate fertilizer input	27.6 A	55.2
Low fertilizer input	21.7 B	43.4

Means in a column per rotation or fertilizer input level followed by the same letter are not significantly different $\underline{P} \leq 0.05$, Tukey's HSD Test.

Table 2. Average number of corn rootworm damaged (goosenecked or lodged) plants (out of 50) per rotation or fertilizer level.

	Avg. number/plot	%
Soybean/wheat/alfalfa/corn	5.9 B	11.8
Soybean/corn/ridge till	12.3 AB	24.6
Soybean/corn/chisel plow	12.7 AB	25.4
Corn on corn	19.3 A	38.6
High fertilizer input	9.8 AA	19.6
Intermediate fertilizer input	11.3 A	22.6
Low fertilizer input	16.5 A	33.0

Means in a column per rotation or fertilizer input level followed by the same letter are not significantly different $\underline{P} \leq 0.05$, Tukey's HSD Test.

rootworm damaged plants were noted among fertilizer input levels although there was a numerical trend for higher damage to occur in low input plots.

CONCLUSIONS

European corn borer damage was probably most related to the quality of the corn grown in the study. Many published reports have suggested that corn borer moths are attracted to taller more mature plants for egg laying during the early growing season. In this experiment the low input fertilizer plants did not grow as quickly or as tall as those in the high and intermediate fertilizer plots. Thus, these plants were probably not as attractive for early season infestations. Since no attempt was made to separate early (1st generation) from late (2nd generation) season damage it is difficult to tell how much damage in low input plots can be attributed to the lack of plant growth and maturity.

It was not surprising that the continual corn rotational plots had higher levels of corn rootworm damage. Western and northern corn rootworm both thrive in corn on corn conditions if they are not managed. The substantial amounts of damage seen in corn/soybean rotations can probably be attributed to extended diapause individuals. Northern corn rootworms have been shown to have varying levels of this trait throughout their populations. Reports from many locations in eastern South Dakota during the 1997 growing season indicated that some growers were experiencing varying amounts of damage in corn grown after soybeans. This damage could possibly be attributed to northern corn rootworm. This situation is certainly not a cause for alarm but should be carefully monitored.

BEAN LEAF BEETLE AND NORTHERN CORN ROOTWORM POPULATIONS IN ROTATED SOYBEANS

Larry Chandler, Research Entomologist
USDA-ARS, Northern Grain Insects Research Laboratory

There are numerous species of insects that can be found inhabiting South Dakota soybean fields. Many of these insects feed on foliage, flowers, and pods throughout the growing season. Fortunately, large numbers of these pests must be present before economic losses occur, which rarely happens in South Dakota. One of the more common insect pests found on beans in our area is the bean leaf beetle, *Cerotoma trifurcata*. This small (1/4 inch long) reddish brown to pale yellow beetle can attack soybeans at any plant growth stage. Early season bean leaf beetle infestations sometimes cause significant stand loss in many midwestern states. Leaf feeding by these insects in later plant growth stages can cause some defoliation, resulting in plant stress and possible yield loss.

Another insect that is commonly found on soybeans during the latter part of the growing season is the northern corn rootworm, *Diabrotica barberi*. This small green beetle is primarily a pest of corn but can be seen frequently feeding on soybean flowers. Little damage is caused by this pest on soybeans. However, the fact that the insect is found in the crop needs to be better documented so that a basis of understanding of it's complex ecological behavior can be developed. It could be possible that northern corn rootworms feeding in soybeans may also lay eggs in the crop. These eggs could hatch in the following growing season when corn is planted in the same field.

The purpose then of this study was to determine the seasonal population dynamics of bean leaf beetles and northern corn rootworm adults on soybeans grown in rotation with other crops. Effects of fertilizer level, tillage method, or crop rotation on insect populations were evaluated.

METHODS

Soybeans grown in a crop rotation/nitrogen fertilizer experiment were sampled weekly beginning on 11 July and continuing through 22 August 1997. The soybeans were grown in a corn-soybean rotation using either ridge or chisel plow tillage methods or in a corn-soybean-alfalfa-wheat rotation using chisel plow ground preparation. Three levels of fertilizer inputs were applied to the rotations. Starter fertilizer was placed on all plots at planting as follows: 100 lbs./ac 14-36-13 for high input; 100 lbs./ac 7-36-13 for intermediate input; and 100 lbs/ac 0-36-13 for low input. All soybean plots were treated with Broadstrike and Dual herbicide. Bean leaf beetles and northern corn rootworm adults 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 adults of the two species collected in the net counted. Appropriate statistical analyses were used to evaluate the results.

RESULTS

Only one bean leaf beetle was collected on the 11 July sample date. Populations slowly increased through the remainder of July and into early August. Beetle populations peaked on 10 August and slowly declined through the remainder of the month. Beetles were not as numerous in 1997 as they were in 1996.

Table 1 shows the effects of crop rotational patterns on the beetles from 10 August through 22 August. Significantly greater numbers of beetles were collected from soybeans in the soybean/corn ridge till rotational plots on 10 Aug. compared to the soybeans in the corn/soybean/alfalfa/wheat rotation plots. Similar numbers of beetles were observed in both of the corn/soybean rotations regardless of tillage type. No statistical differences between bean leaf beetle numbers were observed among rotations during the remainder of the sampling period, although numbers of beetles remained numerically higher in the soybean/corn ridge till plots. These results are different than those observed in 1996 when greater numbers of beetles were observed in the corn/soybean chisel plow plots.

Fertilizer input level did not have an effect on bean leaf beetle numbers (Table 1). In 1996 beetle numbers seemed to be affected by the amount of nitrogen fertilizer present in each plot, with the lowest nitrogen level having the greatest number of insects. The results from 1997, however, do not support this observation. Obviously, a combination of factors, including rotational patterns, plant nutrition, and soil type must be considered when developing a more thorough understanding of the population dynamics of this insect.

Table 1. Average number of bean leaf beetles per 30 sweeps on date indicated.

	Aug. 10	Aug. 15	Aug. 22
Soybean/corn chisel plow	10.2 AB	7.8 A	8.6 A
Soybean/corn/ridge till	16.2 A	8.1 A	13.7 A
Soybean/wheat/alfalfa/corn	7.8 B	4.1 A	7.0 A
High fertilizer input	9.6 A	5.6 A	12.7 A
Intermediate fertilizer input	10.2 A	5.6 A	9.4 A
Low fertilizer input	14.4 A	8.9 A	7.1 A

Means in a column per rotation or fertilizer input level followed by the same letter are not significantly different ($\underline{P} \leq 0.05$, Tukey's HSD Test.

Table 2. Average number of northern corn rootworm adults per 30 sweeps on date indicated.

	Aug. 15	Aug. 22
Soybean/corn/chisel plow	5.3 A	6.1 A
Soybean/corn/ridge till	4.7 A	3.6 B
Soybean/wheat/alfalfa/corn	4.3 A	3.4 B
High fertilizer input	4.7 A	4.1 A
Intermediate fertilizer input	5.1 A	4.8 A
Low fertilizer input	4.6 A	4.2 A

Means in a column per rotation or fertilizer input level followed by the same letter are not significantly different ($\underline{P} \leq 0.05$, Tukey's HSD Test.

Approximately 5 northern corn rootworm adults were found per 30 sweeps in all soybean plots on 15 and 22 August (Table 2). Adults were first noted in soybeans on 25 July. However, numbers of rootworms in the beans did not substantially increase until after 10 August. Crop rotation patterns did not affect total number of adults collected on 15 August. However, significantly greater numbers of adults were observed on soybeans in corn/soybean rotation chisel plow plots on 22 August compared to the other two rotations (Table 2). Fertilizer input level did not have an effect on rootworm numbers.

CONCLUSIONS

Information gathered over the last two years on bean leaf beetle population dynamics does not provide conclusive evidence on the effects of rotational patterns, tillage practices, or nitrogen fertilizer input levels on infestation patterns. Although subtle trends exist that suggest bean leaf beetles are more numerous in corn/soybean rotational schemes, one cannot fully recommend the altering of these rotations to reduce potential damage from the pest. It is obvious that more information is needed to fully understand the ecology/biology of this insect in South Dakota. We do know, however, that beetle populations peak in late season and are more likely to damage crops at that time than at planting.

Northern corn rootworms are unlikely to become a soybean pest. The larval stages currently cannot survive on soybean roots. There is value, however, in learning more about their preferential feeding sites and the components that attract them to these places. If northern corn rootworms behaviorally adapt to corn/soybean rotations, changes in the manner in which we have to manage these pests could occur. Large numbers of rootworm adults inhabiting soybeans late in the growing season could lay substantial numbers of eggs which could result in damage to the following year's corn crop. A better understanding of the mechanisms behind rootworms movement into soybeans could provide for the development of long term management strategies to prevent or minimize possible adaptations.

WING COVER PATTERNS IN WESTERN CORN ROOTWORM BEETLES: IMPLICATIONS FOR MANAGEMENT DECISIONS

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Overview: We evaluated the color patterns on wing covers (elytral vittae) of male and female adult western corn rootworm beetles (WCR). Our study examined >1000 beetles taken from a field population, a laboratory colony, and a reference collection containing 712 specimens from 15 of the United States and from the province of Ontario, Canada. The humeral and sutural vittae of each beetle's elytra were classified as being separate, partially confluent, or totally confluent with each other. The distribution of these elytral patterns was not independent of sex. Males tended to have confluent or partially confluent vittae, whereas females largely had separate vittae. Nonetheless, all three patterns of elytral vittae were found in both sexes of WCR, and many beetles of each sex had partially confluent vittae.

Implications: Our studies show that color patterns on the wing covers of WCR are poor indicators of the sex of the adult beetles, because there is considerable overlap in the patterns of male and female beetles. So, field scouts should not use these color patterns in deciding whether to recommend sprays for female beetles in the fall to suppress their egg-laying. Instead, they must base their recommendations on beetle counts of both sexes on plants and traps, or else they must determine the percentage of females in counts by more time-consuming and reliable means than the use of elytral color patterns.

Publication:

Hesler, L.S. & L. Hammack. 1997. Sex-related color patterns in elytral vittae of Diabrotica virgifera virgifera (Coleoptera: Chrysomelidae). The Great Lakes Entomol. 30: 45-50.

TILLAGE SYSTEM EFFECTS ON PHYSICAL PROPERTIES OF A WESTERN SOUTH DAKOTA VERTISOL FOLLOWING THE CONSERVATION RESERVE PROGRAM - LYMAN COUNTY

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*USDA-ARS, Morris, Minnesota

INTRODUCTION

In September 1997, final measurements were taken from a study to measure soil physical properties after return of CRP land to crop production initiated in May 1994. The objectives of this study were to determine 1) the effects of tillage systems on soil physical properties upon the return of western South Dakota CRP acres to crop production; 2) the influence of conventional tilling after CRP, and 3) the substitution of a legume to function as a green manure, in place of traditional "black" fallow in winter wheat rotations. This report describes research results from the 1996 and 1997 field seasons. Additional information concerning previous results from this study can be found in the Soil/Water Research Progress Reports SOIL PR 95-27.

SITE DESCRIPTION

The 30 acre study site, located on the Steve Taylor farm in northern Lyman County, SD (legal description - NE 1/4 section 23 T. 107 R. 78) was enrolled into CRP in 1988 and planted to intermediate wheat-grass and alfalfa. In 1994 this study was initiated. The soil on the site is a Promise clay (very fine, montmorillonitic, mesic Udic Haplusterts) that is subject to extensive cracking when dry and sealing when wet. The site has 2-4% slopes and is classified as highly erodible based on wind erosion estimates. Average annual rainfall is 18 inches/year.

The study site consisted of 6 treatments replicated 4 times in a randomized complete block design. The 6 treatments were: 1. CRP; 2. Conventional tillage ("black fallow) winter wheat - fallow (CT); 3. Conservation tillage to meet the conservation compliance plan, winter wheat - green fallow (CP); 4, No-till winter wheat - green fallow (NT1); 5. No-till winter wheat - corn - green fallow (NT2); 6. Conventional breakout of the CRP followed by no-till after the first winter wheat harvest using a winter wheat - green fallow rotation (NT3). Each treatment included subplots so that each crop in the rotation was represented every year, resulting in 12 plots/block.

MEASUREMENTS

Measurements used to evaluate soil physical properties included surface residue cover, unsaturated hydraulic conductivity, seasonal soil profile water content, surface runoff, soil water propagation velocity, aggregate stability, microbial activity, and organic carbon content.

RESULTS AND DISCUSSION

Residue Cover

As expected, residue cover was substantially higher when no-till management occurred (Table 1). Conventional breakout followed by no-till (NT3) had a surface cover of only 31% in 1995 but was close to other no-till treatments in following years.

Table 1. Residue Cover at Wheat Planting

Treatment	Residue Cover 1996	Residue Cover 1997
	%	%
CP	36	39
CT	23	14
NT1	87	81
NT2	82	86
NT3	81	61
P > (F)	.001	.000
$LSD_{(0.05)}$	24	15

Unsaturated Hydraulic Conductivity

Tension infiltrometer measurements are a measure of water movement into macropores in the soil. Using this device, unsaturated hydraulic conductivity was measured immediately following winter wheat planting on CT, NT1, NT3, and CRP treatments in 1996. As table 2 indicates, CT resulted in the highest unsaturated hydraulic conductivity.

Table 2. Unsaturated Hydraulic Conductivity -1996

	Tension		
	30 mm	60 mm	120 mm
Trt		mm (min^{-1} x 10^{-4})	
CT	11.74	5.58	1.63
NT1	4.04	1.40	0.56
NT3	3.93	1.45	0.40
CRP	7.17	3.31	1.01
P > (F)	0.03	0.001	0.08
$LSD_{(0.05)}$	5.20	1.76	NS

The CP and NT2 treatments were added to the existing tension infiltrometer measurements in 1997. As table 3 indicates, treatment differences in tension infiltrometer measurements were statistically insignificant. However, the trend was consistent with results from previous years. The tension infiltrometer readings are a measure of macropores immediately below the soil surface. These measurements were made without the prior surface crust removed except for the CT treatment. This treatment had received a recent tillage operation that loosened the soil surface. These results suggest that macropores below the surface were not open to surface infiltration and therefore, would be less effective in conducting water into the soil profile.

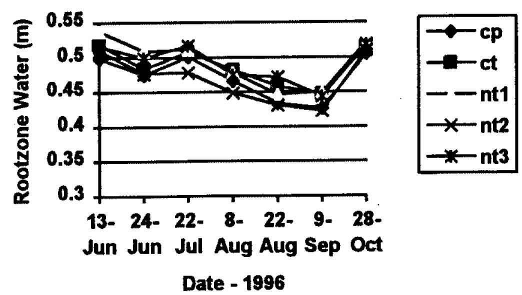
Table 3. Unsaturated Hydraulic Conductivity (Fallow Period-1997)

	Tension		
	30 mm	60 mm	120 mm
Trt		mm (min^{-1} x 10^{-4})	
CP	6.34	3.19	1.01
CT	19.45	4.01	0.42
NT1	8.15	4.15	1.00
NT2	5.73	1.92	1.49
NT3	10.65	3.81	1.02
CRP	5.71	2.14	1.62
P > (F)	0.07	0.46	0.08
$LSD_{(0.05)}$	NS	NS	NS

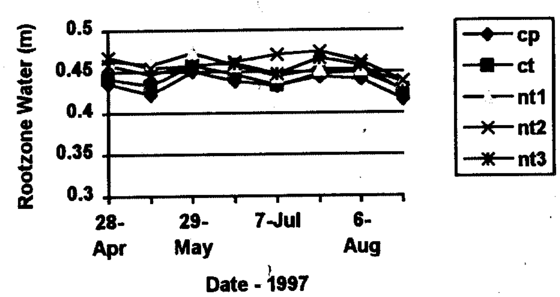
Seasonal Profile Water Content

Growing season rainfall amounts were 30% greater than normal in 1996 and 1997. This led to a wet soil profile in all treatments. All cropped treatments except CT were seeded to soybeans to obtain a green cover in the fallow year of the rotation. During both years, soil water content was often significantly higher under NT treatments, suggesting that the residue cover on the soil surface was effective in slowing evaporation and reducing surface runoff.

Figure 1a. Rootzone Water Content 1996 Fallow Period



Figures 2a, 2b. Rootzone Water Content - 1997 Fallow Period



Surface Runoff

Drip infiltrometer measurements were made immediately after planting at a rate of 2.5 inches/hour. The initial run was conducted at antecedent soil moisture conditions (dry run). The wet run followed 24 hr later. Five inches of rainfall within 1 wk prior to infiltration runs resulted in only wet runs in 1996. In 1997 the CP treatment was added. Runoff was highest from the CT treatment, where residue was sparse. The CRP treatment yielded little to no runoff, while the NT treatments were intermediate (Table 4). This trend was observed in dry and wet runs. These results when combined with the tension infiltrometer measurements indicated that residue cover played the most important role in reducing surface runoff through water droplet energy dissipation, thus preventing surface sealing.

Table 4. Surface Water Runoff from Rainfall Simulator Tests

	Year			
	1996		1997	
	Run			
Trt	Dry	Wet	Dry (in)	Wet (in)
CP	*	*	0.20	1.09
CT	*	1.26	0.17	0.48
NT1	*	0.82	0.04	0.46
NT3	*	0.84	0.40	0.25
CRP	*	0.33	0.00	0.02
P > (F)	*	0.02	0.21	0.06
$LSD_{.05}$	*	0.61	NS	NS

Soil Water Propagation Velocity

Time domain reflectrometry measurements were taken at the time of drip infiltrometer applications at 10cm, 20cm, 30cm, and 40cm depth. Soil water propagation velocity is referred to as the downward movement of water in the soil profile under the forces of gravity (Miyazaki 1993). A higher propagation velocity indicates more rapid water movement through soil pores. Treatment differences were not statistically significant again suggesting that surface sealing was the main factor controlling surface runoff in this study. Residue cover protects the surface from sealing allowing water movement into the soil.

Aggregate Stability

The aggregate stability of soil was measured to determine the susceptibility of the soil surface to sealing. Treatment differences were not significant except for the fallow period of 1997 (Table 5). The CT treatment contained the highest stable aggregate percentage at sampling time (Tables 5 and 6). This suggests that the lower surface runoff on the no-till plots was not a result of increased resistance to rain drops, but rather due to the protection by surface residue.

Table 5. Aggregate Stability - Fallow Period

	Year	
	1996	1997
Trt	% stable aggregates	
CP	52	72
CT	56	73
NT1	52	65
NT2	54	50
NT3	49	63
CRP	52	60
P > (F)	0.65	0.00
$LSD_{.05}$	NS	6.1

Table 6. Aggregate Stability - Wheat Period

	Year	
	1996	1997
Trt	% stable aggregates	
CP	53	63
CT	56	61
NT1	55	64
NT2	53	62
NT3	52	62
CRP	51	60
P > (F)	0.50	0.96
$LSD_{.05}$	NS	NS

Microbial Activity

Microbial activity was measured on surface soil samples using the fluorescein diacetate hydrolysis method (Inbar et al. 1991). Treatment differences were not significant in fallow and wheat cropped plots in 1996 and 1997. However, there was a trend toward greater microbial activity at the surface in NT1. This was probably due to residue accumulation.

Table 7. Microbial Activity

	Year			
	1996		1997	
	μg FDA Hydrolyzed			
Trt	Fallow	Wheat	Fallow	Wheat
CP	53	38	37	46
CT	58	26	20	39
NT1	57	68	47	55
NT3	45	27	22	34
CRP	42	39	32	41
P > (F)	0.94	0.61	0.17	0.77
$LSD_{.05}$	NS	NS	NS	NS

Organic Carbon

Organic carbon samples were analyzed in 1997 only, on wheat and fallow plots. Organic carbon percentage was measured using a stable isotope analysis system. Treatment differences were not statistically significant.

CONCLUSIONS

These results indicated that the different soil management systems had little direct effect on soil properties. The most noticeable treatment differences were found in residue cover, surface runoff, and seasonal water content in the soil profile. This indicated that residue cover protecting the soil surface from sealing by raindrop impact had the greatest effect on water runoff.

The use of a "green" legume cover crop during the fallow period did not result in a lower water content than the traditional "black" fallow, during these wet years, indicating that a legume cash crop may actually be substituted during the fallow period, resulting in greater return per acre.

Results indicated that no-till drilling winter wheat directly into sod (NT1 and NT2) led to greater residue cover, soil water content, and less runoff than the intense tillage system after CRP. The NT3 results demonstrated that the advantages of no-till on these soils could be obtained even after one year of conventional tillage. The greatest hazard for erosion and water conservation will occur in the year of tillage. After the implementation of no-till one can expect immediate benefits from the increased surface residue coverage.

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ROW SPACING AND NITROGEN FERTILIZER FOR OPTIMAL SOYBEAN YIELD: ARE THERE POTENTIAL EFFECTS ON WATER QUALITY?

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INTRODUCTION

Symbiotic bacteria associated with soybean root systems use nitrogen (N) from the atmosphere to produce N fertilizer for the crop. Soybeans that are well inoculated with symbiotic bacteria are not likely to respond to additional N fertilizer applied to the soil. Some soybean varieties can exhibit N deficiency during the first 30 to 40 days after planting in soils low in N and/or in cooler climates. This temporary N deficiency prompts farmers to apply N fertilizer to soybeans.

Soybeans can use either soil N or N fixed from the air to supply their N requirements. Excess soil N during seedling development, however, can inhibit root nodule formation. The addition of too much fertilizer N to nodulated soybean can reduce N fixation by causing nodule senescence. Fertilizer N that is not used by the crop may leach below the root zone and pollute groundwater.

The number of acres in eastern South Dakota planted to soybean has steadily increased over the past few years. Because farmers seek crop production strategies to increase soybean yield, research on the effects of narrow row spacing and N fertilizer applications was performed.

Our objectives were to determine if crop row spacing would interact with N fertilizer applications to affect soybean yield and if these N fertilizer applications could potentially cause problems with N contamination of the ground water.

METHODS

The experiment was conducted on Vienna loam soils at the Eastern South Dakota Soil and Water Research Farm near Brookings SD during the 1997 growing season. We used a split-plot experimental design with soybean (variety 'Hendricks') row spacing (7.5-inch, 15-inch, and 30-inch) as main plot treatments and N fertilizer rate (0, 30, 60, or 90 lbs N/acre provided by dry urea 46-0-0 broadcast and disked in at planting time) as sub-plot treatments with 5 replications.

A JD750 drill calibrated to deliver 200,000 live seeds per acre was used for the 7.5-inch row spacing treatment. The 15-inch row spacing (190,000 live seeds per acre) and 30-inch row spacing (180,000 live seeds per acre) treatments were established with a JD7200 8-row planter. Two planter passes through the plot with the hitch offset by 15 inches were required to achieve the 15-inch row spacing. Planting depth for all row spacing treatments was 1.5 inches.

Pre-season soil test results were: 7 lbs/acre NO_3-N in the top 6 inches of the soil profile, 59 lbs/acre NO_3-N in the top 24 inches of the soil profile, 7 ppm P, and 132 ppm K. SDSU Soil Testing Laboratory recommendations for 60 bushel/acre soybean yield were no additional N, 35 lbs/acre P, and no additional K. All plots were fertilized with 50 lbs/acre P at the same time the N fertilizer treatments were applied. Broadstrike-Dual pre-emergent herbicides and cultivator (30-inch row spacing only-10 July 1997) treatments were used to manage weeds. Plots were planted on 15 May 1997 and harvested on 29 September 1997 with a plot combine.

Yield data were analyzed using SAS ANOVA procedures appropriate for a split-plot design. With the occurrence of significant main or sub-plot effects, means were separated using Duncan's Multiple Range Test.

The Nitrogen Leaching and Economic Analysis Package (*NLEAP*) is a computer software program that predicts the amount of nitrate-N available for leaching from the root zone. The amount of N potentially available for leaching out of the root zone was estimated using the *NLEAP* computer simulation model. The model takes into consideration farm management practices, soils, and climate data to develop estimated N budgets and potential nitrate-N leaching below the root zone (Shaffer et al., 1991).

RESULTS AND DISCUSSION

Growing Season Characteristics

Below average rainfall amounts for the months of April (1.7 inches below average), May (1.9 inches below average), June (1.8 inches below average), and August (1.4 inches below average) were recorded at our research plots during 1997. July (3 inches) and September (2 inches) rainfall totals were slightly above average. The upper portion of the soil profile was relatively dry at planting time (15 May 1997) and remained dry until the plots received 1.5 inches of rain on 19 June 1997. The dry soil resulted in slow seed germination and plant emergence in all treatments (emergence began on 4 June 1997). Early growth in the 7.5-inch row spacing treatment was uniform while the 15-inch and 30-inch row spacing treatments had about 50 percent emergence. The remaining 50 percent of these seeds emerged after extensive rainfall on 19 June. Consequently, about 50 percent of the plants in the 15-inch and 30-inch row spacing treatments were about 2 weeks behind in their development.

The differences in early soybean growth may be the result of an extra press wheel on the JD750 drill that provided better seed to soil contact than the JD7200 row planter.

Treatment Effects on Soybean Yield

The delay in emergence resulted in significantly higher seed moisture percentages at harvest in the 15-inch and 30-inch row spacings compared to the 7.5-inch row spacing (Table 1). Seed moisture also was significantly higher in the 90 lbs/acre N fertilizer treatment compared to the 0 N fertilizer treatment (Table 2), suggesting that N fertilizer delayed crop maturity. There was no significant interaction between row spacing and N fertilizer treatments suggesting that seed moisture under the row spacing treatments did not respond differently to the N fertilizer treatments.

Test weight was not significantly affected by either row spacing treatments (Table 1) or N fertilizer treatments (Table 2). Yield was significantly higher as the row spacing decreased (Table 1). All N fertilizer treatments increased yield when compared with the 0 N fertilizer treatment (Table 2). There were no significant interactions between row spacing and N fertilizer treatments suggesting that test weight and yield under the row spacing treatments did not respond differently to the N fertilizer treatments.

Table 1. Row spacing effects on soybean yield

Row Spacing	Seed Moisture	Test Weight	Yield
(inches)	(%)	(lbs/bushel)	(bushels/acre)
7.5	9.6 b †	56.2 ns ‡	40.6 a
15.0	10.0 a	56.4	38.4 b
30.0	10.1 a	56.3	32.9 c

† Means followed by the same letter are not significantly different (Duncan's Multiple Range Test, α=0.05)
‡ Not significant

Table 2. N fertilizer effects on soybean yield

N Fertilizer	Seed Moisture	Test Weight	Yield	N Available for Leaching
(lbs N/acre)	(%)	(lbs/bushel)	(bushels/acre)	(lbs NO_3/acre)
0	9.8 b †	56.4 ns	35.7 b	0 ‡
30	9.9 ab	56.0	37.9 a	19.4
60	9.9 ab	56.3	37.4 a	43.1
90	10.1 a	56.4	37.9 a	66.8

† Means followed by the same letter are not significantly different (Duncan's Multiple Range Test, α=0.05)
‡ Values represent number of pounds of N available for leaching from the root zone as determined by the Nitrogen Leaching and Economic Analysis Package (*NLEAP*) computer program

Potential Nitrogen Leaching from the Root Zone

The results of an *NLEAP* analysis of our experiment predicted that no nitrate-N would be available for leaching from the root zone under the 0 N fertilizer treatment (Table 2). As the amount of broadcast N fertilizer applied at planting increased, the amount of nitrate-N potentially available for leaching from the root zone also increased (Table 2).

CONCLUSIONS

Crop production methods that included broadcast N fertilizer or narrow soybean row spacing each produced significantly higher soybean yields when compared with no fertilizer or wide row spacing in the relatively dry 1997 growing season. Soybeans grown with narrow row (7.5-inch) spacing had about 23 percent higher yield than soybeans grown with wide row (30-inch) spacing. N fertilizer application increased soybean yield about 6 percent when compared with 0 N treatment. Assuming urea costs about $300.00 per ton and soybean commodity priced at about $6.00 per bushel, the 2 bushel per acre soybean yield increase would pay for the price of the fertilizer at the 30 lbs N/acre fertilizer treatment but not at the higher levels. However, N fertilizer application at all rates applied resulted in nitrate-N potentially available for leaching out of the root zone.

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ACKNOWLEDGMENTS

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CEREAL APHID SURVEY: 1997

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Cereal aphids were present in low numbers during Fall 1997 in two winter wheat plots, one at the Soil and Water Farm and one at the NGIRL Farm. Populations were diverse and included bird-cherry oat aphids (BCO, most abundant species), greenbugs, English grain aphids, corn leaf aphids (CLA), and rice root aphids. Some individual plants had 15 or more BCO or CLA, but overall aphid numbers were well below economic thresholds.

A FUTURISTIC TECHNIQUE FOR ANALYSIS OF PASTURE QUALITY

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Most forage producers are familiar with the use of near infrared reflectance spectroscopy (NIRS) to analyze forage samples. The basic premise of NIRS is that high-intensity light is reflected off the sample. Patterns in the reflected light are used to describe sample biochemistry. Recently, a device was developed that can measure light reflected from the sun, possibly permitting an application of NIRS principles in the field. This research was conducted to evaluate the use of reflected solar radiation for analysis of pasture and forage quality. Analysis was done on grass mixtures containing various combinations of orchardgrass, intermediate wheatgrass, creeping foxtail, big bluestem and switchgrass. Four N fertility levels (0, 42, 83, and 125 lb N/A) were also examined. Field-based calibration equations were developed for crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF). Results from field-based calibration statistics were very promising. For forage quality traits, SECV values ranged from 1.3% for CP to 3.2% for NDF. These levels of error represent 16, 5, and 8 % of the grand mean for CP, NDF, and ADF, respectively. The highest R^2 and 1-VR values occurred for CP; .91 and .80, respectively. The NIRS calibration equations were validated with known values from 274 samples. Standard errors of prediction were 2.3, 3.3, and 2.9% for CP, NDF, and ADF, respectively. These results suggest a field radiometer may be used for non-destructive analysis of grass canopies using NIRS development techniques to determine chemical composition.

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YIELD IMPACT OF WESTERN CORN ROOTWORM AND EUROPEAN CORN BORER ON DIFFERENT MATURING VARIETIES OF FIELD CORN - 1997

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European corn borer, *Ostrinia nubilalis*, and western corn rootworm, *Diabrotica virgifera virgifera*, are serious pests of corn in the United States. Economic losses caused by both pests result from feeding damage and control costs and can run into the billions of dollars each year. Both insects are commonly found in corn fields at the same time, feeding on the same plants. Corn borer larvae feed on leaf tissue before burrowing into the stalks and earshanks to complete development. Rootworm larvae feed on corn roots. Little research has been conducted to look at the possible interactions that may exist between these two insects when feeding on the same host. This study was developed to assess yield reduction in field corn caused by feeding activities of artificially infested European corn borer and western corn rootworm in a field experiment and to compare damages caused by the two insect species when infestations were applied in different combinations and population densities to corn hybrids with different relative maturities. Results from the second year of experimentation are reported here.

METHODS

Three different field corn varieties (Pioneer 3907 - 87 day maturity; Pioneer 3751 - 97 day maturity; and Pioneer 3525 - 106 day maturity) were planted on 6 May using 30 inch rows. Prior to planting, the field was chisel plowed and 100 lbs/ac of 46-0-0 custom applied. Starter fertilizer (100 lb/ac of 14-36-13) was applied at planting. Herbicide (Lasso and Bladex each at 3 qt/ac) was applied before corn emergence. The three varities of corn were planted side by side in a strip-split-split plot design with four replications and a 3x4x3 factorial arrangement. There were 12 insect infestation treatments per replicate. Treatments included: 1) control; no insect infestations; 2) western corn rootworm infested at 1600 eggs/foot of row; 3) western corn rootworm infested at 600 eggs/foot of row; 4) late season infestation of newly hatched European corn borer larvae; 5) western corn rootworm infested at 1600 eggs/foot of row plus late season infestation of European corn borer larvae; 6) western corn rootworm infested at 600 eggs/foot of row plus late season infestation of European corn borer larvae; 7) western corn rootworm infested at 600 eggs/foot of row and early season infestation of European corn borer larvae; 8) western corn rootworm infested at 1600 eggs/foot of row and early season infestation of European corn borer larvae; 9) early season infestation of European corn borer larvae; 10) western corn rootworm at 600 eggs/foot of row and early + late season infestation of European corn borer larvae; 11) western corn rootworm at 1600 eggs/foot of row and early + late season infestation of European corn borer larvae; and 12) early + late season infestation of European corn borer larvae.

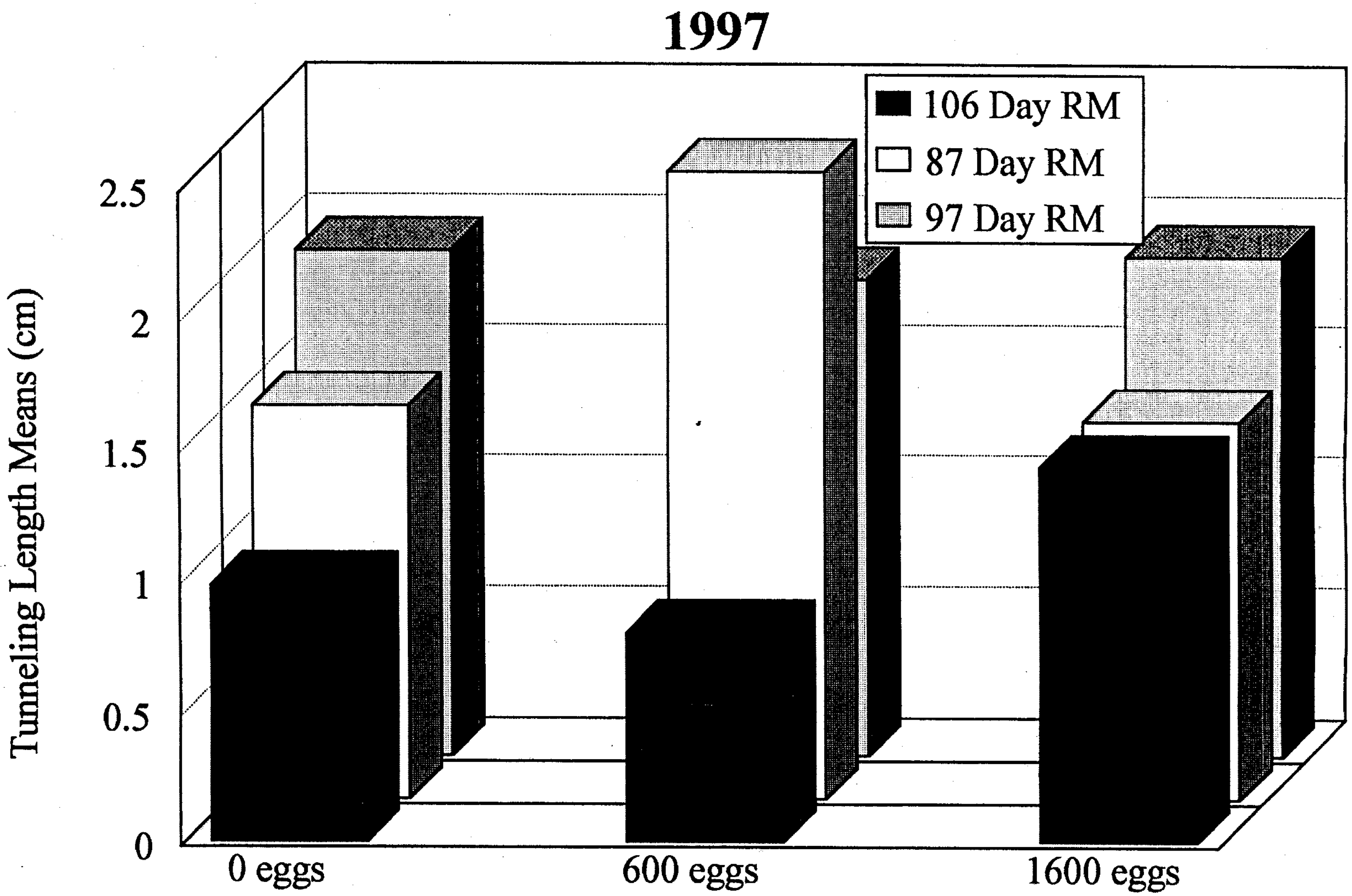
Throughout the growing season, damage assessments were made that consisted of the following: roots were extracted from the soil and were rated according to the amount of feeding damage (root pruning) inflicted by western corn rootworm larvae. Ratings were made using a 1 to 6 damage scale where 1 = no damage. Stalks were split to observe tunneling caused by early (1st generation) and late (2nd generation) season infestations of European corn borers. The number of larvae were counted and size of tunnels measured. Finally, corn yield (ear length and grain production) were recorded at harvest. All data were then analyzed with appropriate statistical procedures.

RESULTS

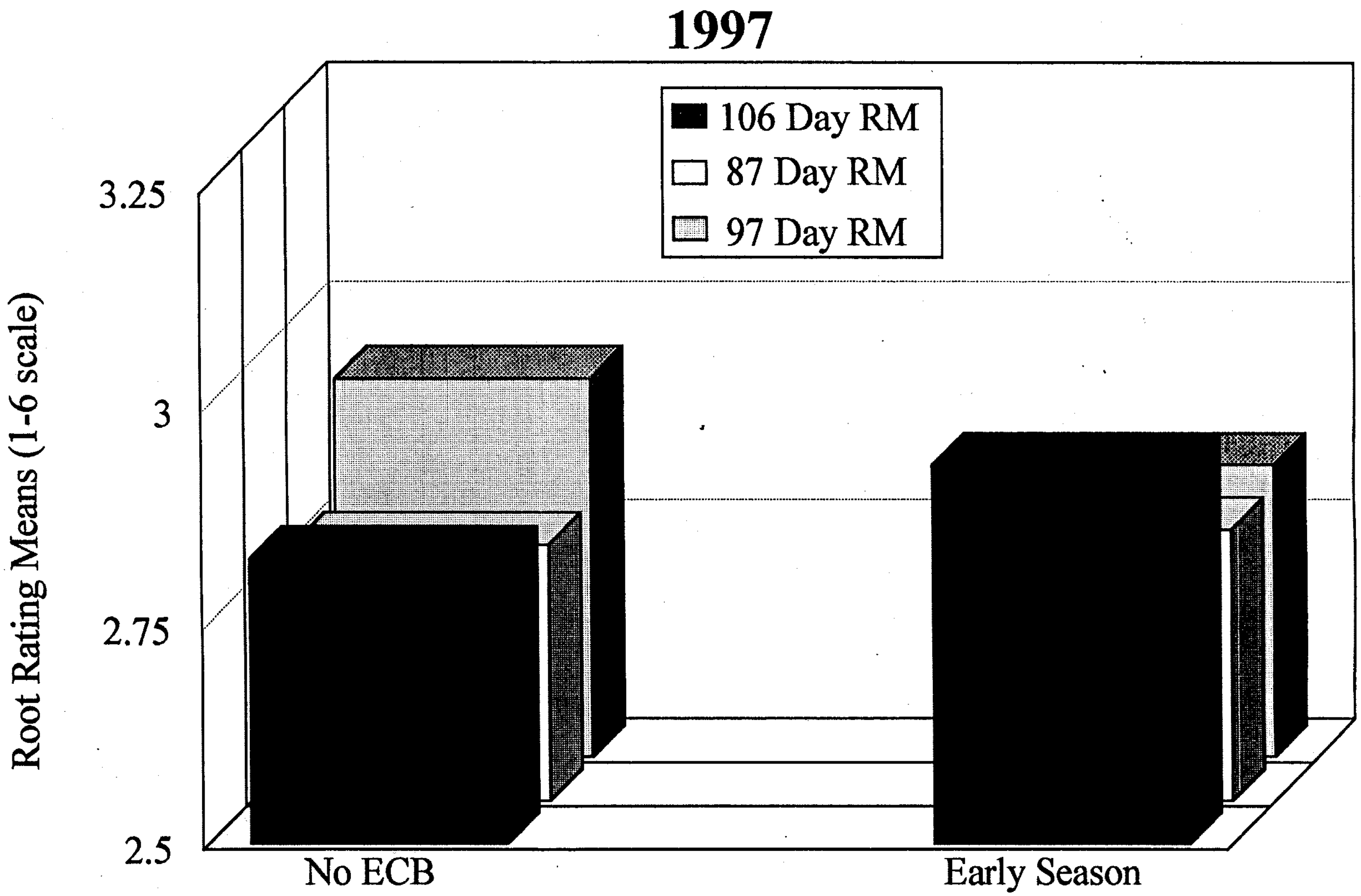
There was a significant interaction between corn hybrids with different relative maturities and European corn borer infestation times for stalk tunneling. The 97 day hybrid had the most tunneling and the 106 day hybrid had the least amount of tunneling for all comparisons. Early season corn borer infestations had a greater impact on yield than did late season infestations. A significant interaction for stalk tunneling was seen between corn hybrids, western corn rootworm infestation rates, and year (1996 vs 1997 data). There was more European corn borer tunneling for all three hybrids receiving western corn rootworm infestations in 1996 than in 1997. In comparing corn rootworm damage, the 106 day hybrid had the lowest root rating of any of the tested varieties. All three hybrids had yield reductions resulting from the 600 and 1600 corn rootworm egg/row foot infestation rates, with the 97 day hybrid having the higher yields. The data indicated that for every 1cm (0.4 inches) of corn borer tunneling there was a yield reduction of 4.5% per ear, and for every unit change in the root rating scale (rootworm larvae feeding damage) there was a yield reduction of 6.6% per ear.

CONCLUSIONS

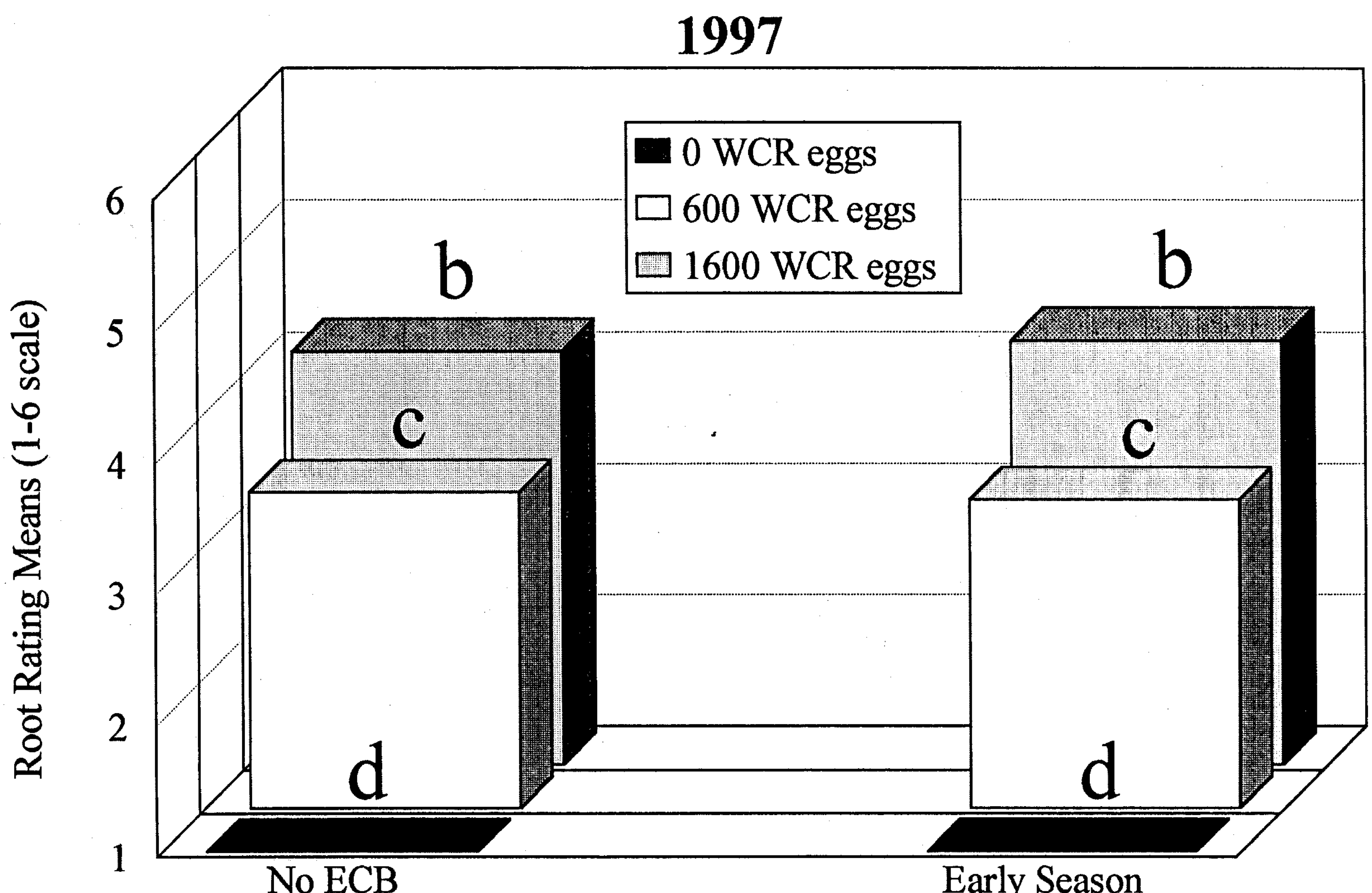
The data show that for this experiment, western corn rootworm had more of an impact on yield than did European corn borer, and there was a greater yield reduction from both insects in 1997 than in 1996. Although this field experiment employed the use of artificial infestation methods in order to gain field-wide uniformity, the infestation rates used were not necessarily excessive. The corn hybrid with the 97 day maturity had higher yields even though it received the most damage from the two insects compared to the other two hybrids. Further studies involving artificial and natural populations of both insects within the same fields are needed in order to obtain more conclusive evidence on the interactions that may occur between these two serious corn pests.



Significant interaction ($P < 0.05$) between WCR infestation rate/30.5 cm row and corn hybrid for ECB tunneling in 1997 ($N = 80$). ANOVA: $F = 3.47$, $df = 4$.



Significant interaction (P < 0.05) between ECB infestation regimes and corn hybrids for root rating in 1997 (N = 120). ANOVA: F = 4.32, df = 2.



Significant interaction ($P < 0.1$) between WCR infestation rate/30.5 cm row and ECB infestation regimes for root rating in 1997 ($N = 120$). LSD mean comparisons were made at the .05 level (LSD value = 0.3607). Bars labelled with different letters are significantly different from each other. ANOVA: $F = 3.00$, $df = 2$.

BT CORN HYBRIDS: EUROPEAN CORN BORER DAMAGE PROTECTION AND YIELD IN 1997

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Numerous outbreaks of European corn borer populations in western Minnesota and eastern South Dakota in the last several years continue to reinforce the need for management programs targeted at this important pest. Plant damage caused by the first generation occurs in the leaf roll at about the time the plant reaches the 6th leaf stage. This damage resembles shot-holes on the leaves. Second generation borers usually damage corn stalks and ear shanks around the time of tassel. In the past both generations have occurred in our region and could be easily observed in the field. Recently, however, there is a tendency to not be able to separate the population into distinct generations. Rather than two peak periods of infestation, many growers and crop managers now report a more continual infestation period that damages the crop throughout the growing season.

Genetically-engineered Bt corn hybrids were first available for growers in 1996. Evaluations of the varieties that were available in that year indicated that corn borer damage could be greatly reduced. The Bt varieties have a bacterial microbe inserted into the plant (genetic engineering) that manufactures a protein toxic to corn borer larvae. As the larvae begin to feed on the plants they ingest the protein and eventually die. Feeding ceases soon after the protein is ingested which helps to limit tunneling and the resulting plant damage and yield loss associated with the pest.

The purpose of the study reported here was to evaluate an increased number of Bt corn varieties (compared to only 2 in 1996) for their ability to resist corn borer damage and to determine the yield associated with each. Comparisons between each Bt variety and a non-Bt (isoline - ISO) variety were made to more fully understand the impact of the Bt technology on corn borer populations.

METHODS

Research plots were established by planting each variety in 2 rows that were 30 inches apart with 9 inch plant spacing. Six Bt and six ISO corn varieties were planted using 5 replications of each. Plants were allowed to grow normally through the growing season. Starter fertilizer (100 lbs./ac 13-33-13) was applied at planting and 100 lbs./ac of 46-0-0 added as a side dress application. Each plot received 3 qts/ac of Lasso and Bladex, respectively. On 25 September (just before the first killing frost), plants were harvested and corn borer damage in stalks and ears evaluated. Leaves were stripped from the stalk, and the number of corn borer exit holes per stalk counted. The stalk was then split down the middle and the length of each corn borer tunnel measure. The crop was harvested by hand at the end of the season and yield determined. All data were analyzed using appropriate statistical procedures.

RESULTS

Results from the 1997 study are shown in Table 1. All Bt varieties significantly reduced European corn borer damage compared to their non-Bt ISO variety with the exception of the P3563 vs P35N05Bt pair. Infestation in non-Bt lines ranged from 40 to 84% while Bt line infestation rates ranged from 4 to 24%. The infestation rates suggest that Bt lines can provide a 3 to 10 fold increase in protection, depending on variety, from corn borers compared to non-Bt lines.

The number of corn borer tunnels per 5 plants ranged from 0.2 to 1.2 in the Bt varieties. DK493 Bt exhibited the highest number of tunnels per plant among the Bt lines evaluated. Corn borer tunnels in non-Bt varieties ranged from 1.6 to 7.2 per 5 plants with P3563 having the fewest number of tunnels. There were no statistical differences in tunnel numbers between the P3563 and the Bt varieties. Little tunneling was observed in ear shanks or ears. Ciba 747Bt had the greatest incidence of ear shank/ear tunnels among all the Bt varieties.

Yield between Bt and non-Bt varieties was similar for all tested pairs. In most instances yield was numerically higher in Bt varieties compared to the non-Bt ISO companion line. The greatest difference in yield was observed between Ciba 88 and Ciba 88Bt where the Bt line produced approximately 33 more bushels per acre.

CONCLUSIONS

No Bt corn variety provided 100% control of European corn borer in our tests. However, Bt variety infestation was minor and probably did not result in significant yield loss. P3563 appears to be a late maturing variety and could provide some natural corn

Table 1. Effects of European corn borer infestations on Bt and non-Bt corn varieties.[1]

Variety	% Plants Infested	Avg. Number of Tunnels in Stalks/5 Plants	Avg. Number of Tunnels in Ears and Shanks/5 Plants	Yield in Bu/Ac
CIBA 747	76 AB	6.0 AB	2.4	135 AB
CIBA 747 Bt	12 C	0.2 E	0.4	127 AB
CIBA 88	84 A	5.0 ABCD	1.6	122 B
CIBA 88 Bt	12 C	0.6 DE	0.0	155 AB
DK 493	84 A	7.2 A	0.6	136 AB
DK 493 Bt	24 C	1.2 CDE	0.2	159 A
NK 4242	80 A	5.8 AB	2.0	137 AB
NK 4242 Bt	4 C	0.2 E	0.0	152 AB
NK 4640	72 AB	5.6 ABC	2.0	132 AB
NK 4640 Bt	8 C	0.4 E	0.0	152 AB
P3563	40 BC	1.6 BCDE	2.2	153 AB
P35NO5 Bt	4 C	0.4 E	0.0	148 AB
			N.S.	

[1]Means in a column followed by the same letter are not significantly different ($\underline{P} \leq 0.05$, Tukey's HSD Test). N.S. indicates no significant difference observed.

borer resistance even though it does not have the Bt protein. Most of the Bt tested varieties yielded well and should be adequate performers for growers in eastern South Dakota and western Minnesota.