Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 6 *Kansas Field Research (1997-2014)*

Article 15

2005

Field research 2005

Kansas State University. Department of Agronomy

Recommended Citation

Kansas State University. Department of Agronomy (2005) "Field research 2005," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 6. https://doi.org/10.4148/2378-5977.3392

Kansas State University

KANSAS STATE UNIVERSITY

Agronomy

Field Research 2005

Report of Progress 956

Agricultural Experiment Station
and Cooperative Extension Service

Agronomy Field Research 2005 Contents

TABLE OF CONTENTS - EAST CENTRAL

EXPERIMENT FIELD PERSONNEL

Dr. Keith A. Janssen, Agronomist-in-Charge
James M. Kimball, Plant Science Technician II
Keith A. Brock, Student

TABLE OF CONTENTS - KANSAS RIVER VALLEY

EXPERIMENT FIELD PERSONNEL

Larry D. Maddux, Agronomist-in-Charge
Charles Clark, Plant Science Technician I
William Riley, Plant Science Technician I

EAST CENTRAL KANSAS EXPERIMENT FIELD

Introduction

The research program at the East Central Kansas Experiment Field is designed to enhance the area's agronomic agriculture. Specific objectives are 1) to identify the top-performing varieties and hybrids of wheat, corn, grain sorghum, and soybean; 2) to determine the amount of tillage necessary for optimum crop production; 3) to evaluate weed-control practices, including chemical, non-chemical, and combination methods; and 4) to test fertilizer rates and application methods for crop efficiency and environmental effects.

Soil Description

Soils on the Field's 160 acres are Woodson. The terrain is upland and level to gently rolling. The surface soil is a dark, gray-brown, somewhat poorly drained, silt loam to silty clay loam, with slowly permeable clay subsoil. The soil is derived from old alluvium. Water intake is slow, averaging less than 0.1 inch per hour when saturated. This makes the soil susceptible to runoff and sheet erosion.

2004 Weather Information

Precipitation during 2004 totaled 40.37 inches, which was 3.59 inches above the 35-yr average (Table 1). Rainfall amounts for April and May were slightly below average. June and July rainfall amounts were above average, and August and September below average. Moisture distribution was good, with no visual evidence of moisture stress.

The coldest temperatures during 2004 occurred during early and late January and the first half of February, with eleven days in single digits or below. The overall coldest temperature recorded was 8°F below zero on February 8. There were 13 days on which temperatures exceeded 90 degrees (this compares with 48 days in 2003). The two hottest days were July 13 and July 20, when air temperatures reached 97 and 96°F, respectively. These were the only two days that air temperatures exceeded 95°F. The last 32°F temperature in the spring was April 14 (average, April 18), and the first killing frost in the fall was November 13 (average, October 21). The number of frost-free days was 212, compared with the long-term average of 185.

Table 1. Precipitation at the East Central Experiment Field, Ottawa, Kansas, inches.

Month	2004	35-yr. avg.	Month	2004	35-yr. avg.
January	1.67	1.03	July	5.13	3.37
February	1.23	1.32	August	3.17	3.59
March	6.11	2.49	September	1.72	3.83
April	2.46	3.50	October	3.55	3.43
May	4.66	5.23	November	4.03	2.32
June	5.71	5.21	December	0.93	1.45
Annual Total				40.37	36.78

INTEGRATED AGRICULTURAL MANAGEMENT SYSTEMS FOR PROTECTION OF KANSAS SURFACE WATERS

Marais Des Cygnes River Basin

K.A. Janssen and G.M. Pierzynski

Summary

The purpose of this study was to evaluate, in large field-size plots, the effects of different combinations of tillage-, fertilizer-, and herbicide-management practices on controlling cropland runoff losses of sediment, nutrients, and herbicides from a terraced Kansas field in the Marais Des Cygnes River Basin. Seven years of runoff-water collections show that no-till with fertilizer pre-plant deep-banded and herbicide split between early pre-plant and planting is one of the most effective combinations for protection of water quality.

Introduction

Water quality is an issue that concerns everyone. Total Maximum Daily Loads (TMDL) are being implemented in Kansas for various contaminants in streams and water bodies. Contaminants of most concern are sediment, nutrients, pesticides, and fecal coliform bacteria. In watersheds with waters not meeting standards, farmers and other land owners are being encouraged to reduce contaminant loading by implementing Best Management Practices (BMP).

For crop producers, various BMP are available to reduce soil erosion and sediment in runoff from cropland. But no-till has been shown to be one of the most effective BMP because it targets sediment control at the source. Tillage/planting systems such as no-till, however, provide little opportunity for incorporating fertilizer, manure, and herbicides. When surface-applied, an increased percentage of these crop inputs contact runoff waters, and that can result in increased contaminant losses.

In consequence, to attain balanced water-quality protection, a comprehensive management strategy beyond just no-till is needed. A system of farming is needed that uses combinations of BMP so that all runoff contaminants are minimized. We refer to such a strategy as "Integrated Agricultural Management Systems."

The purpose of this study was to test, in large field-size plots, effects of different combinations of tillage-, fertilizer-, and herbicide-management practices for balanced water-quality protection.

Procedures

The study was located on an approximately 10-acre, parallel-terraced field near Lane in southeastern Franklin County, Kansas. Soils in the field were a mixture of Eram-Lebo with some Dennis-Bates complex (Argiudolls, Hapludolls, and Paleudolls). Bray-1 P soil test initially was 13 ppm, which is a low-to-medium P soil test, according to recommendations from Kansas State University Research and Extension.

Three combinations of tillage-, fertilizer-, and herbicide-management practices were evaluated, starting in 1998. The combinations were: 1) no-till, with fertilizer and herbicides broadcast on the soil surface; 2) no-till, with all of the fertilizer deep-banded (3- to 5-inch depth) and herbicides broadcast on the soil surface; and 3) chisel-disk-field cultivate, with fertilizer and herbicides incorporated by tillage. All treatments were replicated twice and were established between terraces to facilitate runoff-water collection. The crops grown were grain sorghum and soybean in alternate years in rotation. The rate of fertilizer applied for

grain sorghum was 70 lb N, 33 lb P_2O_5, and 11 lb K_2O per acre. No fertilizer was applied for soybean. Atrazine (1.5 lb/acre ai) and Dual® (metolachlor 1.25 lb/acre ai) herbicides were applied for weed control in grain sorghum. For soybean, Roundup Ultra® (glyphosate 1 lb/acre ai) and metolachlor (1.25 lb/acre ai) herbicides were applied.

Rainfall amounts were recorded, and runoff was collected by instrumentation of all treatment areas with weirs and automated ISCO samplers. The runoff water collected was analyzed for sediment, nutrients, and herbicide concentrations. Mass losses of contaminants were calculated by multiplying the runoff concentrations times runoff volumes.

Results

Rainfall and Runoff

Averaged across all sampling dates and years (1998-2004), rainwater runoff was 2.86 inches (25%) in the no-till system and 1.72 inches (15 %) in the chisel-disk-field cultivate system (Figure 1). Part of the reason that runoff was greater in no-till than in the chisel-disk-field cultivate system was that no-till conserved surface soil moisture, which then generated runoff more quickly. Also, each time the soil in the chisel-disk-field cultivate system was tilled, it loosened and dried the soil, which then increased the soil's capacity to absorb rainwater.

Soil Erosion and Sediment Losses

Even though runoff was less in the chisel-disk-field cultivate system, the amount of soil loss was three times greater, compared with that of no-till (Figure 2). Seasonal soil loss averaged across seven growing seasons was 0.58 ton/acre with the chisel-disk-field cultivate system and 0.19 ton/acre with no-till.

Nutrient and Herbicide Losses

Total P losses in the runoff generally paralleled soil losses (Figure 3). This is because sediment (soil) in runoff accounts generally for most total P losses. Soluble-P and atrazine losses in the runoff water were greatest with surface applications in no-till (Figures 4 and 5). Incorporation of P fertilizer and atrazine with tillage decreased losses. Deep-banding fertilizer P in no-till also reduced soluble-P losses. Concentrations of soluble-P and atrazine in runoff were generally greatest during the first couple of runoff events after application (data not shown), because that is when the largest amounts of these materials are still present on the soil surface and directly in contact with runoff water.

Conclusions

Data from this study confirm that no-till is one of the most effective BMP for reducing soil erosion and sediment P in runoff from cropland. If fertilizer and herbicides are surface-applied, however, losses of these crop inputs may be increased, compared with losses when they are incorporated by tillage. Therefore, to obtain balanced runoff-water protection, it will be important to subsurface-apply P fertilizer when planting crops no-till. This could be accomplished by pre-plant deep banding (3- to 5-inch coulter knife depth on 15 inch centers, which was used here), 2x2 inch placement beside the seed row with the planter, or some combination of these methods. Steps to reduce herbicide losses when planting crops no-till will also be needed. This might be accomplished partly by timing the herbicide applications when there is less opportunity for runoff-producing rains (fall and early spring), or as post-emergence applications instead of planting-time applications.

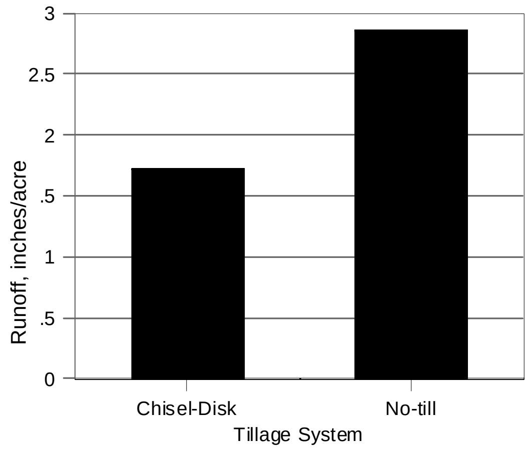


Figure 1. Volume of runoff as influenced by tillage (7-yr growing-season avg.).

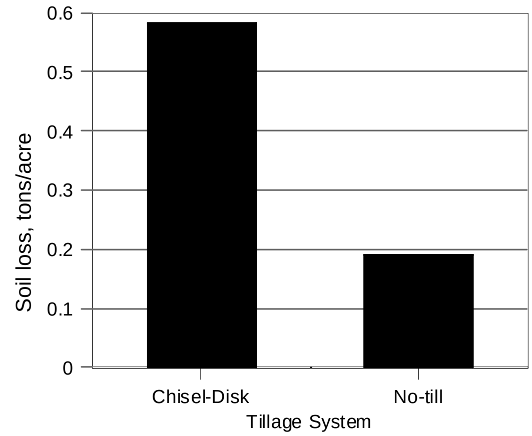


Figure 2. Soil loss as influenced by tillage (7-yr growing-season avg.).

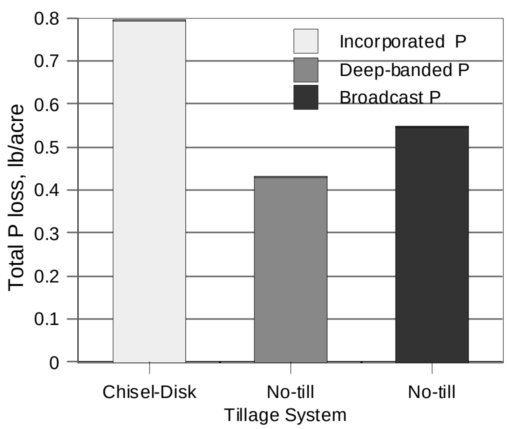


Figure 3. Total P loss as influenced by tillage and P placement (7-yr growing-season avg.).

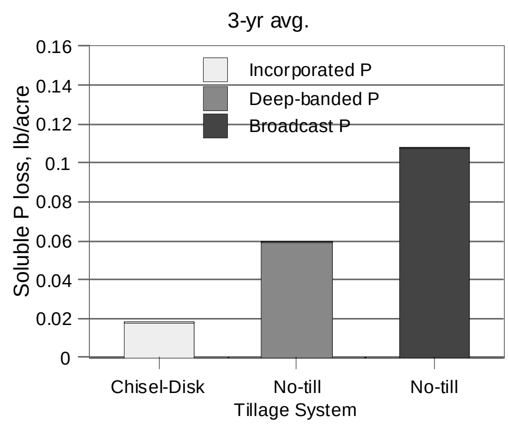


Figure 4. Soluble P loss as influenced by tillage and P placement (7-yr growing-season avg.).

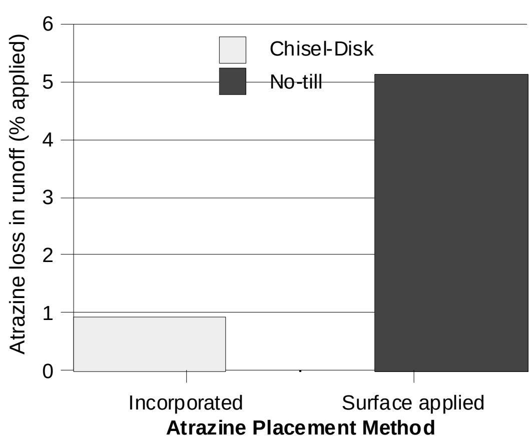


Figure 5. Atrazine loss as influenced by tillage and placement (4-yr growing-season avg.).

STRIP-TILLAGE AND NO-TILL TILLAGE/FERTILIZER SYSTEMS COMPARED FOR EASTERN KANSAS RAIN-FED CORN

K. A. Janssen, W.B. Gordon, and R.E. Lamond

Summary

Strip-tillage and no-till tillage/fertilizer systems were compared for rain-fed corn at the East-Central Experiment Field at Ottawa in 2003 and 2004. Averaged across all fertilizer treatments and years, fall strip-tillage with fall-banded fertilizers increased plant populations, 6-leaf dry matter, 6-leaf nutrient uptake, and corn yields, compared with no-till. There was no indication that performance of fall-banded fertilizer was inferior to that of spring planter-banded fertilizer. More testing is necessary, but strip-tillage with accompanying fall under-the-row banded fertilizer seems to have promise for eastern Kansas corn production. Additional studies are planned for 2005.

Introduction

Long-term daily rainfall and air temperature patterns for east-central and southeastern Kansas show that, for best growing conditions, rain-fed corn needs to be planted early. Corn producers in these Kansas regions also are under increasing pressure to plant more acres by using conservation tillage to reduce sediment and nutrient losses via runoff. Planting corn early can be a challenge, especially when planting corn no-till and on imperfectly drained soils with dense clay subsoils. The extra residue cover associated with no-till reflects sunlight, slows soil warming, and keeps no-till soils cooler and wet longer in the spring, and that can interfere with timely early planting

In contrast, strip-tillage is a conservation tillage system that provides a seed bed environment more like conventional tillage. Tillage is performed in strips, but only where the seed rows are to be planted. The tilled strips create raised beds 4 to 5 inches wide and 3 to 4 inches high, which speeds soil drying and warming. By planting, the raised tilled soil settles to 1 to 2 inches high, and the field is level after planting . The between-row areas are left untilled, which maintains residue cover and soil erosion protection. Application of fertilizer generally is performed in the same strip-tillage operation. Fall and/or early spring strip-tillage with fertilizer banded under the row, would seem to be applicable, especially for eastern Kansas conditions.

The objectives of this study were 1) to compare the effectiveness of fall strip-tillage and no-till tillage/fertilizer systems for rain-fed corn in east-central Kansas, and 2) to assess the effects of fall versus spring applications of N-P-K-S fertilizer on growth, grain yield, and nutrient uptake of corn.

Procedures

This study was conducted at the East-Central Kansas Experiment Field near Ottawa on a somewhat poorly drained Woodson silt loam soil that had been managed no-till for five years before the study. The crop preceding the 2003 corn study was corn, and the crop preceding the 2004 corn study was soybean. The tillage/fertilizer planting systems, and the dates that fertilizers and herbicides were applied, are shown in Tables 2 and 3. The corn hybrid planted both years was Pioneer 35P12. Plant counts were taken, and whole, above-ground plants (six plants per plot) were taken for biomass and nutrient uptake measurements at approximately the 6-leaf growth stage each year. Harvest was August 28, 2003, and September 10, 2004.

Results

The 2003 corn growing season was hot and very dry. Rainfall during April, May, and June was average, but July and most of August were very hot and dry. There were 48 days during the summer of 2003 in which air temperatures exceeded 90ºF. In 2004, rainfall for April and May was 1.61 inches below average, June and July were 2.26 inches above average, and August and September were 2.58 inches below average, for a total growing-season deficit of 1.88 inches. Rainfall distribution in 2004 was good, however, and there were no visual symptoms of moisture stress. Also, there were just 13 days in 2004 on which temperatures exceeded 90ºF.

Corn Emergence, Plant Stands, and Early-Season Growth

Corn emergence in both years tended to be better and more uniform in corn planted with strip-tillage than with no-till. Plant stands were 15% better in 2003, and 7% better in 2004, in strip-tillage treatments, compared with stands in no-till (Tables 2 and 3). In 2003, early-season corn growth (plant dry matter, lbs/acre), when averaged across 40, 80, and 120 lb N/acre rates, was 45% greater with strip-tillage and fall-applied fertilizer than with no-till and planter-banded fertilizer. This same comparison for 2004 produced a 20% advantage, but for no-till. The differences in early-season dry matter between tillage systems and years may have been because of the extreme differences in weather, fewer differences in plant stands, and/or the moving of the planter fertilizer band in 2004 from 2x2 to 2.5x2.5 inches from the seed row for extra fertilizer safety.

Nutrient Uptake

In 2003, uptakes of nitrogen, phosphorus, potassium and sulfur averaged across all fertilizer rates, were 39, 39, 9, and 56% greater, respectively, with strip-tillage and fall-applied fertilizer than with no-till and planting-time, row-banded fertilizer. In 2004, the same treatments produced insignificant nutrient-uptake differences, with only slightly less K uptake and slightly more N-P-S uptake with no-till than with strip-tillage.

Yield

Strip-tillage alone improved corn yield 12 bu/acre, compared with no-till and no fertilizer in 2003. With strip-tillage and 40-30-5-5 lb/acre fertilizer applied at planting, strip-tillage increased yield 10 bu/acre, compared with the same fertilizer treatment for no-till. At the 80-30-5-5 lb/acre fertilizer rate in 2003, there were no statistically significant differences in yield between the tillage systems. In 2004, the fall strip-tillage system with 80-30-5-5 lb/acre fertilizer fall banded yielded more than no-till with the same fertilizer placed 2.5x2.5 at planting. The 120-30-5-5 fertilizer rate did not increase corn yields, compared with yield at the 80-30-5-5 rate, in either tillage system in either year. The fall strip-tillage system with 120-30-5-5 fertilizer banded 2x2 at planting in 2003 reduced yields, compared with the same rate of fertilizer applied with fall strip-tillage. It seems that there was increased fertilizer sensitivity from this higher rate of fertilizer banded close to the seed row in soil loosened by fall strip-tillage. The highest-yielding treatment in 2003 was fall strip-tillage, with 80-30-5-5 fertilizer applied in the fall; in 2004, the combination of fall strip-tillage plus planter-banded fertilizer (80-15-2.5-2.5 fall + 40-15-2.5-2.5 at planting) produced the highest yield. There was no evidence that performance of fall-applied fertilizer was inferior to that of spring-applied fertilizer in either year.

Conclusions

These studies show that fall strip-tillage, with accompanying fertilizer banded under the row, improved stands and increased yields, compared with no-till and planter-banded

fertilizer. Largest yield differences occurred in 2004 when growing conditions were best. More testing is needed, but fall strip-tillage with fall-banded fertilizer seems to have some advantages for rain-fed corn production in eastern Kansas. Additional studies are planned for 2005.

Table 2. Strip-tillage and no-till tillage/fertilizer comparison study for corn, Ottawa, Kansas, 2003.

Treatments **Tillage x (N-P-K-S, lb/acre)**	2003 Yield	Plant Stand	6-leaf Stage Plant Dry Matter	6-leaf Stage Nutrient Uptake N	P	K	S
	bu/a	1000/a	lb/a	- - - - - - - lb/a - - - - - - -			
Fall Strip-tillage + Fall-banded Fertilizer (5" below row)							
1. Check 0-0-0-0	78	21.1	124	4.0	0.54	2.4	0.25
2. 40-30-5-5	85	21.1	305	10.8	1.21	5.4	0.67
3. 80-30-5-5	96	21.2	335	12.8	1.37	6.0	0.72
4. 120-30-5-5	91	21.8	345	13.9	1.37	6.4	0.77
5. 80-15-2.5-2.5 fall + 40-15-2.5-2.5 at planting	89	21.1	363	14.7	1.50	10.4	0.75
Fall Strip-till + Planter-banded Fertilizer (2.0 x 2.0 from seed row)							
6. 40-30-5-5	90	21.0	423	14.1	1.70	7.7	0.81
7. 80-30-5-5	88	21.3	361	14.4	1.45	6.5	0.72
8. 120-30-5-5	78	22.2	326	13.7	1.31	6.3	0.66
No-tillage + Planter-banded Fertilizer (2.0 x 2.0 from seed row)							
9. Check 0-0-0-0	66	18.4	97	2.9	0.43	2.4	0.18
10. 40-30-5-5	80	18.8	254	9.3	1.06	6.0	0.51
11. 80-30-5-5	90	18.8	231	9.4	0.94	5.4	0.43
12 120-30-5-5	86	18.1	193	8.3	0.80	4.7	0.42
No-tillage + Pre-plant Deep-banded Fertilizer (15" Centers x 4" depth)							
13. 120-30-5-5	87	18.9	201	8.2	0.78	4.3	0.41
LSD (0.05)	9	2.4	91	3.2	0.32	2.3	0.17

2003
Fall strip-tillage and fall-banded fertilizer: 11/2/02
Pre-plant fertilizer, no-till: 3/26/03
Burn-down herbicide: 1qt/acre Atrazine 4L + 0.66pt/acre 2,4-D LVE + 1 qt/acre COC (3/31/03)
Planting date: 4/10/03; Hybrid: Pioneer 35P12
Pre-emergence herbicide: 0.33 qt/acre Atrazine 4L + 1.33 pt/acre Dual II Magnum® (4/23/03)
Harvest date: 8/28/03

Table 3. Strip-tillage and no-till tillage/fertilizer comparison study for corn, Ottawa, Kansas, 2004.

Treatments	2004 Yield	Plant Stand	6-leaf Stage Plant Dry Matter	6-leaf Stage Nutrient Uptake N	P	K	S
	bu/a	1000/a	lb/a	- - - - - - - lb/a - - - - - - -			
Fall Strip-tillage + Fall-banded Fertilizer (5" below row)							
1. Check 0-0-0-0	54	22.0	484	12.4	1.49	8.7	0.71
2. 40-30-5-5	123	22.2	599	18.7	2.11	11.5	1.08
3. 80-30-5-5	160	21.9	668	22.3	2.38	12.0	1.45
4. 120-30-5-5	161	21.7	610	20.2	2.04	11.4	1.12
5. 80-15-2.5-2.5 fall + 40-15-2.5-2.5 at planting	167	21.9	858	28.7	2.87	13.3	1.67
Fall Strip-tillage + Planter-banded Fertilizer (2.5 x 2.5 from seed row)							
6. 40-30-5-5	116	22.4	868	26.6	2.90	12.4	1.55
7. 80-30-5-5	144	22.1	884	30.6	2.98	13.2	1.61
8. 120-30-5-5	160	22.1	814	29.9	2.81	13.5	1.48
No-tillage + Planter-banded Fertilizer (2.5 x 2.5 from seed row)							
9. Check 0-0-0-0	44	20.2	373	9.8	1.22	6.8	0.63
10. 40-30-5-5	101	21.1	786	22.3	2.51	10.7	1.41
11. 80-30-5-5	133	20.3	660	23.3	2.31	10.6	1.20
12 120-30-5-5	149	21.1	765	27.3	2.44	11.7	1.39
No-tillage + Pre-plant Deep-banded Fertilizer (15" Centers x 4" depth)							
13. 120-30-5-5	163	20.1	662	23.1	2.03	9.1	1.32
LSD (0.05)	17	1.9	109	3.9	0.44	2.3	0.30

2004
Fall strip-tillage and fall-banded fertilizer: 12/2/03
Pre-plant fertilizer, no-till: 4/14/04
Burn-down herbicide: 1qt/acre Atrazine 4L + 1.0 pt/acre 2,4-D LVE + 1 qt/acre COC (3/26/04)
Planting date: 4/15/04; Hybrid: Pioneer 35P12
Pre-emergence herbicide: 0.5 qt/acre Atrazine 4L + 1.33 pt/acre Dual II Magnum® (4/17/04)
Harvest date: 9/10/04

KANSAS RIVER VALLEY EXPERIMENT FIELD

Introduction

The Kansas River Valley Experiment Field was established to study how to manage and use irrigation resources effectively for crop production in the Kansas River Valley. The Paramore Unit consists of 80 acres located 3.5 miles east of Silver Lake on US 24, then 1 mile south of Kiro, and 1.5 miles east on 17th street. The Rossville Unit consists of 80 acres located 1 mile east of Rossville or 4 miles west of Silver Lake on US 24.

Soil Description

Soils on the two fields are predominately in the Eudora series. Small areas of soils in the Sarpy, Kimo, and Wabash series also occur. The soils are well drained, except for small areas of Kimo and Wabash soils in low areas. Soil texture varies from silt loam to sandy loam, and the soils are subject to wind erosion. Most soils are deep, but texture and surface drainage vary widely.

2004 Weather Information

The frost-free season was 176 days at the Paramore Unit and 167 days at the Rossville Unit (173 days is average). The last 32° F frost in the spring was on May 3 at both fields (average is April 21). The first frost in the fall was on October 17 at the Rossville Unit and October 26 at the Paramore Unit (average is October 11). Precipitation was slightly below normal at both fields (Table 1), but precipitation during the growing season (May, June, July, and August) was above normal, distribution was ideal, and irrigation was not necessary. Only one day over 100° F was recorded (July 13) and only 20 days were 90 ° F or higher. Some sudden death syndrome was observed in soybeans, but was not as severe as in 2003. Corn yields were the highest ever recorded at the field, and soybean yields were good.

Table 1. Precipitation at the Kansas River Valley Experiment Field, inches.

Month	Rossville Unit		Paramore Unit	
	2003-2004	30-yr. Avg.	2003-2004	30-yr. avg.
October	0.83	0.95	0.67	0.95
November	0.51	0.89	0.27	1.04
December	1.59	2.42	2.33	2.46
January	0.69	3.18	0.46	3.08
February	1.90	4.88	1.67	4.45
March	4.23	5.46	4.86	5.54
April	1.81	3.67	1.42	3.59
May	4.72	3.44	3.88	3.89
June	5.98	4.64	5.51	3.81
July	6.86	2.97	5.90	3.06
August	4.55	1.90	7.02	1.93
September	0.96	1.24	0.91	1.43
Total	34.63	35.64	34.90	35.23

CORN HERBICIDE PERFORMANCE TEST

L.D. Maddux

Summary

Two studies were conducted at the Rossville Unit. Timeliness of application is a major factor in determining effective weed control. These two studies evaluated several pre-emergence and post-emergence treatments, both as stand-alone treatments and in combinations. Most treatments gave good to excellent control of large crabgrass, palmer amaranth, and common sunflower. Acceptable control of ivyleaf morningglory required a post-emergence herbicide application in most instances.

Introduction

Chemical weed control and cultivation have been used to control weeds in row crops to reduce weed competition, which can reduce yields. Results of 17 selected treatments from a weed-control test, including 34 pre-emergence and/or post-emergence herbicide treatments, are presented in this paper. The weeds evaluated in these tests were large crabgrass (lacg), palmer amaranth (paam), common sunflower (cosf), and ivyleaf morningglory (ilmg).

Procedures

Two tests were conducted on a Eudora silt loam soil previously cropped to soybeans at the Rossville Unit. Test 1 included mainly pre-emergence (PRE) treatments; Test 2 included mostly PRE + post-emergence or all post-emergence treatments. The test site had a pH of 6.9 and an organic matter content of 1.1%. Asgrow RX752RR hybrid corn was planted April 21 at 30,000 seeds/acre in 30-inch rows. Anhydrous ammonia at 150 lb N/acre was applied preplant, and 120 lb/acre of 10-34-0 fertilizer was banded at planting. Herbicides were broadcast in 15 gal water/acre, with 8003XR flat fan nozzles at 17 psi, and three replications per treatment. Pre-emergence (PRE) applications were made April 21. Early post-emergence (EP) treatments were applied May 26 to 6-leaf corn, seedling to 1-inch lacg, 1- to 3-inch paam, 1- to 6-inch cosf, and 1- to 2-inch ilmg. The post-emergence (MP) treatments were applied June 3 to 7-leaf corn, 1- to 2-inch lacg, 2- to 5-inch paam, a few 2- to 8-inch cosf, and seedling ilmg. The late post-emergence (LP) treatments were applied June 11 to 1- to 3-inch lacg, 1- to 5-inch paam, 3- to 10-inch cosf, and 1- to 3-inch ilmg. Populations of all four weed species were moderate to heavy. But weed populations were generally fairly light at post-emergence time in plots receiving a pre-emergence treatment. Plots were not cultivated. The crop-injury and weed-control ratings reported were made June 9 and June 24, respectively. The first significant rainfall after PRE herbicide application was on April 22 through 24 (0.63 inches total over the three days). The plots were not irrigated. The test was harvested September 23 with a modified John Deere 3300 plot combine.

Results

Rainfall of 0.63 inch occurred over the three days immediately after planting. Crop injury was observed from the application of various post-emergence treatments in both tests (Tables 2 and 3), but none of the injury observed was severe enough to result in yield reduction. Good to excellent control of lacg, paam, and cosf was obtained with most treatments in both tests. Control of ilmg was better this year than in years past. Soil moisture conditions were conducive to activating the soil-applied herbicides and promoted good growing conditions for good

post-emergence activity. Even though there were some large variations in yield in this test, the differences seemed due to variations in the test area, and not to treatment differences (as indicated by the large LSD of 59 bu/acre.

Table 2. Effects of pre- and post-emergence herbicides on injury, weed control, and grain yield of corn, Kansas River Valley Experiment Field, Rossville, Kansas, 2004.

Treatment	Rate	Appl Time[2]	Corn Injury[1]	Weed Control[1,3] lacg	paam	cosf	ilmg	Grain Yield
	product/a		---%---	----------------%---------------				bu/a
Untreated check		---	0	0	0	0	0	111
Bicep II Magnum	2.1 qt	PRE	0	87	96	83	78	238
Lumax	2.5 qt	PRE	0	85	96	95	85	212
Lexar	3.0 qt	PRE	0	83	95	91	85	227
Lumax + AAtrex	2.5 qt + 1.0 qt	PRE	0	90	98	99	82	237
Lexar + Princep 90	3.0 qt + 1.1 lb	PRE	0	88	99	99	88	210
Harness Xtra 5.6	2.44 qt	PRE	0	68	96	99	52	210
Epic	12.0 oz	PRE	0	80	86	81	78	197
Keystone	2.65 qt	PRE	0	72	95	85	92	137
Keystone + Hornet	2.65 qt + 3.0 oz	PRE	2	67	91	98	88	141
Keystone + Balance Pro	1.3 qt + 2.25 oz	PRE	0	78	95	93	95	184
Guardsman Max	2.0 qt	PRE	0	78	92	98	91	187
Fultime	3.35 qt	PRE	0	82	98	90	90	175
Bicep II Magnum *fb*	2.1 qt	PRE	12	99	99	99	96	215
Callisto + AAtrex	3.0 oz + 0.5 oz	EP						
Surpass *fb*	2.5 pt	PRE	0	85	99	96	98	215
Starane	0.67 pt	EP						
Surpass *fb*	+ 1.25 qt	PRE	5	93	99	99	99	138
Starane + Atrazine 90	0.67 pt + 0.83 lb	EP						
Keystone *fb*	2.65 qt	PRE	7	93	99	99	98	214
Hornet + Atrazine 90	3.0 oz + 0.83 lb	EP						
Keystone *fb*	2.65 qt	PRE	3	82	99	96	99	165
Hornet + Callisto + Atrazine	3 oz + .75 oz + .28 lb	EP						
LSD (0.05)			3	11	6	11	12	59

[1] Corn injury - 6/09/04; weed control - 6/24/04.

[2] PRE = pre-emergence; SP = spike; EP = early post-emergence. EP treatments had surfactants added (NIS, COC, UAN, and/or AMS) according to label recommendations.

[3] lacg = large crabgrass; paam = palmer amaranth; cosf = common sunflower; ilmg = ivyleaf morningglory.

Table 3. Effects of pre- and post-emergence herbicides on injury, weed control, and grain yield of corn, Kansas River Valley Experiment Field, Rossville, Kansas, 2004.

Treatment	Rate	Appl Time[2]	Corn Injury[1]	Weed Control[1,3] lacg	paam	cosf	ilmg	Grain Yield
	product/a		---%--	----------------%--------------				bu/a
Untreated check	---	---	0	0	0	0	0	99
Lumax	3.0 qt	PRE	0	85	95	88	77	245
Dual II Magnum *fb*	1.0 qt	PRE	10	99	99	99	88	233
Callisto + AAtrex	3.0 oz + 0.5 qt	EP						
Outlook *fb*	0.66 qt	PRE	0	90	99	99	85	255
Distinct	4.0 oz	EP						
Keystone LA *fb*	2.25 qt	PRE	0	82	88	99	63	223
Hornet	3.0 oz	EP						
Cinch *fb*	0.66 pt	PRE	13	95	99	99	93	239
Steadfast + Callisto + AAtrex	.76 oz + 3 oz + .5qt	EP						
Define *fb*	15 oz	PRE	5	93	99	98	78	224
Option + Distinct	1.5 oz + 2.0 oz	EP						
Harness Xtra 6L *fb*	1.0 qt	PRE	0	85	99	99	67	241
Roundup WeatherMax	21 oz	EP						
Roundup WeatherMax *fb*	21 oz	EP	0	98	99	99	90	218
Roundup WeatherMax	21 oz	LP						
BalancePro + Harness Xtra 5.6	1.0 oz + 2.0 qt	PRE	0	77	82	72	77	235
Define + BalancePro + Atrazine	16 oz + 1oz + 1.4 lb	PRE	0	87	78	83	63	231
Equip + Distinct	1.5 oz + 4.0 oz	EP	2	87	99	99	96	228
Option + Distinct	1.5 oz + 4.0 oz	EP	2	83	99	99	85	239
Option + Callisto	1.5 oz + 2.0 oz	EP	2	92	98	69	78	223
Option + Callisto + Atrazine	1.5 oz + 2 oz + .83 lb	EP	7	96	99	99	93	233
Option + Define + Atrazine	1.5 oz + 8 oz + 3 oz	EP	12	87	99	98	85	223
Define + Atrazine *fb*	8.0 oz + 1.1 lb	PRE	0	96	99	99	83	228
Option + Distinct	1.5 oz + 2.0 oz	EP						
Bicep II Magnum *fb*	2.1 qt	PRE	0	98	99	99	62	231
Touchdown Total	19 oz	EP						
Expert	3.75 qt	EP	2	96	99	99	99	219
Fultime *fb*	2.25 qt	PRE	0	92	99	99	88	255
Glyphomax XRT	24 oz	EP						
Keystone *fb*	1.75 qt	PRE	0	61	96	94	86	250
Glyphomax XRT	24 oz	EP						
Cinch ATZ *fb*	2.0 pt	PRE	0	90	99	99	90	237
Steadfast + Callisto + AAtrex	.75 oz + 2 oz + 16 oz	EP						
Cinch ATZ *fb*	2.0 pt	PRE	0	97	99	99	96	253
Steadfast + Distinct	0.75 oz + 2.0 oz	EP						
Cinch ATZ *fb*	2.0 pt	PRE	0	99	99	99	90	250
Rimsulfuron + RoundupWM	0.75 + 22 oz	EP						
Rimsulfuron + RoundupWM	0.75 + 22 oz	EP	0	99	99	99	73	248
LDS (0.05)			4	17	4	16	20	26

[1] Corn injury - 6/09/04; weed control - 6/24/04.

[2] PRE = pre-emergence; SP = spike; EP = early post-emergence; LP = late post-emergence. EP and LP treatments had surfactants added (NIS, COC, UAN, and/or AMS) according to label recommendations.

[3] lacg = large crabgrass; paam = palmer amaranth; cosf = common sunflower; ilmg = ivyleaf morningglory.

SOYBEAN HERBICIDE PERFORMANCE TEST

L.D. Maddux

Summary

This study was conducted at the Rossville Unit. Soybean injury was observed with post-emergence applications of Flexstar®, but had no significant effect on grain yield. All of the herbicide treatments gave satisfactory weed control, except for the one-pass application of Flexstar + Fusion® and Flexstar + Fusion + FirstRate®, which resulted in poor control of palmer amaranth.

Introduction

Chemical weed control and cultivation have been used to control weeds in row crops to reduce weed competition, which can reduce yields. Results of 16 selected treatments from a weed-control test, including 27 pre-emergence and/or post-emergence herbicide treatments, are presented here. The weeds evaluated in these tests were large crabgrass (lacg), palmer amaranth (paam), common sunflower (cosf), and ivyleaf morningglory (ilmg).

Procedures

This test was conducted on a Eudora silt loam soil previously cropped to corn. The test site had a pH of 6.9 and an organic matter content of 1.2%. Garst 3824 soybean was planted May 5 at 144,000 seeds/acre in 30-inch rows, and 10-34-0 fertilizer was banded at 120 lb/acre. Herbicides were broadcast in 15 gal water/acre, with 8003XR flat fan nozzles at 17 psi, and three replications per treatment. Pre-emergence (PRE) applications were made May 5. Early post-emergence (EP) treatments were applied June 11 to 4-trifoliate soybean, 1- to 2-inch lacg, 1- to 8-inch paam, 1- to 8-inch cosf, and 1- to 3-inch ilmg. The late post-emergence (LP)treatments were applied July 11 to 1- to 3-inch lacg, 1- to 5-inch paam, 1- to 5-inch cosf, and 1- to 3-inch ilmg. Populations of all four weeds were moderate to heavy. Plots were not cultivated. The injury ratings reported were made on June 24, and the weed control ratings were made August 2. The first significant rainfall after PRE herbicide application was on May 10 (1.66 inches). The plots were not irrigated and were harvested October 5 with a modified John Deere 3300 plot combine.

Results

A significant rain of 1.66 inches occurred on May 10. This was the most rainfall received in one day during May and June. Rainfall amounts and distribution were ideal during the growing season.

Significant crop injury was observed with treatments containing Flexstar, but the injuries seemed to have no effect on grain yield (Table 4).

Weed control overall was very good to excellent. The exception was the two treatments of Flexstar + Fusion, which resulted in poor control of paam. Some of the other plots, particularly the one-pass glyphosate treatments, got a little weedy late in the season, but the weeds didn't seem to influence yield. The soybean variety used in this test was discovered to be sensitive to Canopy XL® in several fields around the country. That would likely explain the somewhat lower yields where Canopy XL was applied PRE. All treatments greatly increased yield over that of the control, but few yield differences were observed between treatments. The large LSD of 15 bu/acre indicates that there was a lot of natural variability in the experimental site.

Table 4. Effects of herbicide application on injury, weed control, and grain yield of soybean, Kansas River Valley Experiment Field, Rossville, Kansas, 2004.

Treatment[1]	Rate	Appl Time[2]	Injury	Weed Control[3] lacg	paam	cosf	ilmg	Grain Yield
	product/a			---------------%--------------				bu/a
Untreated check		---	0	0	0	0	0	4
FirstRate + Valor + Pendimax	0.6 oz + 2.5 oz + 3 pt	PRE	0	91	88	98	93	38
FirstRate + Valor *fb*	0.3 oz + 1.5 oz	PRE	0	90	99	99	95	48
Glyphomax XRT	18 oz	EP						
FirstRate + Valor *fb*	0.4 oz + 2.0 oz	PRE	0	93	99	99	95	35
Glyphomax XRT	18 oz	EP						
Python + Valor *fb*	0.66 oz + 1.5 oz	PRE	0	85	99	99	93	49
Glyphomax XRT	18 oz	EP						
Glyphomax XRT	1.5 pt	EP	0	85	96	99	83	42
FirstRate *fb*	0.3 oz	PRE	0	88	96	99	93	42
Glyphomax XRT	18 oz	EP						
Pendimax + FirstRate *fb*	3.0 pt + 0.3 oz	PRE	0	98	99	99	95	41
Glyphomax XRT	18 oz	EP						
Glyphomax XRT *fb*	24 oz	EP	0	99	99	99	93	41
Glyphomax XRT	24 oz	LP						
Touchdown Total	24 oz	EP	0	92	98	99	89	46
Touchdown Total *fb*	24 oz	EP	0	99	99	99	90	37
Touchdown Total	24 oz	LP						
Roundup WeatherMax	22 oz	EP	0	87	96	99	93	46
Boundary *fb*	1.5 pt	PRE	0	80	98	99	96	36
Touchdown Total	24 oz	EP						
Boundary *fb*	1.5 pt	PRE	8	96	99	99	95	32
Flexstar + Fusion	12 oz + 10 oz	EP						
Boundary *fb*	1.5 pt	PRE	7	96	96	99	98	48
Flexstar + FirstRate	12 oz + 0.3 oz	EP						
Touchdown Total + Flexstar	24 oz + 8 oz	EP	8	95	98	99	88	33
Touchdown Total *fb*	24 oz	EP	0	99	99	99	93	34
Touchdown Total + FirstRate	24 oz + 0.3 oz	LP						
Flexstar + Fusion	16 oz + 10 oz	EP	13	80	75	99	83	27
Flexstar + Fusion + FirstRate	16 oz + 10 oz + .3 oz	EP	8	75	65	99	99	30
Canopy XL *fb*	3.5 oz	PRE	0	88	93	99	93	35
Roundup WeatherMax	22 oz	EP						
Outlook + Canopy XL *fb*	16 oz + 6 oz	PRE	0	83	96	99	98	28
Roundup WeatherMax	22 oz	EP						
Outlook + Canopy XL *fb*	12 oz + 3.0 oz	PRE	0	87	96	99	98	32
Roundup WeatherMax	22 oz	EP						
LSD (0.05)			3	15	5	19	10	15

[1] Post-emergence treatments had surfactants added (NIS, COC, UAN, and/or AMS) according to label recommendations.
[2] PRE = pre-emergence (5/5); EP = early post-emergence (6/1); LP = Late post-emergence (7/11).
[3] lacg = large crabgrass; paam = palmer amaranth; cosf = common sunflower; ilmg = ivyleaf morningglory.

EVALUATION OF TIME AND RATE OF NITROGEN APPLICATION ON STRIP-TILLED CORN FOLLOWING SOYBEANS

L.D. Maddux

Summary

A one-year study conducted on a Eudora silt loam soil in the Kansas River Valley in 2004 compared fall and spring applications of N and P on corn following soybeans. Results indicated that, although the spring-applied fertilizer resulted in heavier 6-leaf plant weights and greater N and P plant uptake, the fall-applied fertilizer actually resulted in higher grain yield, especially at the middle N rates (120 and 150 lb N/acre). Yield was maximized at the 150 lb N/acre rate. These results seem to indicate that fall application of N with strip tillage is a workable alternative when weather conditions are favorable for it.

Introduction

Strip tillage is a conservation tool that combines the advantages of a tillage operation for seed placement with greater surface residues. In addition, the strip-tillage operation can place fertilizer in an area under where the crop row will be located. Strip tillage can be done in the fall or in early spring before planting, whenever weather is favorable. The objectives of this experiment were to 1) evaluate fall versus spring application of N and P fertilizer, and 2) evaluate N rates for corn following soybeans.

Procedures

The study was conducted in 2004 on a Eudora silt loam soil, with a pH of 6.8, medium Bray #1 P test, high K test, and organic matter content of 1.9%. Anhydrous ammonia was applied with a strip tiller in the fall and spring, at rates of 0, 120, 150, and 180 lb N/acre. In addition, 80 lb/acre of 11-52-0 dry fertilizer was applied with the N. Dates of N and P application with the strip tiller were November 25 and March 12, respectively. DeKalb 60-19RR hybrid corn was planted at 30,000 seeds/acre in 30-inch rows on April 15. FieldMaster® at 1 gal/acre was applied on April 16 for weed control. Plant samples were taken at the 6-leaf stage of growth and were analyzed for N and P content. Plots were harvested on September 19, and grain yields were calculated and corrected to 15.5% moisture.

Results

Corn plant weights at the 6-leaf stage increased as N rate increased. The spring-applied N treatments resulted in heavier plant weight than the fall-applied N did. Plant uptake of N and P also increased as N rate increased. Nitrogen and phosphorus uptake was greater with spring-applied fertilizer than with fall-applied fertilizer (N uptake was significant at only the 15% level of probability). But this apparent advantage for spring-applied fertilizer did not manifest itself in grain yield, and the fall-applied fertilizer actually had the highest yield, especially at the 120 and 150 lb N/acre rates. The application of 180 lb N/acre did not significantly increase corn yield over that of the 150 lb N/acre rate. These results would tend to indicate that fall application of N and P fertilizer on corn will not require applying more N to have equivalent yields to spring-applied fertilizer. It should be kept in mind that this is only one year's results. The fall of 2004 was too wet to apply fall treatments, so this study could not be continued for the 2005 crop year. A separate study in 2004 (data not shown) also indicated that strip-tilled corn had comparable yields to those of conventional and no-till corn.

Table 5. Effect of fall and spring application of N with strip-tillage on 6-leaf plant weight, N and P uptake, and grain yield of corn, Kansas River Valley Experiment Field, 2004.

Application Time	N Rate	6-leaf Weight	N Uptake	P Uptake	Yield
	lb N/a	lb/a	lb N/a	lb P/a	bu/a
Fall	0	239	6.1	0.88	165
Fall	120	421	15.1	1.39	218
Fall	150	473	17.7	1.65	230
Fall	180	441	15.6	1.59	220
Spring	0	320	8.0	1.27	162
Spring	120	577	18.1	2.44	202
Spring	150	584	20.2	2.59	212
Spring	180	486	18.4	2.36	221
Interaction LSD (0.05)		NS	NS	NS	(10%)
Application Time Means:					
Fall		393	13.6	1.38	208
Spring		492	16.2	2.16	199
LSD (0.05)		(5.4%)	NS	0.46	6
N Rate Means:					
	0	280	7.0	1.08	163
	120	499	16.6	1.92	210
	150	529	18.9	2.12	221
	180	464	17.0	1.97	221
LSD (0.05)		142	5.0	0.65	9

TABLE OF CONTENTS

EXPERIMENT FIELD PERSONNEL

Mark M. Claassen, Agronomist-in-Charge
Lowell Stucky, Plant Science Technician II
Kevin Duerksen, Plant Science Technician I

Supporting Agencies and Companies

BASF
Covered Acres Cluster
Monsanto
Pioneer
Sorghum Partners, Inc.
Triumph Seed Co.
Syngenta

HARVEY COUNTY EXPERIMENT FIELD

Introduction

Research at the Harvey County Experiment Field deals with many aspects of dryland crop production on soils of the Central Loess Plains and Central Outwash Plains of central and south-central Kansas, and is designed to directly benefit the agricultural industry of the area. The focus is primarily on wheat, grain sorghum, and soybean, but research is also conducted on alternative crops such as corn and sunflower. Investigations include variety and hybrid performance tests, chemical weed control, reduced tillage/no-tillage systems, crop rotations, cover crops, fertilizer use, and planting practices, as well as disease and insect resistance and control.

Soil Description

The Harvey County Experiment Field consists of two tracts. The headquarters tract (North Unit), 75 acres immediately west of Hesston on Hickory St., is all Ladysmith silty clay loam with 0-1% slope. The second tract (South Unit), located 4 miles south and 2 miles west of Hesston, is composed of 142 acres of Ladysmith, Smolan, Detroit, and Irwin silty clay loams, as well as Geary and Smolan silt loams. All have 0-3% slope. Soils on the two tracts are representative of much of Harvey, Marion, McPherson, Dickinson, and Rice Counties, as well as adjacent areas. These are deep, moderately well to well-drained upland soils with high fertility and good water-holding capacity. Water run-off is slow to moderate. Permeability of the Ladysmith, Smolan, Detroit, and Irwin series is slow to very slow, whereas permeability of the Geary series is moderate.

2003-2004 Weather Information

Heavy rains in early October delayed wheat planting. Then no meaningful rainfall occurred until mid-December. Average October and November temperatures were slightly below normal, but December temperatures were above average. Wheat emerged 10 days after planting. Fall wheat development was good, despite dry conditions.

Winter precipitation was slightly above normal through February. Heavy rainfall occurred in early March. Coldest temperatures of the winter occurred during brief periods in early and late January, as well as in early February. But mean temperatures continued slightly above normal during most of January. Mean daily temperatures averaged 4 ºF below normal in February and 3 ºF above normal in March. Wheat survival was normal.

Rainfall was about 4 inches less than normal for the April-May period. Rains returned during the second week of June and interfered with harvest. April temperatures were slightly cooler than normal, but May averaged about 2 ºF above normal. No soil-borne mosaic (SBM) symptoms were observed in wheat. Powdery mildew was moderately severe on susceptible varieties during the early spring, but development of this disease was curtailed by warm, dry conditions during the first week of May. Very low levels of tan spot were present. Leaf rust mostly appeared after mid-May and did not seriously affect wheat. Flag leaves had dried up by the end of May. Dry and warm conditions persisted after heading, resulting in early desiccation of flag leaves and a shortened grain-filling period. Nevertheless, wheat yields were good, and test weights were very good.

Seasonal conditions were phenomenally favorable for row crops, especially those planted early. Rainfall patterns and soil moisture dictated later soybean and grain sorghum planting dates when these crops were not planted by mid-May. Corn planting dates were on schedule in early April and were

complemented with light rains during the first weeks that followed. Moderate rains also followed May-planted soybean and grain sorghum. A wet period in June prevented field work for more than two weeks. July rains were especially helpful to corn, but also strongly benefitted soybean and grain sorghum. Mean air temperatures were 2 to 3 °F below normal in June, and about 6ºF below normal in July and August. During these months, there were only 3 days with temperatures at or above 100 ºF. Rainfall was 2.1 to 3.7 inches more than normal in July, but 1.1 to 1.6 inches less than average in August. September temperatures averaged 1.5 ºF above normal, and monthly rainfall totals were 1.0 to 1.6 inches drier than usual. Shortage of rainfall in August and September limited the yield of June-planted row crops. A light freeze in early October killed the upper sorghum leaves and also may have negatively impacted yields.

Freezing temperatures occurred last in the spring on April 14. First frost occurred next on October 2, when temperatures dropped briefly to 32 ºF, but the next fall freeze did not occur until November 4. The frost-free season of 171 days was about 3 days longer than normal.

Table 1. Monthly precipitation totals, inches - Harvey Co. Experiment Field, Hesston, Kansas.[1]

Month	N Unit	S Unit	Normal	Month	N Unit	S Unit	Normal
	2003				2004		
October	3.63	4.53	2.94	March	5.07	5.25	2.72
November	0.15	0.09	1.87	April	1.58	1.61	2.94
December	1.18	1.37	1.12	May	2.09	2.32	5.02
				June	4.45	5.31	4.39
	2004			July	7.41	5.84	3.71
January	1.02	1.28	0.69	August	2.94	2.44	3.99
February	1.18	0.99	0.93	September	1.93	1.31	2.93
Twelve-month total					32.63	32.34	33.25
Departure from 25-year Normal at N. Unit					-0.62	-0.91	

[1] Three experiments reported here were conducted at the South Unit: *Residual Effects of Late-maturing Soybean and Sunn Hemp Summer Cover Crops and Nitrogen Rate on No-till Wheat After Grain Sorghum; Soybean for Forage;* and *Herbicides for Weed Control in Corn*. All other experiments in this report were conducted at the North Unit.

REDUCED TILLAGE AND CROP ROTATION SYSTEMS WITH WHEAT, GRAIN SORGHUM, CORN, AND SOYBEAN

M.M. Claassen

Summary

Tillage-system effects on continuous wheat, continuous grain sorghum, and annual rotations of wheat with row crops were investigated for an eighth consecutive year. As in most seasons, tillage in alternate years did not affect no-till wheat after row crops. Crop-rotation effects on wheat yield were significant. Wheat in rotation with corn, grain sorghum, and soybean averaged 68.0, 65.3, and 55.1 bu/a, whereas continuous wheat averaged 68.6 bu/a over all tillage systems. Lower wheat yields following soybean possibly were caused by injury from residual herbicide. Continuous wheat with no-till yielded 71.9 bu/a versus 67.2 and 66.6 bu/a for chisel and burn systems, respectively. Row crop yields reflected an unusually favorable weather pattern. Corn and soybean averaged 136.5 and 51.0 bu/a, respectively. Overall effects of tillage systems on row crops were not significant, but sorghum yields with no-till tended to be somewhat lower in rotation with wheat and higher in continuous sorghum. Crop rotation and planting date had a major influence on sorghum production. Sorghum after wheat averaged 151.5 bu/a, 30.8 bu/a more than continuous sorghum. May-planted sorghum produced 36.7 bu/a more than June-planted continuous sorghum.

Introduction

Crop rotations facilitate reduced-tillage practices, while enhancing control of diseases and weeds. Long-term research at Hesston has shown that winter wheat and grain sorghum can be grown successfully in an annual rotation. Although subject to greater impact from drought stress than grain sorghum, corn and soybean also are viable candidates for crop rotations in central Kansas dryland systems that conserve soil moisture. Because of their ability to germinate and grow under cooler conditions, corn and soybean can be planted earlier in the spring and harvested earlier in the fall than sorghum, thereby providing opportunity for soil moisture replenishment as well as a wider window of time within which to plant the succeeding wheat crop. This study was initiated at Hesston on Ladysmith silty clay loam to evaluate the consistency of corn and soybean production versus grain sorghum in an annual rotation with winter wheat and to compare these rotations with monoculture wheat and grain sorghum systems.

Procedures

Three tillage systems were maintained for continuous wheat, two for each row crop (corn, soybean, and grain sorghum) in annual rotation with wheat, and two for continuous grain sorghum. Each system, except no-till, included secondary tillage as needed for weed control and seedbed preparation. Wheat in rotations was planted after each row-crop harvest without prior tillage. The following procedures were used:

<u>Wheat after Corn</u>
WC-NTV = No-till after V-blade (V-blade, sweep-treader, mulch treader) for corn
WC-NTNT = No-till after No-till corn

<u>Wheat after Sorghum</u>
WG-NTV = No-till after V-blade (V-blade, sweep-treader, mulch treader) for sorghum
WG-NTNT = No-till after No-till sorghum

Wheat after Soybean
WS-NTV = No-till after V-blade (V-blade, sweep-treader, mulch treader) for soybean
WS-NTNT = No-till after No-till soybean

Continuous Wheat
WW-B = Burn (burn, disk, field cultivate)
WW-C = Chisel (chisel, disk, field cultivate)
WW-NT = No-till

Corn after Wheat
CW-V = V-blade (V-blade, sweep-treader, mulch treader)
CW-NT = No-till

Sorghum after Wheat
GW-V = V-blade (V-blade, sweep-treader, mulch treader)
GW-NT = No-till

Soybean after Wheat
SW-V = V-blade (V-blade, sweep-treader, mulch treader)
SW-NT = No-till

Continuous Sorghum
GG-C = Chisel (chisel, sweep-treader, mulch treader)
GG-NT = No-till

Continuous wheat no-till plots were sprayed with Roundup Ultra Max + 2,4-D_A + Banvel + Placement Propak (26 oz + 3 oz + 3 oz/a + 1% v/v) on July 21. Additional fallow application of Roundup Original II + ammonium sulfate (AMSU) at 1 qt + 1.7 lb/a was made on October 22. Late-season weeds and volunteer growth in row crop stubble were sprayed in mid September with Roundup Original II + AMSU (1 qt + 1.7 lb/a), alone or with 2,4-D_{LVE} 6 EC at 0.67 pt/a. Variety Overley was planted on October 23 in 8-inch rows at 90 lb/a with a CrustBuster no-till drill equipped with double disk openers. Wheat was fertilized with 121 lb N/a and 35 lb P_2O_5/a as preplant, broadcast ammonium nitrate and in-furrow diammonium phosphate at planting. No herbicides were used on wheat in any of the tillage and cropping systems. Wheat was harvested on June 25, 2004.

No-till corn after wheat plots received the same fallow herbicide treatments as WW-NT during the summer and fall, plus a late November application of AAtrex 4L + 2,4-D $_{LVE}$ 6EC + crop oil concentrate (COC) at 1.5 qt + 0.67 pt + 1 qt/a. A preplant application of Roundup Ultra Max + AMSU (26 oz + 1.6 lb/a) was made 11 days before planting. Weeds were controlled during the summer and fall fallow period in CW-V plots with two tillage operations. Two spring tillage operations were necessary for final weed control and seedbed preparation. Corn was fertilized with 101 lb/a N as ammonium nitrate broadcast before planting. An additional 14 lb/a N and 37 lb/a P_2O_5 were banded 2 inches from the row at planting. A White no-till planter with double-disk openers on 30-inch centers was used to plant Gaucho-treated Pioneer 35P12 at approximately 18,700 seeds/a on April 6, 2004. Corn plots were sprayed shortly after planting with Dual II Magnum alone at 1.67 pt/a (CW-NT), or with Dual II Magnum + Atrazine 90 DF at 1.33 pt + 0.83 lb/a (CW-V), for preemergence weed control. Row cultivation was not used. Corn was harvested on September 9.

No-till sorghum after wheat plots received the same fallow (July-March) herbicide treatments as no-till corn. In addition, Roundup Ultra Max II + Dual II Magnum (11 oz + 1.67 pt + 1.7 lb AMSU) were applied to GW-NT two days before sorghum planting. Continuous NT sorghum plots were treated with AAtrex 4L + 2,4-D $_{LVE}$ 6EC + COC (1.5 qt + 0.67 pt + 1 qt/a) in late November. GG-NT_{May} areas received a preplant application of Roundup Ultra Max II + Dual II Magnum + AMSU (22 oz + 1.33 pt + 1.7 lb/a) on May 10, followed by AAtrex 4L at 1 qt/a preemergence. GG-NT_{June} plots were treated with Roundup Ultra Max II + Dual II Magnum + AMSU (22 oz + 1.33 pt + 1.7 lb/a) on June

2 and Roundup Ultra Max II + AMSU (16 oz + 1.3 lb/a) on June 29. GW-V plots were managed like CW-V areas during the fallow period between wheat harvest and planting. Between crops, all GG_{May}-C plots were tilled once in the fall (chisel) and twice in the spring (mulch treader and sweep-treader). $GG\text{-}NT_{June}$ plots required two additional spring tillage operations because of delayed planting. Sorghum was fertilized like corn. Pioneer 8500 treated with Concep® safener and Gaucho insecticide was planted at 42,000 seeds/a in 30-inch rows on May 12, 2004. A second set of continuous sorghum plots was planted on June 29. Preemergence herbicides for sorghum in tilled plots were as follows: GW-V - Dual II Magnum at 1.33 pt/a + AAtrex 4L at 1.5 pt/a; $GG\text{-}C_{May}$ - Dual II Magnum at 1.33 pt/a + AAtrex 4L at 1 qt/a; and $GG\text{-}C_{June}$ - Dual II Magnum at 1.33 pt/a + Atrazine 90 DF at 1.1 lb/a. Sorghum was not row cultivated. May- and June-planted sorghum were harvested on September 20 and November 9, respectively.

Fallow weed control procedures in 2003 for no-till soybean after wheat were the same as for CW-NT and GW-NT, except that the late fall herbicide application consisted of Roundup Original II + 2,4-D $_{LVE}$ 6EC + AMSU (1.5 pt + 0.67 pt + 1.7 lb/a). Roundup Ultra Max II + AMSU (22 oz + 1 lb/a) controlled emerged weeds before planting. SW-V tillage treatments were the same as for GW-V. Asgrow 3302 RR soybean was planted at 7 seeds/ft in 30-inch rows on May 12. After planting, weeds were controlled in SW-V plots with Roundup Original II + AMSU (1.5 pt + 1.7 lb/a) on June 2, and in all soybean plots with Roundup Ultra Max II + AMSU (22 oz + 1.2 lb/a) on June 24. Soybean was harvested on September 20, 2004.

Results

Wheat

Crop residue cover in wheat after corn, sorghum, and soybean averaged 63, 59, and 27%, respectively (Table 2). WW-B, WW-C, and WW-NT averaged 4, 22, and 73% residue cover after planting, respectively. Most wheat emerged two weeks after planting. Wheat stands averaged 99% complete, and were not affected by tillage or cropping system. Cheat control was excellent. Plant N concentration in wheat at late boot-early heading stage was numerically highest in rotation with corn (1.99%), but differences among crop rotations and tillage systems were not significant. Wheat heading date occurred one day earlier in continuous wheat and in wheat after soybean than in wheat after corn or sorghum. Tillage system effect on heading date was not significant in continuous wheat or in wheat rotations with corn and soybean, but tended to be slightly delayed by NT in rotation with grain sorghum.

Yields were highest in continuous wheat, as well as in wheat rotated with corn and sorghum, averaging 68.6 (all treatments), 68.0, and 65.3 bu/a, respectively. No-till continuous wheat performed unusually well at 71.9 bu/a, despite the fact that foliar diseases were more severe in these plots. Wheat yields following soybean was unexpectedly low, with an average of 55.1 bu/a. Although the recropping interval exceeded the label requirements, Scepter herbicide residual from the 2003 soybean crop may have been a contributing factor, as evidenced by a wheat height reduction of three to four inches. Tillage-system effects on wheat yield were not significant in any of the row crop rotations. In continuous wheat, no-till yield was 5.3 bu/a better than with the burn treatment. Crop rotation and tillage systems effects on test weights generally were not significant.

Row Crops

Corn, sorghum, and soybean following wheat had an average of 42, 43, and 24%, respectively, crop residue cover after planting in V-blade systems (Table 3). Where these row-crops were planted NT after wheat, crop residue cover averaged 83%, with little difference among rotations. The chisel system in continuous sorghum resulted in 26% less ground cover than the V-blade system in sorghum after wheat did. Also, NT sorghum after wheat averaged 18% more ground cover than May-planted NT continuous sorghum had.

Seasonal conditions favored excellent yields in all row crops. In corn, NT reduced stands by 2,200 plants/a and grain test weight by 1.1 lb/bu, delayed silking by two days, and increased leaf nutrient level by 0.36% N. Tillage systems did not affect corn yields, however, which averaged 136.5 bu/a.

In sorghum after wheat, NT delayed bloom stage by two days and reduced sorghum yield 11.1 bu/a. In May-planted continuous sorghum, however, NT did not affect maturity, and increased sorghum yield by 9.9 bu/a. In June-planted continuous sorghum, NT delayed silking by two days, reduced the leaf nutrient content by 0.24% N, but had a slightly positive effect on yield. When all systems and planting dates were considered, the overall effect of tillage on sorghum was not significant.

Crop rotation and planting date both had large effects on grain sorghum. Following wheat in rotation, sorghum had 0.3 more heads/plant and produced 151.5 bu/a, 30.8 bu/a more than continuous sorghum produced when planted on the same date. June-planted continuous sorghum reached bloom stage 3 days earlier, had 0.8 fewer heads/plant, and yielded an average of 84 bu/a, 36.7 bu/a less, and with 3.7 lb/bu lower test weight, than May-planted continuous sorghum did.

Soybean had excellent yields, averaging 51 bu/a, and was not affected by tillage system.

Table 2. Effects of row crop rotation and tillage on wheat, Harvey County Experiment Field, Hesston, Kansas, 2004.

Crop Sequence[1]	Tillage System	Crop Residue Cover [2]	Yield[3] 2004	Yield[3] 8-Yr	Test Wt	Stand[4]	Head-ing[5]	Plant N[6]	Cheat Control[7]
		%	bu/a		lb/bu	%	date	%	----%----
Wheat-corn (No-till)	V-blade	61	68.6	56.5	58.8	99	30	1.93	100
	No-till	66	67.4	57.9	58.9	100	30	2.06	100
Wheat-sorghum (No-till)	V-blade	54	64.9	47.5	58.8	99	29	1.71	100
	No-till	63	65.8	47.1	58.7	100	30	1.79	100
Wheat-soybean (No-till)	V-blade	20	53.1	55.1	59.1	99	29	1.92	100
	No-till	34	57.2	58.5	58.7	98	29	1.84	100
Continuous wheat	Burn	4	66.6	49.6	59.2	100	29	1.85	100
	Chisel	22	67.2	47.4	59.3	98	29	1.75	98
	No-till	73	71.9	48.4	58.9	98	29	1.89	98
LSD .05		8	6.0	8.9	NS	NS	0.4	NS	NS
LSD .10		6	4.9	7.5	0.4	NS	0.4	NS	1.8
Main effect means: Crop Sequence									
Wheat-corn		63	68.0	57.2	58.8	99	30	1.99	100
Wheat-sorghum		59	65.3	47.3	58.7	100	30	1.75	100
Wheat-soybean		27	55.1	56.8	58.9	99	29	1.88	100
Continuous wheat		48	69.6	47.9	59.1	98	29	1.82	98
LSD .05		6	4.2	9.0	NS	NS	0.3	NS	1.6
Rotation Tillage System									
No-till/V-blade		45	62.2	53.0	58.9	99	29	1.85	100
No-till/no-till		54	63.5	54.5	58.8	99	30	1.90	100
LSD .05		4	NS	NS	NS	NS	0.3	NS	NS

[1] All wheat planted no-till after row crops. Crop-sequence main-effect means exclude continuous wheat-burn treatment.
Tillage main-effect means exclude all continuous wheat treatments.
[2] Crop residue cover estimated by line transect after planting.
[3] Means of four replications adjusted to 12.5% moisture.
[4] Stands evaluated in early June.
[5] Date in April on which 50% heading occurred.
[6] Whole-plant N levels at late boot to early heading.
[7] Visual rating of cheat control just before harvest.

Table 3. Effects of wheat rotation and reduced tillage on corn, grain sorghum, and soybean, Harvey County Experiment Field, Hesston, Kansas, 2004.

Crop Sequence	Tillage System	Crop Residue Cover [1]	Yield[2] 2004	Yield[2] Mult-Yr	Test Wt	Stand	Maturity[3]	Ears or Heads/ Plant	Leaf N[4]
		%	-----bu/a-----		lb/bu	1000's/a	days		%
Corn-wheat	V-blade	42	138	72.7	57.9	17.7	77	1.03	2.82
	No-till	81	135	67.9	56.8	15.5	79	1.18	3.18
LSD .05		12	NS	NS	1.0	2.2	0.9	NS	0.30
Sorghum-wheat	V-blade	43	157.1	92.1	61.8	35.7	66	1.59	2.99
	No-till	87	146.0	93.8	61.8	34.7	68	1.67	2.88
Contin. sorghum (May)	Chisel	17	115.7	74.9	61.7	36.2	67	1.31	2.76
	No-till	69	125.6	75.8	62.1	35.8	67	1.35	2.74
Contin. sorghum (June)	Chisel	---	81.4	65.1	58.4	37.0	65	1.27	2.70
	No-till	---	86.7	68.6	58.0	36.8	63	1.23	2.46
LSD .05[5]		12	13.3	16.8	0.6	1.9	1.3	0.13	0.32
Soybean-wheat	V-blade	24	51.6	27.9	---	---	---	---	---
	No-till	82	50.4	27.4	---	---	---	---	---
LSD .05		25	NS	NS	---	---	---	---	---
Main effect means for sorghum:									
Crop sequence									
Sorghum-wheat		65	151.5	93.0	61.8	35.2	67	1.63	2.93
Contin. sorghum (May)		43	120.7	75.3	61.9	36.0	67	1.33	2.75
Contin. sorghum (June)		---	84.0	66.9	58.2	36.9	64	1.25	2.58
LSD .05		8	9.4	11.9	0.4	1.3	0.9	0.09	0.23
Tillage system									
V-blade/chisel		30	118.0	77.4	60.6	36.3	66	1.39	2.81
No-till/no-till		78	119.4	79.4	60.6	35.8	66	1.41	2.69
LSD .05		8	NS	NS	NS	NS	NS	NS	NS

[1] Crop residue cover estimated by line transect after planting.

[2] Means of four replications adjusted to 15.5% moisture (corn), 12.5% moisture (sorghum), or 13% moisture (soybean).

Multiple-year averages: 1997-1999, 2001-2004 for corn and 1997-2004 for sorghum and soybean.

[3] Maturity expressed as follows: corn - days from planting to 50% silking; grain sorghum - number of days from planting to half bloom.

[4] Sorghum flag leaf at late boot to early heading.

[5] LSD's for comparisons among means for continuous-sorghum and sorghum-after-wheat treatments.

NO-TILL CROP ROTATION EFFECTS ON WHEAT, CORN, GRAIN SORGHUM, SOYBEAN, AND SUNFLOWER

M.M. Claassen and D.L. Regehr

Summary

A field experiment consisting of eleven 3-yr, no-till crop rotations was initiated in 2001 in central Kansas on Ladysmith silty clay loam. Cropping systems involving winter wheat (W), corn (C), grain sorghum (GS), double-crop grain sorghum ([GS]), soybean (SB), double-crop soybean ([SB]), and sunflower (SF) are as follows: W-C-SB, W-[SB]-C-SB, W-SB-C, W-GS-SB, W-[SB]-GS-SB, W-[GS]-GS-SB, W-GS-SF, W-[SB]-GS-SF, W-[GS]-GS-SF, GS-C-SB, and GS-GS-GS. Data collection to determine cropping-system effects commenced in 2004. Wheat after SB, C, and SF in these rotations averaged 62.3, 59.6, and 53.9 bu/a, respectively. Corn averaged 143.3 bu/a in W-C-SB and W-[SB]-C-SB, 138.2 bu/a in GS-C-SB, and 133.4 bu/a in W-SB-C rotations. Grain sorghum, limited by weather-delayed planting dates, produced the highest yields, averaging 108.2 bu/a in rotations in which grain sorghum followed wheat. Sorghum yields in the other rotations ranged from 98.6 to 102.9 bu/a, and were not significantly different. Double-crop grain sorghum yielded 78.8 bu/a, with no rotation effects. Soybean yields averaged 59.1 bu/a, with no significant differences among the seven rotations. When results were pooled over common antecedent crop, however, SB after C and W averaged 61.7 bu/a, whereas SB after GS yielded 6.8 bu/a less. Double-crop soybean averaged 13.2 bu/a, and yield was unaffected by crop rotation. Sunflower yielded 2131 lb/a, with no rotation effect.

Introduction

The number of acres devoted to no-till crop production in the United States has risen steadily over the past 10 years, most notably since 2002. In 2004, according to the Conservation Technology Information Center, no-till was used on 62.4 million acres, nearly 23% of the cropland. Kansas currently ranks seventh in the nation, with 4.2 million acres of no-till annual crops, representing 21.2% of planted acres. Soil and water conservation issues; cost of labor, fuel, and fertilizers; changes in government farm programs; development of glyphosate-tolerant crops; and lower glyphosate herbicide cost have all contributed to no-till adoption by growers. Research has shown that crop rotation reduces pest control costs, enhances yields, and contributes significantly to successful no-till crop production. Selection of appropriate crop rotations brings adequate diversity of crop types to facilitate the realization of these benefits and also provides sufficient water-use intensity to take full advantage of available moisture.

In central and south-central Kansas, long-term no-till research on multiple crop rotations is needed to determine their profitability and reliability. The experiment reported here includes 11 three-year rotations. Nine of these involve winter wheat, corn or grain sorghum, and soybean or sunflower. One rotation consists entirely of row crops. Continuous grain sorghum serves as a monoculture check treatment. Double-crop soybean and grain sorghum after wheat are used as intensifying components in five of the rotations. One complete cycle of these rotations was completed in 2003. Official data collection began in 2004.

Procedures

The experiment site was located on a Ladysmith silty clay loam where no-till soybean had been grown in year 2000. Lime was applied according to soil test recommendation and incorporated by light tillage in late fall of that year. Detailed soil sampling was done in early April of 2001, just before the establishment of the cropping systems. Average soil-test values at that time included: pH 6.2, organic matter of 2.7%, available phosphorus (P) of 46 lb/a, and exchangeable potassium of 586 lb/a.

Eleven crop rotations were selected to reflect adaptation across the region. These involved winter wheat (W), corn (C), grain sorghum (GS), double-crop grain sorghum ([GS]), soybean (SB), double-crop soybean ([SB]), and sunflower (SF) as follows: W-C-SB, W-[SB]-C-SB, W-SB-C, W-GS-SB, W-[SB]-GS-SB, W-[GS]-GS-SB, W-GS-SF, W-[SB]-GS-SF, W-[GS]-GS-SF, GS-C-SB, and GS-GS-GS. A randomized complete-block design was used, with four replications of 31 treatments representing each crop in each rotation.

Row-crop plots to be planted to wheat were sprayed with Roundup Original II + AMSU (1 qt + 1.7 lb/a) on October 23, 2003, to control volunteer-crop growth and/or late emerged weeds. Overley wheat was planted on October 24 in 8-inch rows at 90 lb/a with a CrustBuster no-till drill equipped with double disk openers. Wheat was fertilized with 121 lb N/a and 35 lb P_2O_5/a as in-furrow diammonium phosphate at planting and as broadcast ammonium nitrate on March 22. No herbicides were used on wheat in any of the cropping systems. Wheat was harvested on June 25, 2004.

Wheat plots to be planted to corn were sprayed with Roundup Ultra Max + 2,4-D_A + Banvel + Placement Propak (26 oz + 3 oz + 3 oz + 1% v/v) on July 21 and with Roundup Original II + AMSU (1.0 qt + 1.7 lb/a) on September 9, 2003. All plots to be planted to corn were treated with atrazine 90 DF + 2,4-D_{LVE} 6EC + COC (1.67 lb + 0.67 pt + 1 qt/a) on January 2, 2004. Wheat and [SB] plots to be planted to corn were sprayed with Roundup Ultra Max II + Dual II Magnum + AMSU (22 oz + 1.33 pt + 1.7 lb/a) on April 6. Soybean and sorghum plots to be planted to corn received a broadcast application of 1.33 pt/a Dual II Magnum on the same day. A White no-till planter with double-disk openers on 30-inch centers was used to plant Gaucho-treated Pioneer 35P12 at approximately 18,700 seeds/a on April 6, 2004. All corn was fertilized with14 lb/a N and 37 lb/a P_2O_5, banded 2 inches from the row at planting. Corn after wheat, [SB], or grain sorghum received 111 lb/a N, and corn after soybean received 81 lb/a N as 28-0-0 injected in a band 10 inches on either side of each row in mid-May. Corn was harvested on September 3, 2004.

Plots to be planted to grain sorghum were treated the same as corn during the preceding summer and winter, except that the January application of atrazine and 2,4-D was not made where [GS] had been grown. Former [GS] plots to be planted to grain sorghum were sprayed with Roundup Ultra Max II + Banvel + AMSU (22 oz + 2 oz + 1.7 lb/a) on April 19. All grain sorghum plots were sprayed with Roundup Ultra Max II + 2,4-D_{LVE} 6EC + AMSU (33 oz + 2 oz + 1.7 lb/a) on May 11. Weather delayed sorghum planting. A final herbicide application of Roundup Ultra Max II + atrazine 90 DF + Dual II Magnum + AMSU (22 oz + 1.1 lb + 1.33 pt + 1.7 lb/a) was made on June 24. Sorghum Partners KS 585, treated with Gaucho insecticide and Concep® safener, was planted at 41,000 seeds/a in 30-inch rows with 30-30-0 fertilizer banded 2 inches from the row on June 29. Sorghum after wheat, sorghum, [GS], or [SB] received an additional 60 lb/a of N, and sorghum after soybean received 30 lb/a of N as 28-0-0 injected in a band 10 inches on either side of each row in mid-July. Sorghum was harvested on November 9, 2004.

Double-crop grain sorghum had a preplant application of Roundup Ultra Max II + AMSU (33 oz + 1.7 lb/a) in late June. Pioneer 85G57 was planted like KS 585 on July 12. An additional 30 lb/a of N was injected on July 15. Postemergence application of atrazine 4L + COC (1.5 qt + 1 qt/a) was made with drop nozzles on August 6. Double-crop grain sorghum also was harvested on November 9.

Wheat plots to be planted to soybean were treated with Roundup applications in July and September like those for corn and sorghum. All plots to be planted to soybean were sprayed with Roundup Ultra Max II + 2,4-D_{LVE} 6EC + AMSU (33 oz + 2 oz + 1.7 lb/a) on May 11. Asgrow A3302 RR soybean was planted at 115,600 seeds/a in 30-inch rows on May 12. One subsequent Roundup Ultra Max II + AMSU (22 oz + 1.2 lb/a) application was made on June 24. Soybean was harvested on September 20.

Double-crop soybean had a preplant application of Roundup Ultra Max II + AMSU (33 oz + 1.7 lb/a) in late June. Asgrow A3302 RR soybean was planted as a double crop at 115,600 seeds/a in 30-inch rows on July 13. Double-crop soybean was sprayed with Roundup Original Max II + AMSU (17 oz + 1.7 lb/a) on August 6 and with Roundup Original Max II + AMSU (11 oz + 0.5 lb/a) on August 31. Yields of [SB] were determined on December 20, 2004.

All sunflower plots were sprayed with Roundup Ultra Max II + 2,4-D_{LVE} 6EC + AMSU (33 oz + 2 oz + 1.7 lb/a) on May 11. Triumph s675 sunflower was planted at 22,000 seeds/a, with 30-30-0 fertilizer banded 2 inches from the row, on May 21. Dual II Magnum (1.67 pt/a) was applied the next day. An additional 40 lb/a of N was injected on June 2. Sunflower was harvested on September 21.

Results

Wheat

Wheat stand establishment was excellent. Heading tended to be slightly earlier, and plant heights slightly greater, in rotations in which wheat followed soybean, in comparison with wheat following corn or sunflower (Table 4). Plant N concentration averaged 2.39%, and was not consistently related to crop rotation. Wheat yields were highest in W-[SB]-C-SB, W-SB-C, W-GS-SB, W-[SB]-GS-SB, and W-[GS]-GS-SB, ranging from 59.6 to 65.2 bu/a. In these rotations, wheat after soybean or corn averaged 62.3 and 59.6 bu/a, respectively, 8.4 and 5.7 bu/a more than wheat after sunflower. Grain test weights averaged 58.7 lb/bu, and were not affected by crop rotation. Grain protein averaged 14.7%, and tended to be greatest in association with lower yields of wheat following sunflower.

Corn

Corn emerged about 13 days after planting. Although specific data on aspects of early corn development were not collected, it was noted that emergence tended to be a little earlier in corn after soybean than after other crops. Seedling vigor and uniformity tended to be somewhat greater in corn after soybean or grain sorghum than after wheat. Final corn populations averaged 17,054 plants/a (Table 5). Corn in W-C-SB and W-[SB]-C-SB required 5 more days to reach 50% silking than corn in W-SB-C and GS-C-SB. Leaf N concentration averaged 3.23%, with no crop-rotation effect. Despite the slower start by corn in W-C-SB and W-[SB]-C-SB, yields were highest in these rotations, averaging 143.4 bu/a. In GS-C-SB, corn produced a comparable yield of 138.2 bu/a. Lowest corn yield of 133.4 bu/a occurred in W-SB-C. Test weight averaged 57.4 lb/bu, with slightly smaller values noted at the highest grain yields. The number of ears/plant ranged from 1.07 to 1.20, and was not significantly affected by crop rotation.

Grain sorghum

Grain sorghum planting was delayed by weather conditions. Emergence occurred rapidly at 5 days after planting. Final populations ranged from 31,100 to 36,800 plants/a. In 2003, [GS] had produced only 12 to 18 bu/a in W-[GS]-GS-SF and W-[GS]-GS-SB rotations. In these rotations, as well as in those in which sorghum followed [SB] or wheat, populations averaged 2,750 plants/a less than in the other rotations. Grain sorghum reached half-bloom stage about one day earlier in purely row-crop rotations versus those involving wheat. Leaf N content averaged 3.15% and was not affected by crop rotation. Highest mean yields of 108.2 bu/a occurred in rotations in which grain sorghum followed wheat. Among the remaining rotations, full-season grain sorghum yields ranged from 98.6 to 102.9 bu/a, and differences lacked statistical significance. Grain test weight was not affected by crop rotation. Number of heads/plant ranged from 1.47 to 1.85. Lowest head count occurred in the GS-C-SB. Lodging was generally minor, with a high of 8% in the GS-C-SB rotation.

Double-crop grain sorghum stands averaged 28,000 plants/a and reached half bloom in 58 days. Leaf N in [GS] averaged 3.16%. Yields averaged 78.8 bu/a, with a test weight of 54.9 lb/bu. [GS] produced 2.41heads/plant, with essentially no lodging. Crop rotations had no effect on any of variables measured in [GS].

Soybean

Soybean emerged 9 days after planting. Stands were excellent, with very minor differences among rotations (Table 6). In rotations in which soybean followed corn, plant heights averaged 33 inches, 3 inches more than in rotations in which the preceding crop was wheat or grain sorghum. In rotations with soybean after wheat or corn, however, highest yields occurred, with an average of 61.7 bu/a. Yields for soybean in rotations with a preceding grain sorghum crop were 6.8 bu/a lower. There was no lodging of consequence.

Double-crop soybean stands averaged 90%. Plant heights averaged 17 inches. Double-crop soybean averaged 13.2 bu/a. No lodging occurred. Crop rotations did not significantly affect any of the [SB] variables measured.

Sunflower

Sunflower emerged 7 days after planting. Populations averaged 14,840 plants/a. Triumph s675 short-stature sunflower reached half-bloom stage at 60 days, and had an average height of 34 inches. Yields averaged 2131 lb/a, with 23% lodging. None of these variables were affected by crop rotation.

Table 4. Effects of crop rotation on no-till wheat, Harvey County Experiment Field, Hesston, Kansas, 2004.

Crop	Crop Rotation[1]	Wheat Yield[2]	Test Wt	Stand	Head-ing[3]	Plant Ht	Plant N[4]	Grain Protein
		bu/a	lb/bu	%	date	inches	%	%
Wheat	W-C-SB	57.8	58.8	100	30	35	2.53	14.7
	W-[SB]-C-SB	65.2	58.8	100	29	36	2.20	14.4
	W-SB-C	59.6	58.6	99	31	34	2.56	14.0
	W-GS-SB	63.4	59.1	100	30	36	2.26	14.6
	W-[SB]-GS-SB	65.0	59.1	100	29	36	2.22	14.5
	W-[GS]-GS-SB	59.9	58.5	100	30	35	2.48	14.6
	W-GS-SF	51.8	58.4	100	31	34	2.59	15.2
	W-[SB]-GS-SF	56.1	58.6	99	30	34	2.34	15.1
	W-[GS]-GS-SF	53.9	58.6	100	31	33	2.37	14.8
	LSD 0.05	7.7	NS	NS	NS	2.0	NS	NS
	LSD 0.10	6.4	NS	NS	1.2	1.7	0.25	NS
	Preceding crop main effect means:							
	Corn	59.6	58.6	99	31	34	2.56	14.0
	Soybean	62.3	58.8	100	30	36	2.34	14.6
	Sunflower	53.9	58.5	100	31	34	2.43	15.0
	LSD 0.05[5]	4.5	NS	NS	0.8	1.2	NS	0.50
	LSD 0.10[5]	3.8	NS	NS	0.7	1.0	NS	0.42

[1] C = corn, GS = grain sorghum, SB = soybean, SF = sunflower, W = wheat, and [ ] = double crop.
[2] Means of four replications adjusted to 12.5% moisture.
[3] Days after March 31 on which 50% heading occurred.
[4] Whole-plant N content at late boot to early heading.
[5] Estimate based on the average number of crop sequences involving the same preceding crop = 3.0.

Table 5. Effects of crop rotation on no-till corn and grain sorghum, Harvey County Experiment Field, Hesston, Kansas, 2004.

Crop	Crop Rotation[1]	Yield[2]	Test Wt	Stand	Matur-ity[3]	Ears or Heads/ Plant	Lodg-ing	Leaf[4] N
		bu/a	lb/bu	1000/a	date		%	%
Corn	W-C-SB	142.5	56.8	17.2	79	1.12	0	3.25
	W-[SB]-C-SB	144.2	57.1	16.5	79	1.20	0	3.31
	W-SB-C	133.4	57.9	17.6	74	1.07	3	3.20
	GS-C-SB	138.2	57.6	16.9	74	1.09	0	3.16
	LSD 0.05	8.1	NS	NS	1.8	NS	NS	NS
	LSD 0.10	6.6	0.7	NS	1.4	NS	2	NS
Sorghum	W-GS-SB	107.8	59.2	34.2	62	1.58	1	3.17
	W-[SB]-GS-SB	101.9	59.4	34.8	62	1.61	6	3.21
	W-[GS]-GS-SB	98.1	59.2	31.3	62	1.69	1	3.17
	W-GS-SF	108.6	59.1	32.8	62	1.71	2	3.10
	W-[SB]-GS-SF	98.2	59.8	31.1	62	1.85	4	3.18
	W-[GS]-GS-SF	102.0	59.2	33.4	63	1.69	1	3.09
	GS-C-SB	102.9	59.5	36.8	61	1.47	8	3.23
	GS-GS-GS	98.6	59.2	34.5	61	1.60	6	3.05
[Sorghum]	W-[GS]-GS-SB	78.5	54.8	28.0	58	2.35	1	3.20
	W-[GS]-GS-SF	79.1	55.0	27.9	58	2.47	2	3.12
	LSD 0.05	9.1	1.5	2.8	0.9	0.19	NS	NS
	LSD 0.10	7.6	1.2	2.3	0.8	0.15	NS	NS
	Preceding crop main effect means:							
Sorghum	Wheat	108.2	59.2	33.5	62	1.64	1	3.13
	[Soybean]	100.1	59.6	32.9	62	1.73	5	3.19
	Soybean	102.9	59.5	36.8	61	1.47	8	3.23
	[Sorghum]	100.1	59.2	32.3	62	1.69	1	3.13
	Sorghum	98.6	59.2	34.5	61	1.60	6	3.05
	LSD 0.05[5]	NS	NS	2.6	0.8	NS	NS	NS
	LSD 0.10[5]	6.0	NS	2.1	0.7	0.14	4	NS

[1] C = corn, GS = grain sorghum, SB = soybean, SF = sunflower, W = wheat, and [ ] = double crop.
[2] Means of four replications adjusted to 15.5% moisture (corn) or 12.5% moisture (grain sorghum).
[3] Maturity expressed as follows: corn - days from planting to 50% silking; grain sorghum - number of days from planting to half bloom.
[4] N content of the ear leaf plus one in corn and of the flag leaf in sorghum.
[5] Estimate based on the average number of crop sequences involving the same preceding crop = 1.6.

Table 6. Effects of crop rotation on no-till soybean and sunflower, Harvey County Experiment Field, Hesston, Kansas, 2004.

Crop	Crop Rotation[1]	Yield[2]	Stand[3]	Plant Ht	Matur-ity[4]	Lodg-ing
		bu/a		inches	date	%
Soybean	W-C-SB	61.7	100	34	---	1
	W-[SB]-C-SB	62.1	100	33	---	1
	W-SB-C	61.2	100	30	---	0
	W-GS-SB	55.2	98	30	---	0
	W-[SB]-GS-SB	56.0	100	30	---	1
	W-[GS]-GS-SB	53.6	100	30	---	0
	GS-C-SB	62.7	100	33	---	1
	LSD 0.05	NS	1.1	3.1	---	NS
	LSD 0.10	NS	1.0	2.5	---	NS
	Preceding crop main effect means:					
	Wheat	61.2	100	30	---	0
	Corn	62.2	100	33	---	1
	Sorghum	54.9	99	30	---	0
	LSD 0.05[5]	NS	NS	1.8	---	NS
	LSD 0.10[5]	5.6	NS	1.5	---	NS
[Soybean]	W-[SB]-C-SB	11.6	91	16	---	0
	W-[SB]-GS-SB	13.3	85	16	---	0
	W-[SB]-GS-SF	14.8	96	18	---	0
	LSD 0.05	NS	NS	NS	---	NS
	LSD 0.10	NS	NS	NS	---	NS
Sunflower	W-GS-SF	2311	15.0	34	61	23
	W-[SB]-GS-SF	2098	14.0	33	60	19
	W-[GS]-GS-SF	1984	15.6	34	60	26
	LSD 0.05	NS	NS	NS	NS	NS
	LSD 0.10	NS	NS	1.0	NS	NS

[1] C = corn, GS = grain sorghum, SB = soybean, SF = sunflower, W = wheat, and [ ] = double crop.
[2] Means of four replications adjusted to 13% moisture (soybean) or 10% moisture (sunflower).
[3] Stand expressed as a percentage for soybean and as plant population in thousands per acre for sunflower.
[4] Sunflower maturity expressed as number of days from planting to half bloom.
[5] Estimate based on the average number of crop sequences involving the same preceding crop = 2.3.

RESIDUAL EFFECTS OF LATE-MATURING SOYBEAN AND SUNN HEMP SUMMER COVER CROPS AND NITROGEN RATE ON NO-TILL WHEAT AFTER GRAIN SORGHUM

M.M. Claassen

Summary

Winter wheat was grown in rotation with grain sorghum in three no-till cropping systems, two of which included either a late-maturing Roundup Ready® soybean or a sunn hemp cover crop established after wheat harvest in 2002. Nitrogen (N) fertilizer was applied for each grain crop at rates of 0, 30, 60, or 90 lb/a. Residual effects of soybean on wheat were comparable to those of sunn hemp. At low N rates, wheat grew taller in systems with cover crops than in plots where no legume had been grown. Increases in plant N attributed to cover crops ranged from 0.2% N to 0.27% N when N rates of 30 or 60 lb/a were applied. Differences in wheat N concentration among the cropping systems tended to disappear at the 90-lb/a rate. Wheat yield increases of 5 to 9 bu/a from cover crops occurred at N rates of 0 and 30 lb/a, but greater N rates resulted in no significant differences in wheat production among cropping systems. Grain test weight and protein content were not affected by cover crop, but test weights tended to decrease somewhat with increasing N rate. Protein content increased only at an N rate of 90 lb/a.

Introduction

Cover crop research at the KSU Harvey County Experiment Field in the past has focused on the use of hairy vetch as a winter crop following wheat in a winter wheat-grain sorghum rotation. Results of long-term experiments showed that, between September and May, hairy vetch can produce a large amount of dry matter with an N content on the order of 100 lb/a. But significant disadvantages also exist in the use of hairy vetch as a cover crop. These include the cost and availability of seed, interference with the control of volunteer wheat and winter annual weeds, and the possibility of hairy vetch becoming a weed in wheat after sorghum.

In 2002, an existing experiment was modified to include late-maturing soybean and sunn hemp, a tropical legume, in lieu of hairy vetch. These summer cover crops were grown from early July through mid-October, following wheat harvest, and produced an average of 3.91 and 3.52 ton/a, respectively, of above-ground dry matter. Corresponding N yields of 146 and119 lb/a were potentially available to the succeeding grain sorghum crop. It was subsequently observed that, when averaged across N fertilizer rates, soybean and sunn hemp significantly increased sorghum leaf nutrient content, by 0.24% N and 0.29% N, respectively. Sunn hemp increased grain sorghum yields by 10.6 bu/a, whereas soybean did not significantly benefit sorghum under existing conditions. In 2004, the residual effects of these cover crops, as well as fertilizer N rate, were determined in no-till winter wheat planted shortly after sorghum harvest.

Procedures

The experiment was established on a Geary silt loam site that had been used for hairy vetch cover-crop research in a wheat-sorghum rotation from 1995 to 2001. In keeping with the previous experimental design, soybean and sunn hemp were assigned to plots where vetch had been grown, and the remaining plots retained the no-cover crop treatment. The existing factorial arrangement of N rates on each cropping system also was retained.

After wheat harvest in 2002, weeds were controlled with Roundup Ultra Max herbicide. Hartz H8001 Roundup Ready® soybean and sunn hemp seed were treated with respective rhizobium inoculants and no-till planted in 8-inch rows with a CrustBuster stubble drill on July 5, at 59 lb/a and 10 lb/a, respectively. Sunn hemp began flowering in late September and was terminated at that time by a combination of rolling with a roller harrow and applying 26 oz/a of Roundup Ultra Max. Soybean was rolled after initial frost in mid October. Forage yield of each cover crop was determined by harvesting a 3.28-ft^2 area in each plot just before termination. Samples were subsequently analyzed for N content.

Weeds were controlled during the fallow period and row-crop season with Roundup Ultra Max, atrazine, and Dual II Magnum. Pioneer 8505 grain sorghum treated with Concep® safener and Gaucho insecticide was planted at approximately 42,000 seeds/a on June 12, 2003.

All plots received 37 lb/a of P_2O_5 banded as 0-46-0 at sorghum planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected at 10 inches from the row on July 9. Grain sorghum was combine harvested on October 24, 2003. Nitrogen rates were reapplied as broadcast 34-0-0 on October 28, 2003. Jagger winter wheat was then no-till planted at 90 lb/a, with 35 lb/a P_2O_5 fertilizer banded as 0-46-0 in the furrow. Wheat was harvested on June 24, 2004.

Results

Early summer rains were sufficient to facilitate good stand establishment by soybean and sunn hemp cover crops. Despite below-normal July and August rainfall in 2002, both crops developed well. Late-maturing soybean reached an average height of 35 inches, showed limited pod development, and produced 3.91 ton/a of above-ground dry matter, with an N content of 1.86% or 146 lb/a (Table 7). Sunn hemp averaged 82 inches in height and produced 3.52 ton/a of dry matter, with 1.71% (119 lb/a) of N. It was noted, however, that sunn hemp roots had little or no nodulation, evidence that the inoculant was ineffective. Soybean and sunn hemp effectively suppressed volunteer wheat, and reduced the density of henbit in the fall, in comparison with areas having no cover crop.

Grain sorghum planted in mid-June suffered extreme drouth stress during the summer of 2003. Cover crops shortened the period from sorghum planting to half bloom by an average of two days, and increased leaf N concentration across N rates by 0.24% to 0.29% N. Sunn hemp increased grain sorghum yields by 10.6 bu/a, whereas soybean did not significantly benefit sorghum under existing conditions.

Winter wheat responded to prior cover crops with increases in plant heights on the order of 2 to 3 inches at zero fertilizer N. This effect diminished or disappeared at N rates of 60 or 90 lb/a. When averaged over fertilizer rates, an increase of 0.12% plant N in wheat at early heading was noted as a positive residual effect of both cover crops. At N rates of 30 and 60 lb/a, the increases in plant N attributed to cover crops were larger, ranging from 0.2% N to 0.27% N. Differences in wheat N concentration among the cropping systems tended to disappear only at the N rate of 90 lb/a. The main effect of cover crops on wheat yield was significant, with increases of 4 bu/a from soybean and 2.3 bu/a from sunn hemp. This was attributable to yield increases of 5 to 9 bu/a from cover crops at N rates of 0 and 30 lb/a. Greater N rates resulted in no significant differences in wheat yield among cropping systems. Grain test weight was not significantly affected by cover crops, but tended to decrease with increasing fertilizer N as a dilution effect associated with higher grain yields. Grain protein also was not significantly affected by prior cover crops. A 1.4% increase in grain protein occurred only at the N rate of 90 lb/a.

Table 7. Residual effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till wheat after grain sorghum, Harvey County Experiment Field, Hesston, Kansas, 2004.

Cover Crop	N Rate[2]	Cover Crop Yield[3] Forage	Cover Crop Yield[3] N	Sorghum Yield 2003	Wheat Yield	Wheat Bushel Wt	Wheat Plant Ht	Wheat Plant N[4]	Wheat Grain Protein
	lb/a	ton/a	lb/a	bu/a	bu/a	lb	in.	%	%
None	0	----	----	49.2	11.4	58.9	22	1.25	12.1
	30	----	----	48.2	31.1	59.1	29	1.27	11.7
	60	----	----	48.8	43.7	58.6	30	1.66	12.1
	90	----	----	45.8	48.9	58.4	32	2.26	13.2
Soybean	0	3.54	130	47.9	20.5	59.4	25	1.36	12.1
	30	3.99	133	48.3	38.5	58.7	31	1.47	11.7
	60	3.88	152	56.2	46.2	58.2	31	1.93	12.6
	90	4.23	170	50.7	45.9	57.5	32	2.19	13.9
Sunn hemp	0	3.93	128	58.8	18.3	59.4	24	1.32	12.2
	30	3.44	122	53.0	36.3	58.5	30	1.48	11.8
	60	3.28	111	59.9	42.1	58.4	32	1.91	12.0
	90	3.42	114	62.6	47.6	57.7	32	2.18	13.5
LSD .05		NS	38	10.0	4.4	0.64	1.9	0.18	0.63
Means:									
Cover Crop									
None									
Soybean		----	----	48.0	33.8	58.7	28	1.61	12.3
Sunn hemp		3.91	146	50.8	37.8	58.5	30	1.73	12.6
LSD .05		3.52	119	58.6	36.1	58.5	29	1.72	12.4
		NS	19	5.0	2.2	NS	0.9	0.09	NS
N Rate									
0		3.74	129	51.9	16.7	59.2	23	1.31	12.1
30		3.72	128	49.9	35.3	58.8	30	1.40	11.7
60		3.58	132	55.0	44.0	58.4	31	1.83	12.2
90		3.82	142	53.0	47.5	57.9	32	2.21	13.5
LSD .05		NS	NS	NS	2.5	0.37	1.1	0.10	0.36

[1] Cover crops planted on July 5, 2002, and terminated in mid October.
[2] N applied as 28-0-0 injected July 9, 2003, for sorghum and 34-0-0 broadcast on October 28, 2003, for wheat.
[3] Oven-dry weight and N content on October 16, 2002.
[4] Whole-plant N concentration at early heading.
[5] Protein calculated as %N x 5.7.

PLANTING DATE, HYBRID MATURITY, AND PLANT POPULATION EFFECTS IN NO-TILL CORN

M.M. Claassen and D.L. Fjell

Summary

Three Pioneer corn hybrids, 38H67, 35P12, and 33B51, representing 97-, 105-, and 111-day maturities, were planted in a soybean rotation under no-till conditions on March 18, April 2, and April 15, with final populations of 14,000, 18,000, and 22,000 plants/a. The growing season was unusually favorable for corn production. All treatment factors significantly affected corn. Planting date had the largest effect on length of time to reach half-silk stage. March 18 and April 2 planting dates delayed silking by 21 and 9 days, respectively, versus April 15 planting. Corn yields averaged 132 bu/a when planted in April, but declined by 9% with the March 18 planting. Hybrid 38H67 produced an average of 118 bu/a, whereas the later-maturing 35P12 and 33B51 had 6 and 19% larger yields, respectively. Yields increased with plant population, averaging 9 and 16% more at 18,000 and 22,000 plants/a, respectively, than at 14,000. Highest yield of 164 bu/a occurred with the latest planting date, latest maturing hybrid, and largest plant population. Treatment effects on grain test weight were minor. Number of ears/plant was 11% larger in corn planted on April 2, versus the other planting dates. Ears/plant declined with increasing hybrid maturity and increasing plant population.

Introduction

In central and south-central Kansas, dryland corn often does not perform as well as grain sorghum under existing seasonal weather conditions, which usually involve some degree of drought. Nevertheless, corn is preferred as a rotational crop by some producers because earlier growth termination and harvest facilitate the planting of double-crop no-till wheat in rotations. Genetic gains in corn drought tolerance, as well as no-till planting practices that conserve soil moisture, have encouraged producer interest in growing corn despite an increased risk of crop failure.

Planting date, hybrid maturity, and plant population all have a major effect on dryland corn production. Recent research at this location indicated that the highest dryland yields occurred at plant populations of 14,000 or 18,000 plants/a. This experiment was initiated in 2004 to determine if drought effects on no-till corn can be minimized by early planting dates, use of hybrids ranging in maturity from 97 to 111 days, and plant populations of 14,000 to 22,000.

Procedures

The experiment was conducted on a Ladysmith silty clay loam site that had been cropped to no-till soybean in 2003. Corn was fertilized with 95 lb/a of N and 37 lb/a of P_2O_5, as 18-46-0 banded close to the row before planting and as 28-0-0 injected in a band 10 inches on either side of each row in mid-May. The experiment design was a split-plot, with planting-date main plots and with subplots that were factorial combinations of three hybrids and three plant populations in four replications. Pioneer 38H67, Pioneer 35P12, and Pioneer 33B51, representing maturities of 97, 105, and 111 days to black layer, respectively, were no-till planted at approximately 26,000 seeds/a into moist soil on March 18, April 2, and April 15. Weeds were controlled with a March 11 application of 1.67 lb/a atrazine 90 DF + 26 oz/a Roundup Ultra Max + 1.7 lb/a ammonium sulfate (AMS), followed by 1.33 pt/a Dual II Magnum broadcast two weeks later. Corn was hand thinned to specified populations of 14,000, 18,000, and 22,000 plants/a.

Evaluations included maturity, plant height, lodging, ear number, yield and grain test weight. Plots planted March 18 and April 2 were combine harvested on September 2 and plots planted April 15 were harvested on September 9.

Results

Rainfall totaled 1.03, 0.38, and 0.89 inch during the first 10 days after the respective planting dates. Corresponding intervals from planting to emergence were 16, 14, and 9 days. Plant populations before hand thinning indicated that field emergence was nearly 100%. On April 11, corn planted on March 18 was impacted by 6 hours of freezing temperatures reaching a low of 28 °F. Corn leaves were lost, but few seedlings died as a result. Cooler-than-normal summer temperatures and abundant July rainfall resulted in minimal moisture stress. There were no significant pest problems.

Length of time to reach half-silk stage increased with early planting, hybrid maturity, and, to a lesser extent, with larger plant populations. March 18 and April 2 planting dates delayed silking by 21 and 9 days versus April 15 planting (Table 8). Hybrid differences in silking date ranged from 2 to 5 days. Plant populations of 18,000 and 22,000 plants/a had an average delay in silking of one day, in comparison with the 14,000 population.

Corn yields were significantly affected by planting date, hybrid, and plant population. All two-way interactions between these variables also were significant. Corn yielded an average of 120, 130, and 134 bu/a when planted on March 18, April 2, and April 15, respectively. Average yields for 38H67, 35P12, and 33B51 were 118, 125, and 140 bu/a, respectively. Plant populations of 14,000, 18,000, and 22,000 plants/a produced average yields of 118, 129, and 137 bu/a, respectively. Hybrids 35P12 and 33B51 produced maximum yields when planted on April 15, whereas 38H67 performed best when planted on either of the April dates. The positive effect of larger plant populations was greater at later planting dates. Highest yield of 164 bu/a occurred with 33B51 planted on April 15 with a population of 22,000 plants/a.

Test weights averaged 58.5 lb/bu. The treatment main effects on test weight were significant, but these differences were relatively minor and not consequential. Number of ears/plant was larger (1.34) with the April 2 planting than with the other planting dates, decreased with increasing hybrid maturity, and also declined with increasing plant population. Plant heights increased by 4 to 13 inches with the later planting dates, increased by 5 to 8 inches with later-maturing hybrids, and tended to decrease slightly with the largest plant population. Lodging was essentially zero.

Table 8. Dryland corn hybrid response to planting date and plant populations, Harvey County Experiment Field, Hesston, Kansas, 2004.

Planting Date	Hybrid[1]	Plant Population	Yield[2]	Moisture	Bu Wt	Ears/ Plant	Days to Silk[3]	Plant Ht	Lodging
		no./a	bu/a	%	lb/bu			inches	%
March 18	38H67	14,000	100	12.4	58.5	1.56	86	69	1
		18,000	110	12.7	59.1	1.29	86	68	0
		22,000	112	12.5	59.1	1.16	87	66	0
	35P12	14,000	108	13.1	58.6	1.41	89	72	1
		18,000	121	13.1	58.7	1.09	89	72	0
		22,000	127	13.2	58.5	1.04	90	71	0
	33B51	14,000	121	15.0	58.9	1.34	90	74	0
		18,000	135	14.7	58.9	1.12	91	73	0
		22,000	142	15.3	58.7	1.03	92	72	0
April 2	38H67	14,000	127	12.6	58.1	2.04	74	71	0
		18,000	119	12.6	58.0	1.58	74	70	1
		22,000	130	12.6	58.3	1.29	74	70	0
	35P12	14,000	111	13.0	58.4	1.54	76	77	0
		18,000	127	13.0	58.7	1.15	76	77	0
		22,000	137	13.3	58.1	1.05	77	75	0
	33B51	14,000	134	14.3	58.6	1.30	78	81	1
		18,000	141	14.6	58.5	1.08	80	80	0
		22,000	146	15.1	58.3	1.00	80	78	0
April 15	38H67	14,000	112	12.5	58.0	1.73	65	79	0
		18,000	124	12.9	58.2	1.34	65	78	1
		22,000	132	12.6	57.3	1.13	66	79	1
	35P12	14,000	117	13.1	58.6	1.36	68	83	1
		18,000	137	13.4	58.6	1.10	69	86	1
		22,000	144	13.0	58.1	1.02	69	86	0
	33B51	14,000	129	14.7	58.8	1.11	71	88	0
		18,000	150	15.0	59.0	1.01	71	89	0
		22,000	164	15.1	58.6	1.01	72	88	0
LSD .05 Means in same DOP[4]			8.5	0.85	0.66	0.09	0.9	2	NS
Means in different DOP[4]			10.5	0.94	0.68	0.09	1.0	3	NS
DOP*Hybrid[4,5]			0.004	NS	0.003	0.0001	0.0001	0.0001	NS
DOP*Population[4,6]			0.001	NS	NS	0.0001	NS	0.02	NS
Hybrid*Population[7]			0.002	NS	NS	0.0001	NS	0.10	NS

(cont. next page)

Table 8 (cont.). Dryland corn hybrid response to planting date and plant populations, Harvey County Experiment Field, Hesston, Kansas, 2004.

Planting Date	Hybrid[1]	Plant Population	Yield[2]	Moisture	Bu Wt	Ears/ Plant	Days to Silk[3]	Plant Ht	Lodging
		no./a	bu/a	%	lb/bu			inches	%
	Main effect means:								
	Planting Date								
	March 18		120	13.5	58.8	1.22	89	71	0
	April 2		130	13.4	58.3	1.34	77	75	0
	April 15		134	13.6	58.4	1.20	68	84	0
	LSD 0.05		6.8	NS	0.30	0.04	0.5	2	NS
	Hybrid								
	38H67		118	12.6	58.3	1.46	75	72	0
	35P12		125	13.1	58.5	1.19	78	77	0
	33B51		140	14.9	58.7	1.11	80	80	0
	LSD 0.05		2.8	0.28	0.22	0.03	0.3	1	NS
	Plant Population								
	14,000		118	13.4	58.5	1.49	77	77	0
	18,000		129	13.5	58.6	1.20	78	77	0
	22,000		137	13.6	58.3	1.08	78	76	0
	LSD .05		2.8	NS	0.22	0.03	0.3	NS	NS

[1] Pioneer brand.
[2] Average of 4 replications adjusted to 56 lb/bu and 15.5% moisture.
[3] Days from planting to 50% silking.
[4] DOP = Date of planting.
[5] Probability of planting-date effect differing with hybrid; NS = not significant.
[6] Probability of planting-date effect differing with plant population; NS = not significant.
[7] Probability of hybrid effect differing with plant population.

SOYBEAN FOR FORAGE

M.M. Claassen

Summary

Four grain-type soybean varieties from maturity groups III to VII and seven forage-type varieties from maturity groups V to VII were grown to evaluate their utility for forage production. Soybean was planted in late June after a weather delay. Subsequent favorable conditions resulted in dry matter yields that exceeded those of 2003 by approximately 0.7 ton/a.

Forage soybean reached a maximum of 48 inches, and averaged 9 inches taller than grain-type soybean in the same maturity groups. Variety XB 32 produced the highest yield, with 2.59 tons/a of dry matter. Other varieties in the top yield group were Donegal, Tyrone, 97 VA 5, and 7P116, with dry matter yields of 2.28 to 2.50 tons/a, respectively. As a group, forage varieties produced 0.59 tons/a more dry matter than the grain-type varieties did. With the exception of Laredo, all forage varieties, as well as late-maturing grain varieties, had the highest total N yields, from 101 to 116 lb/a.

Introduction

Soybean represents a potentially valuable alternative crop for growers in central and south-central Kansas. It can provide helpful broadleaf and legume diversity to adapted crop rotations that typically emphasize wheat and grain sorghum. Such diversity aids in the disruption of pest cycles. Particularly attractive is the ease with which wheat can be no-till planted into soybean stubble after late-summer or early-fall harvest. But the economics of soybean production can be difficult in a full-season or double-crop setting when summer drought stress results in low yield and poor grain quality. Little attention has been given to the potential for soybean as a forage crop in this area of the state. This investigation was initiated in 2003 to determine the forage-production characteristics of several grain-type and forage-type soybean.

Procedures

The experiment site was located on Ladysmith silty clay loam and had been cropped to wheat in 2003. Four grain-type soybean varieties from maturity groups III to VII and seven forage-type soybean varieties from maturity groups V to VII were no-till planted in four, 30-inch rows per plot on June 26, 2004, at 137,000 seeds/a. Several new experimental varieties were included: XB 32, 7P116, and 97 VA 5 were obtained via the USDA forage soybean breeding program at Beltsville, Maryland. Weeds were controlled with a mid-April application of 22 oz/a Roundup Ultra Max II + 0.67 pt/a 2,4-D $_{LVE}$ 6EC + 0.6 oz/a Banvel + 1 qt/a Boundary, plus 1 qt/a COC + 1.7 lb/a AMSU followed by limited hand weeding after crop establishment. Soybean emerged 5 days after planting. To determine forage yield, subplot areas were hand harvested at a height of three inches above the soil surface when the most mature pods were approximately 1 to 1.5 inches long. Actual harvest dates were August 24 (Iowa 3010 and KS 4702 sp) and September 17 (all remaining varieties).

Results

Final stands ranged from 78,400 to 126,300 plants per acre and differed significantly among varieties (Table 9), but variation in stands did not affect forage yield beyond the effect attributed to varieties. Plant heights ranged from 23 inches for Iowa 3010 to 48 inches for variety 97 VA 5. Notably, grain-type varieties in maturity groups V through VII averaged nine inches shorter than

forage varieties in the same maturity range. XB 32 had the highest yield, with 2.59 tons/a of dry matter. Other varieties in the top yield group were Donegal, Tyrone, 97 VA 5, and 7P116, with dry matter yields of 2.28 to 2.50 tons/a. As a group, the forage varieties produced 0.59 tons/a more dry matter than the grain-type varieties did. Moisture content of Iowa 3010 and KS 4702 sp was 7% greater than for the other varieties, which averaged 70%. Forage N concentrations were similar among all varieties except Iowa 3010 and KS4702 sp, which had an average of 1% more N. This was attributable to a lower forage yield and somewhat greater pod development by these two varieties. Iowa 3010, KS4702 sp, and Laredo had lowest total N yields, from 79 to 88 lb/a. The other varieties had N yields of 101 to 116 lb/a. Laredo and XB 32 had 5% lodging; the other varieties had none.

Table 9. Soybean variety forage production, Harvey County Experiment Field, Hesston, Kansas, 2004.

					Forage				
					Yield[2]				
Brand	Variety[1]	Maturity Group	Plant Popula-tion	Plant Ht	2004	2003	Mois-ture	--------	
			1000's	Inch	-------ton/a-------		%	%	lb/a
Public	Iowa 3010	III	78.4	23	1.10	1.01	77	3.59	79
Public	KS 4702 sp	IV	68.2	26	1.40	1.34	77	3.17	88
Public	Hutcheson	V	94.4	36	2.02	1.30	70	2.57	104
Hartz	H7242 RR	VII	110.4	38	2.26	1.27	70	2.28	102
Public	Derry	VI	90.0	42	1.99	1.25	70	2.53	100
Public	Donegal	V	103.1	45	2.50	1.43	70	2.32	116
Public	Laredo	---	101.6	44	1.87	1.29	67	2.37	88
Public	Tyrone	VII	103.1	47	2.43	1.30	71	2.32	113
Public	XB 32	V	124.9	47	2.59	----	68	2.03	105
Public	7P116	VI	122.0	46	2.28	----	70	2.45	111
Public	97 VA 5	VII	126.3	48	2.39	----	70	2.12	101
LSD .05			21.1	2.5	0.38	NS	1.2	0.20	16
LSD .10			17.5	2.1	0.32	0.20	1.0	0.17	14
Main effect means for soybean type:									
Grain			87.8	31	1.70	1.23	74	2.90	93
Forage			110.1	45	2.29	1.32	69	2.30	105
LSD .05			12.1	2.8	0.26	NS	1.5	0.23	9
LSD .10			10.1	2.4	0.22	NS	1.3	0.19	7

[1] Derry, Donegal, Laredo, Tyrone, XB 32, 7P116, and 97 VA 5 are forage soybean.
[2] Dry matter yield.

INSECTICIDE SEED TREATMENT RATE EFFECTS ON NO-TILL CORN

M.M. Claassen and G.E. Wilde

Summary

The effects of Cruiser and Poncho seed treatments at multiple rates were evaluated on NK N67-T4 corn no-till planted on a site cropped to wheat in 2003. Apparent insect activity was limited to a sparse population of chinch bugs. Seedling vigor scores and plant populations were excellent. Favorable weather resulted in outstanding corn yields, averaging 164 bu/a. Seed treatments had no effect on seedling vigor, stands, maturity, lodging, dropped ears, yield, or grain test weight.

Introduction

Wireworms, flea beetles, and chinch bugs are insects that may affect stand establishment or development of corn. Limited information is available concerning the response of these crops to insecticide seed treatment in the presence of small numbers of these pests. Previous work with Cruiser and Gaucho on corn at Hesston showed that yields increased with the use of insecticide seed treatments under these conditions in some years. Corn yield response ranged from 0 to 24 bu/a over a three-year period and varied with hybrid. A greater benefit was observed in corn following wheat than in corn after grain sorghum or soybean. The experiment reported here was established in 2004 to determine the relative efficacy of different rates of Cruiser and Poncho seed treatments on insects in corn, as well as to assess the impacts these pests may have on yields.

Procedures

The experiment was conducted on a Ladysmith silty clay loam soil. Wheat was grown on the site in 2003. Corn was fertilized with 125 lb N/a and 37 lb P_2O_5/a. Hybrid NK N67-T4 was planted in four replications on April 6, 2004, in 30-inch rows at 20,800 seeds/a. Weeds were controlled with an early preplant application of Roundup Ultra Max + Banvel + AMSU (26 oz + 2 oz + 2.6 lb/a) in late March and an application of atrazine 90 DF + Dual II Magnum + COC (1.1 lb + 1.33 pt + 1 qt/a) just after planting. Seedling vigor ratings were obtained at 23 days after planting. Plant population counts were made in early May and early June. Corn was combine harvested on September 14.

Results

Corn was planted into moist and somewhat sticky soil. Light rains during the first two weeks after planting totaled 0.42 inches. Corn emerged 13 days after planting. A few chinch bugs were seen in the area, but no quantitative evaluation was made. Seedling vigor was excellent and showed no differences among treatments (Table 10). Plant populations averaged from 94% to 104% of the 20,000 plant/a target and were not affected by seed treatments.

Summer conditions were much better than usual for corn production. Rainfall in July was particularly beneficial, and temperatures were moderate when subsequent moisture was limiting. Corn uniformly reached the half-silk stage at 78 days after planting, with no treatment effect.

Harvest conditions were excellent. There was essentially no lodging. Corn yields were at a record high level for this location. Insecticide seed treatments did not affect the number of dropped ears, grain yield, moisture, or test weight.

Table10. Insecticide seed treatment effects on corn, Harvey County Experiment Field, Hesston, Kansas, 2004.

Seed Treatment	Rate[1]	Yield[2]	Bu Wt	Plant Vigor[3]	Stand[4]	Days to Silk[5]	Lodging
	ai/unit seed	bu/a	lb/bu	score	%		%
1 Maxim XL	2.5 g/100 kg	168	57	1	104	78	1
2 Maxim XL	3.5 g/100 kg	169	57	1	103	78	0
Cruiser FS	0.125 mg/seed						
3 Maxim XL	3.5 g/100 kg	164	57	1	100	78	0
Cruiser FS	0.1875 mg/seed						
4 Maxim XL	3.5 g/100 kg	163	57	1	98	78	0
Cruiser FS	0.25 mg/seed						
5 Maxim XL	3.5 g/100 kg	162	57	1	94	78	0
Cruiser FS	1.25 mg/seed						
6 Maxim XL	3.5 g/100 kg	163	57	1	98	78	1
Poncho SC	0.25 mg/seed						
7 Maxim XL	3.5 g/100 kg	162	57	1	100	78	0
Poncho SC	1.25 mg/seed						
LSD .05		NS	NS	NS	NS	NS	NS

[1] Recommended label rates: Maxim at 2.5 to 3.5 grams active ingredient per 100 kg of seed; Cruiser at 0.125 milligram active ingredient per seed for most soil insects and 1.25 milligram active ingredient per seed for corn rootworm; and Poncho at 0.25 milligram active ingredient per seed for most soil insects and 1.25 milligram active ingredient per seed for corn rootworm.
[2] Average of 4 replications adjusted to 56 lb/bu and 15.5% moisture.
[3] Vigor score on April 29: 1 = good; 5 = poor.
[4] Percentage of 20,000 target plant population on June 4.
[5] Days from planting to 50% silking.

HERBICIDES FOR WEED CONTROL IN CORN

M.M. Claassen

Summary

Fourteen herbicide treatments were evaluated for crop tolerance and weed control efficacy in corn. Weed competition consisted of dense large crabgrass populations, moderate domestic sunflower populations, and light stands of Palmer amaranth. Large crabgrass control initially was excellent with all treatments, but by early July the control declined somewhat with Bullet and Guardsman Max. Palmer amaranth control was complete with all treatments throughout the evaluation period. Sunflower control was perfect with all treatments involving Lumax, Lexar, Callisto, or Keystone plus Hornet. Bicep II Magnum, Epic, or Keystone plus Balance Pro also provided very good control, whereas Bullet, Harness Extra, Guardsman Max, and Keystone (alone) were somewhat less effective on sunflower.

Corn stands were not affected by herbicide treatments and showed no injury symptoms of consequence. All herbicide treatments significantly increased corn yields, by an average of 64 bu/a in comparison with the untreated check. Yield differences among herbicide treatments were not significant.

Introduction

In recent years, Callisto (mesotrione) has been one of the newer herbicides to join the arsenal available to corn growers. Premix options with Callisto include Lumax and Lexar. Lumax contains 2.68 lb S-metolachlor (Dual II Magnum) + 1 lb atrazine + 0.268 lb mesotrione/gal. Lexar has 1.74 lb S-metolachlor + 1.74 lb atrazine + 0.224 lb mesotrione/gal. This experiment evaluated weed control with Callisto-based preemergence treatments for broad-spectrum weed control in comparison with competitive products. These treatments were also compared with postemergence Callisto + atrazine following preemergence Bicep II Magnum.

Procedures

Winter wheat was grown on the experiment site in 2002. Soil was a Geary silt loam with pH 6.3 and 2.0% organic matter. A reduced tillage system with v-blade, sweep-treader, and field cultivator was used to control weeds and prepare the seedbed. Corn was fertilized with 125 lb N and 37 lb P_2O_5/a. Palmer amaranth and large crabgrass seed was broadcast over the area to enhance the uniformity of weed populations. Also, domestic sunflower was planted in 30-inch rows across all plots. Pioneer 35P12 with Gaucho insecticide seed treatment was planted at approximately 18,700 seeds/a in 30-inch rows on April 16, 2004. Seedbed condition was good. All herbicides were broadcast in 15 gal/a of water, with three replications per treatment (Table 11). Preemergence (PRE) applications were made shortly after planting with AI TeeJet 110025-VS nozzles at 30 psi. A postemergence (POST) treatment was applied with Greenleaf TurboDrop TDXL025 venturies, in combination with Turbo Tee 11005 nozzles, at 30 psi on May 19. This treatment was applied to 2- to 5-inch domestic sunflower and 0.5- to 2-inch large crabgrass in 11-inch corn. Plots were not cultivated. Crop injury and weed control were rated several times during the growing season. Corn was harvested on September 13, 2004.

Results

Light rains totaling 0.20 inch fell within four days after planting. Additional rainfall of 0.32, 0.41, and 0.24 inches occurred at 7, 8,

and 14 days after planting, respectively. During the week preceding postemergence herbicide application, rainfall totaled 2.15 inches. Dry weather prevailed during the first 10 days afterward. Total rainfall for April, May, June, and July was 1.46, 2.52, 5.31, and 5.84 inches, respectively.

Dense populations of large crabgrass, light populations of Palmer amaranth, and moderate populations of domestic sunflower developed. Corn population was not affected by treatments. There was no apparent crop injury of consequence from any of the herbicides.

All treatments initially gave excellent or perfect control of large crabgrass. By early July, however, control declined somewhat with several treatments, most notably Bullet and Guardsman Max. Minor decline in large crabgrass control was observed with Bicep II Magnum and Keystone. Palmer amaranth was completely controlled by all herbicide treatments. This level of control remained constant through the last evaluation in early July.

Sunflower control was perfect with all treatments involving Lumax, Lexar, Callisto, or Keystone plus Hornet. Very good control also was achieved with Bicep II Magnum, Epic, or Keystone plus Balance Pro. Somewhat less control occurred with Bullet, Harness Extra, Guardsman Max, or Keystone alone.

Summer drouth stress was minimal because July and August average temperatures were about 6 °F below normal. Harvest conditions were excellent. There was essentially no corn lodging. Yields were higher than usual for this location. All herbicide treatments significantly increased corn yields, by an average of 64 bu/a in comparison with the untreated check. Yield differences among herbicide treatments were not significant. Notably, these treatments resulted in yields as good as, or better than, that of the weed-free check. Herbicides did not affect grain moisture or test weight.

Table 11. Weed control in corn, Harvey County Experiment Field, Hesston, Kansas, 2004.

Herbicide Treatment[1]	Product Form	Rate/a	Unit	Timing[2]	Injury 5/24	Lacg[3] Control 7/7	Paam[4] Control 7/7	Dosf[5] Control 7/7	Yield	Cost[6]
					%	%	%	%	bu/a	$/a
1 Bicep II Magnum	5.5 SC	2.1	qt	PRE	0	91	100	96	146	20.33
2 Lumax	3.95 SE	2.5	qt	PRE	0	100	100	100	141	26.85
3 Lexar	4.43 SE	3	qt	PRE	0	100	100	100	147	25.24
4 Lumax +	3.95 SE	2.5	qt	PRE	0	100	100	100	149	29.27
AAtrex	4 F	1	qt	PRE	0					
5 Lexar +	3.7	3	qt	PRE	0	100	100	100	142	29.05
Princep	4F	1	qt	PRE	0					
6 Bicep II Magnum	5.5 SC	2.1	qt	PRE	0	100	100	100	143	38.66
Callisto +	4 SC	3	qt	POST						
AAtrex +	4 F	0.5	qt	POST						
COC +		1	qt	POST						
UAN		2.5	qt	POST						
7 Harness Xtra	5.6 L	2.44	qt	PRE	0	98	100	86	150	23.64
8 Epic	58 WG	12	oz wt	PRE	0	100	100	97	146	24.96
9 Keystone	5.25 SE	2.65	qt	PRE	0	95	100	92	137	22.41
10 Keystone	5.25 SE	2.65	qt	PRE	0	98	100	100	148	31.53
Hornet	68.5 WG	3	oz wt	PRE	0					
11 Keystone +	5.25 SC	1.3	qt	PRE	0	99	100	99	148	25.88
Balance Pro	4 SC	2.25	fl oz	PRE	0					
12 Bullet	4 F	3.5	qt	PRE	0	81	100	85	142	17.78
13 Guardsman Max	5 F	2	qt	PRE	0	88	100	89	139	19.50
14 Weed Free Check Dual II Magnum	7.64 SC	0.44	pt	PRE	0	97	100	100	136	8.91
15 No Treatment					0	0	0	0	80	
LSD .05					NS	3	6	4	15	

[1] COC = Farmland Crop Oil Plus. NIS = Pen-A-Trate II nonionic surfactant.
[2] PRE= preemergence on April 16; POST = postemergence 33 days after planting.
[3] Lacg =large crabgrass.
[4] Paam = Palmer amaranth. Weed population included some redroot pigweeds.
[5] Dosf = domestic sunflower.
[6] Total herbicide cost based on prices from an area supplier and spraying cost of $3.74 per acre per application.

TABLE OF CONTENTS

EXPERIMENT FIELD PERSONNEL

W.B. Gordon, Agronomist-in-Charge
Mike R. Larson, Plant Science Technician
A. Dean Milner, Plant Science Technician

IRRIGATION AND NORTH CENTRAL KANSAS EXPERIMENT FIELDS

Introduction

The 1952 Kansas legislature provided a special appropriation to establish the Irrigation Experiment Field to serve expanding irrigation development in north-central Kansas. The original 35-acre field was located 9 miles northwest of Concordia. In 1958, the field was relocated to its present site on a 160-acre tract near Scandia in the Kansas-Bostwick Irrigation District. Water is supplied by the Miller canal and stored in Lovewell Reservoir in Jewell County, Kansas, and Harlan County Reservoir at Republican city, Nebraska. In 2001, a linear sprinkler system was added on a 32-acre tract 2 miles south of the present Irrigation Field. In 2002, there were 125,000 acres of irrigated cropland in north-central Kansas. Current research on the field focuses on managing irrigation water and fertilizer in reduced-tillage and crop-rotation systems.

The 40-acre North Central Kansas Experiment Field, located 2 miles west of Belleville, was established on its present site in 1942. The field provides information on factors that allow full development and wise use of natural resources in north-central Kansas. Current research emphasis is on fertilizer management for reduced-tillage crop production and management systems for dryland corn, sorghum, and soybean.

Soil Description

The predominant soil type on both fields is a Crete silt loam. The Crete series consists of deep, well-drained soils that have a loamy surface underlain by a clayey subsoil. These soils developed in loess on nearly level to gently undulating uplands. The Crete soils have slow to medium runoff and slow internal drainage and permeability. Natural fertility is high. Available water holding capacity is approximately 0.19 in. of water per inch of soil.

2004 Weather Information

Climatic data for the North Central Kansas Experiment Fields.

	Rainfall, inches			Temperature, ^{0}F		Growth Units	
	Scandia 2004	Belleville 2004	Average 30-year	Daily Mean 2004	Avg Mean	2004	Average
April	2.4	1.7	2.3	53	52	257	217
May	7.5	6.1	3.7	65	63	497	421
June	5.4	4.1	4.6	70	73	585	679
July	4.1	2.1	3.4	74	78	713	807
August	2.0	1.1	3.4	72	77	637	780
Sept	3.0	2.1	3.6	71	68	628	551
Total	24.0	17.2	20.9			3316	3479

MAXIMIZING IRRIGATED CORN YIELDS IN THE GREAT PLAINS

W.B. Gordon

Summary

This experiment was conducted in 2000 through 2002 on a producer's field in the Republican River Valley, on a Carr sandy loam soil, and in 2003 and 2004 on the North Central Kansas Experiment Field, on a Crete silt loam soil. Treatments consisted of two plant populations (28,000 and 42,000 plants/a) and nine fertility treatments consisting of three N rates (160, 230, and 300 lb/a), in combination with rates of P, K, and S. Results from the 3-yr study on the Carr sandy loam soil show a clear interaction between plant density and fertility management. Increasing plant density had no effect on yield unless fertility was increased simultaneously, and one-third of the fertility response was lost if plant density was not increased. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response. The addition of P, K, and S increased yield by 88 bu/a over the N-alone treatment. Results from the 2-yr study on the Crete silt loam soil were similar. At the low fertility rate, yields were decreased when population was increased. When additional fertility was added, corn yield responded to denser plant populations. Addition of P, K, and S all resulted in yield increases, although the magnitude of the sulfur response was not as great on the Crete silt loam as it was on the sandy Carr soil. Results of this experiment illustrate the importance of using a systems approach when attempting to increase yields.

Introduction

With advances in genetic improvement of corn, yields continue to rise. Modern hybrids suffer less yield reduction under conditions of water and temperature stress. Hybrids no longer suffer major yield loss due to insect, weed, and disease infestations. Newer hybrids have the ability to increase yields in response to denser plant populations. Since 1970, the national average corn yield has increased at a rate of 1.75 bushels per acre per year. Corn yields reached an all time high of 142 bu/a in 2003; yields obtained in university hybrid-performance trials and in state corn-grower contests have been much greater. The average corn yield increase during the period 1970 through 2003 in Republic County, Kansas, was the same as the national average, but yields in K-State's Irrigated Corn Performance Test increased at the rate of 2.8 bu/a/yr. There is a large gap between attainable yields and present average yields. One important aspect of yield advance is that it comes from synergistic interactions between plant breeding efforts and improved agronomic practices. Innovations in each field successively open up opportunities for the other. The overall objective of the research project is to find practical ways of narrowing the existing gap between average and obtainable yield. This study evaluates more intensive fertility management at standard and more dense plant populations.

Procedures

The experiment was conducted in 2000 through 2002 on a producer's field located in the Republican River Valley near the North Central Kansas Experiment Field, at Scandia, Kansas, on a Carr sandy loam soil. In 2003 and 2004, the experiment was conducted at the Experiment Field on a Crete silt loam soil. On the Carr sandy loam site, analysis by the Kansas State University Soil Testing laboratory showed that the initial soil pH was 6.8, organic matter was 2%, Bray-1 P was 20 ppm, exchangeable K was 240 ppm, and SO_4-S was 6 ppm. Soil test values for the Crete silt loam site were:

pH, 6.5; organic matter, 2.6%; Bray-1 P, 25 ppm; exchangeable K 170 ppm; and SO_4-S, 15 ppm. Treatments included two plant populations (28,000 and 42,000 plants/a) and nine fertility treatments. Fertility treatments consisted of three nitrogen (N) rates (160, 230, and 300 lb/a), in combination with 1) current soil test recommendations for P, K, and S (this would consist of 30 lb/a P_2O_5 at these two sites), with the three N rates applied in two split applications; 2) 100 lb P_2O_5 + 80 lb K_2O + 40 lb SO_4-S/a applied preplant (split 1/2 preplant and 1/2 at V4); and 3) 100 lb P_2O_5 + 80 lb K_2O + 40 lb SO_4-S/a applied preplant, with N applied in four split applications (preplant, V4, V8, and tassel). In 2001, treatments were included to determine which elements were providing yield increases. Additional treatments included an unfertilized check, 300 lb/a N alone, 300 lb N + 100 lb P_2O_5/a, 300 lb N + 100 lb P_2O_5 + 80 lb K_2O/a, and 300 lb N + 100 lb P_2O_5 + 80 lb K_2O + 40 lb SO_4-S/a. Preplant applications were made 14 to 20 days before planting each year. Fertilizer sources were ammonium nitrate, monoammonium phosphate (MAP), ammonium sulfate, and potassium chloride (KCL). The experiment was fully irrigated. Irrigation was scheduled by using neutron attenuation methods. Irrigation water was applied when 30% of the available water in the top 36 inches of soil was depleted.

Results

The results from the 3-yr study on the Carr sandy loam soil clearly illustrate the interaction between plant density and fertility management (Table 1). Increasing plant density had no effect on yield unless fertility was increased simultaneously, and one-third of the fertility response was lost if plant density was not increased. Fertility rates must be adequate to take advantage of the added yield potential of modern hybrids grown at dense plant populations. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response (Table 2). The addition of P, K, and S increased yield by 88 bu/a over the N-alone treatment.

Results from the 2-yr study on the Crete silt loam study were similar (Table 3). At the low fertility rates, treatment yields were decreased when population was increased. When additional fertility was added, corn yield responded to denser plant populations. As in the experiment on the Carr soil, one third of the fertility response was lost if plant population was not increased. Addition of P to the N increased yield by 56 bu/a (Table 4). Addition of K further increased yield by 13 bu/a, and adding sulfur to the mix further increased yield by 9 bu/a. With both soils, yield increased with increasing N rate up to 230 lb/a. Increasing the number of N applications from 2 to 4 did not increase yields on either soil in any year of the experiment.

Results of this experiment have shown a clear interaction between plant density and fertility management, thus illustrating the importance of using a systems approach when attempting to increase yield. This 5-yr study also points out the need for soil-test calibration and fertility-management research that is conducted at high yield levels. Standard soil-test recommendations on these two soils would not have produced maximum yield.

Table 1. Maximizing irrigated corn yields, Carr sandy loam soil, 2000 through 2002, Scandia, Kansas.

Population, Plants/a	$P_2O_5 + K_2O$ + S (lb/a)* 30+ 0 +0	100 +80 + 40	Response
	Grain Yield, bu/a		
28,000	162	205	43
42,000	159	223	64
Response	-3	18	

*Plus 230 lb N/a (1/2 preplant; 1/2 at V4)

Table 2. Maximizing irrigated corn yields, Carr sandy loam soil, 2001 and 2002, Scandia, Kansas.

Fertility Treatment	Grain Yield, bu/a
Unfertilized check	80
N	151
N + P	179
N + P + K	221
N + P + K + S	239
LSD (0.05)	10

Table 3. Maximizing irrigated corn yields, Crete silt loam soil, 2003 and 2004, Scandia, Kansas.

Population Plants/a	P2O5 + K2O + S (lb/a) 30 + 0 + 0	100 + 80 + 40	Response
	Grain Yield, bu/a		
28,000	202	225	23
42000	196	262	66
Response	-6	37	

Table 4. Maximizing irrigated corn yields, Crete silt loam soil, 2003 and 2004, Scandia, Kansas.

Fertility Treatment	Grain Yield, bu/a
Unfertilized check	137
N	187
N + P	243
N + P + K	256
N + P + K + S	265
LSD (0.05)	7

USE OF STRIP TILLAGE FOR CORN PRODUCTION IN KANSAS

W.B. Gordon and R.E. Lamond

Summary

Conservation-tillage production systems are being used by an increasing number of producers. Early-season plant growth and nutrient uptake can be poorer in no-till than in conventional-tillage systems. Strip tillage may offer many of the soil-saving advantages of the no-till system while establishing a seed-bed that is similar to conventional tillage. Field studies were conducted at Belleville, Kansas, to compare the effectiveness of strip tillage and no-till and to assess the effects of fall versus spring applications of N-P-K-S fertilizer on growth, nutrient uptake, and yield of corn. The 2003 growing season was characterized by rainfall that was considerably less than normal. Corn yields were severely reduced by the hot, dry conditions. Even though grain yields were low, strip tillage improved early-season growth and nutrient uptake of corn. Strip tillage shortened the time from emergence to mid-silk by 7 days and also reduced grain moisture content at harvest. Strip-tillage plots yielded 15 bu/a more than no-till plots did. In 2004, the growing season was nearly ideal, except for an early-season hail storm that reduced plant population. Yields were very good, and the use of strip tillage increased yields by 16 bu/a over yields of no-till corn. Soil temperature was consistently warmer in strip tillage than in no-till in both 2003 and 2004. Early-season growth was greatly improved in strip tillage, compared with no-till. Fall fertilization was as effective as spring fertilization. Strip tillage seems to be an attractive alternative to no-till for Great Plains producers.

Introduction

Production systems that limit tillage are being used by an increasing number of producers in the central Great Plains because of several inherent advantages. These include reduction of soil erosion losses, increased soil water-use efficiency, and improved soil quality. But early-season plant growth can be poorer in reduced-tillage systems than in conventional systems. The large amount of surface residue present in a no-till system can reduce seed-zone temperatures. Lower than optimum soil temperature can reduce the rate of root growth and nutrient uptake by plants. Soils can also be wetter in the early spring with no-till systems. Wet soils can delay planting. Early-season planting is done so that silking can occur when temperature and rainfall are more favorable. Strip tillage may provide an environment that preserves the soil- and nutrient-saving advantages of no-till while establishing a seed bed that is similar to conventional tillage. The objectives of this experiment were to compare the effectiveness of strip tillage to no-till and to assess the effects of fall, spring, or split applications of N-P-K-S fertilizer on growth, grain yield, and nutrient uptake of corn grown in strip-till or no-till systems.

Procedures

This experiment was conducted at the North Central Kansas Experiment Farm near Belleville, Kansas, on a Crete silt loam soil to compare strip tillage and no-till systems for dryland corn production. Fertilizer treatments consisted of 40, 80, or 120 lb N/a with 30 lb P_2O_5, 5 lb K_2O, and 5 lb S/a. An unfertilized check plot also was included. In the strip-tillage system, fertilizer was either applied in the fall at the time of tilling or in the spring at planting. Fertilizer was applied in the spring at planting in the no-till system. Strip tillage was done in wheat stubble in early October in both years of the study. The zone receiving tillage was 5 to 6 inches

wide. Fertilizer was placed 5 to 6 inches below the soil surface in the fall with the strip-tillage system. Spring-applied fertilizer was placed 2 inches to the side and 2 inches below the seed at planting. Nutrients were supplied as 28% UAN, ammonium polyphosphate (10-34-0), and potassium thiosulfate. Corn was planted in early April both years. Soil test phosphorus, potassium, and sulfur were in the "high" category.

Results

Because the growing season was very dry in 2003, grain yields were very low, and response to applied N was variable. Strip tillage improved early-season growth, nutrient uptake, and grain yield of corn, compared with no-till (Table 5). When averaged over fertility treatments, strip-tilled plots reached mid-silk 7 days earlier than no-till plots did. The early-season growth advantage seen in the strip-tilled plots carried over all the way to harvest. Grain moisture in the strip-tilled plots was 2.8% less than in no-till plots. In this very dry year, the yield advantage may have been the result of the increased rate of development in the strip-till system. The corn plants reached the critical pollination period sooner in the strip-tilled plants, while some stored soil water was still available. The soil water reserve was depleted one week later when the plants in the no-till plots reached mid-silk. In 2004, rainfall was above normal in May, June, and July. A hail storm in early June did reduce the plant population by an average of 12%, but surviving plants developed normally and grain yields were very good. When averaged over fertility treatments, strip-tilled plots yielded 16 bu/a more than no-till plots yielded (Table 6). As in 2003, early-season growth was increased, and days from emergence to mid-bloom were decreased, in the strip-till system.

Soil temperature in the early growing season was warmer in the strip tillage system than in the no-till system in both 2003 and 2004 (Figures 1 and 2). Soil temperature differences between the two tillage systems persisted into late May. Although final stand did not differ in the two tillage systems, plant emergence in the strip-tillage system reached 100% three days sooner than in the no-till system. In both 2003 and 2004, yields in the strip-till system were greater than yields in no-till at all rates of applied fertilizer (Tables 7 and 8). Under Kansas conditions, fall-applied fertilizer was as effective as spring-applied fertilizer was (Tables 9 and Table 10). Splitting fertilizer application did not significantly improve yields over applying all in either the spring or the fall (Tables 11 and 12).

Strip tillage proved to be an effective production practice in both low- and high-yielding environments. Strip tillage does provide a better early-season environment for plant growth and development, while still preserving a large amount of residue on the soil surface. This system may solve some of the major problems associated with conservation tillage, thus making it more acceptable to producers.

Table 5. Early-season growth, number of days from emergence to mid-silk, grain moisture at harvest, and yield of corn, averaged over fertility treatments, Belleville, Kansas, 2003.

Treatment	V-6 Dry Weight lb/a	Days from Emergence to Mid-silk	Harvest Moisture %	Yield bu/a
Strip Tillage	299	56	14.5	60
No-Till	168	66	17.5	45
LSD (0.05)	20	3	1.2	7

Table 6. Early-season growth, number of days from emergence to mid-silk, grain moisture at harvest, and yield of corn, averaged over fertility treatments, Belleville, Kansas, 2004.

Treatment	V-6 Dry Weight lb/a	Days from Emergence to Mid-silk	Harvest Moisture %	Yield bu/a
Strip Tillage	421	55	13.8	160
No-Till	259	66	16.2	144
LSD (0.05)	26	3	1.8	10

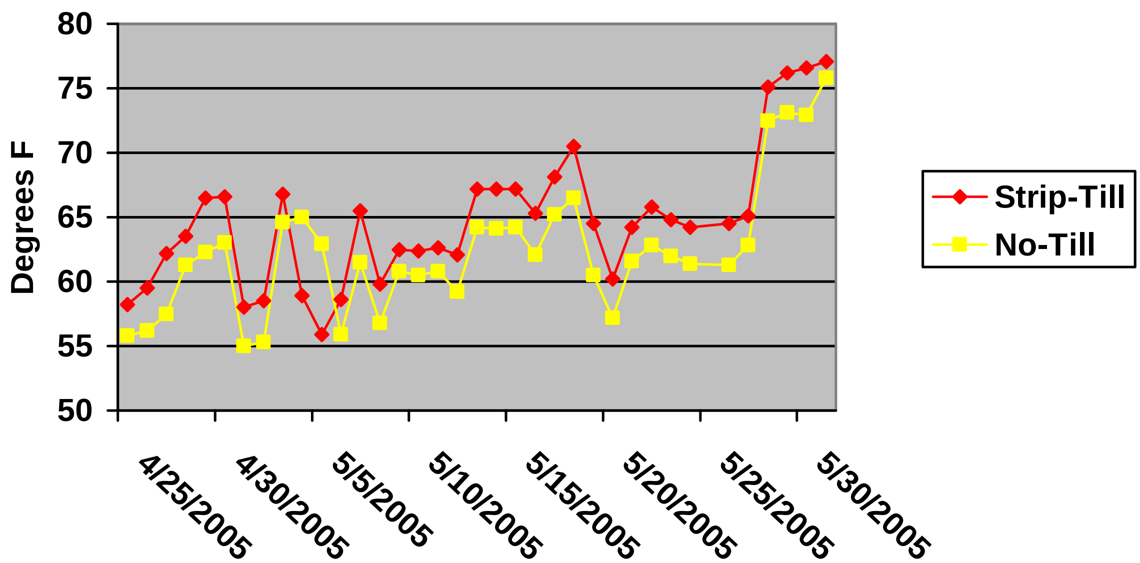


Figure 1. Soil temperature at planting depth, Belleville, Kansas, 2003.

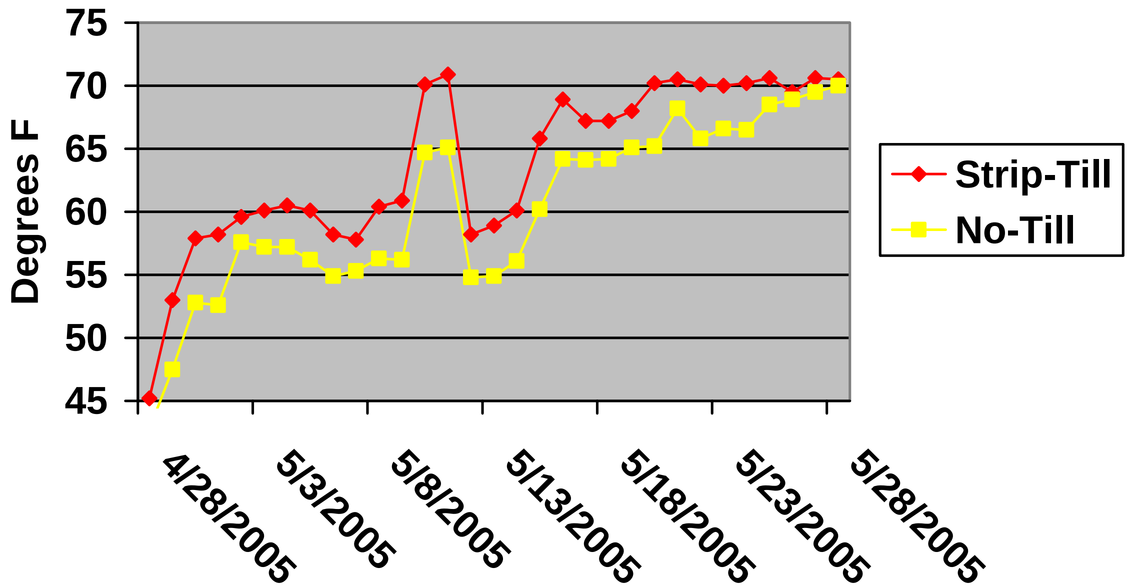


Figure 2. Soil temperature at planting depth, Belleville, Kansas, 2004.

Table 7. Corn grain yield as affected by tillage and spring-applied fertilizer, Belleville, Kansas, 2003.

Fertilizer Treatment	Strip Tillage	No-till
lb/a	Grain yield, bu/a	
40-30-5-5	52	45
80-30-5-5	60	48
120-30-5-5	71	51
Average	61	48
LSD (0.05) = 5		

Table 8. Corn grain yield as affected by tillage and spring-applied fertilizer, Belleville, Kansas, 2004.

Fertilizer Treatment	Strip Tillage	No-till
lb/a	Grain yield, bu/a	
40-30-5-5	161	146
80-30-5-5	174	159
120-30-5-5	186	165
Average	174	157
LSD (0.05) = 8		

Table 9. Corn grain yield as affected by fall- or spring-applied fertilizer in the strip-tillage system, Belleville, Kansas, 2003.

Fertilizer Treatment	Fall Fertilizer	Spring Fertilizer
lb/a	Grain Yield, bu/a	
40-30-5-5	56	52
80-30-5-5	58	60
120-30-5-5	68	71
Average	61	61
LSD (0.05) = 6		

Table 10. Corn grain yield as affected by fall- or spring-applied fertilizer in the strip-tillage system, Belleville, Kansas, 2004.

Fertilizer Treatment	Fall Fertilizer	Spring Fertilizer
lb/a	Grain Yield, bu/a	
40-30-5-5	161	161
80-30-5-5	174	174
120-30-5-5	185	186
Average	173	174
LSD (0.05) = 10		

Table 11. Corn grain yield as affected by timing of fertilizer application in the strip-tillage system, Belleville, Kansas, 2003.

Fertilizer Treatment	Grain Yield, bu/a
120-30-5-5 Fall	68
120-30-5-5 Spring	71
120-30-5-5 Split (2/3 fall, 1/3 spring)	75
LSD (0.05) = NS*	

* Not significant.

Table 12. Corn grain yield as affected by timing of fertilizer application in the strip-tillage system, Belleville, Kansas, 2004.

Fertilizer Treatment	Grain Yield, bu/a
120-30-5-5 Fall	185
120-30-5-5 Spring	186
120-30-5-5 Split (2/3 fall, 1/3 spring)	186
LSD (0.05) = NS*	

* Not significant.

USE OF FOLIAR POTASSIUM FOR SOYBEAN PRODUCTION IN REDUCED-TILLAGE SYSTEMS

W.B. Gordon

Summary

Potassium (K) deficiency can be a problem on soils that have been managed with reduced-tillage practices. The large amount of residue left on the soil surface can depress soil temperature and interfere with plant growth, nutrient uptake, and grain yield. Soil temperature influences both K uptake by roots and K diffusion through the soil.

The appearance of K deficiency in fields managed with conservation-tillage systems has been reported with greater frequency in recent years and has become a concern for producers. In this experiment, preplant broadcast application of Trisert K+(5-0-20-13) was compared with a planting-time starter application of Trisert-K+ and foliar application at three growth stages of soybean. The experimental area had been in a ridge-tillage production system since 1984. All treatments improved soybean seed yield over the untreated check plot, except for the broadcast application. Yields were maximized with either planting-time application of Trisert K+ in combination with foliar application of Trisert-K+ at the early-pod stage or with two foliar applications of Trisert-K+, at early vegetative stage and again at early-pod stage. Three foliar applications of Trisert K+ did not significantly improve yields over yields with two applications. All treatments increased whole-plant K content at the beginning of seed fill (R5) over that of the untreated check. Tissue K content was greatest in the treatment receiving three foliar applications of 2.5 gal/a Trisert K+.

Introduction

The use of conservation tillage has increased in recent years because of its effectiveness in conserving soil and water. Potassium (K) deficiency can be a problem on soils that have been managed with reduced-tillage practices. The large amount of residue left on the soil surface can depress soil temperature early in the growing season. Low soil temperature can interfere with plant root growth, nutrient availability in soil, and crop nutrient uptake. Soil temperature influences both K uptake by roots and K diffusion through the soil. Limited soil water content or zones of soil compaction also can reduce K availability.

In plant physiology, K is the most important cation, not only in concentration in tissues but also with respect to physiological functions. A deficiency in K affects such important physiological processes as respiration, photosynthesis, chlorophyll development, and regulation of stomatal activity. Plants suffering from a K deficiency show a decrease in turgor, making resistance to drought poor. The main function of K in biochemistry is its function in activating many different enzyme systems involved in plant growth and development. Potassium also influences crop maturity and plays a role in reducing disease. The appearance of K deficiency in fields managed with conservation-tillage systems has been reported with greater frequency in recent years and has become a concern for producers. The objective of these studies was to determine if K applied as a starter at planting, alone or in combination with foliar applications of K, could improve K uptake and yield of soybean on soils that had been managed in a ridge-tillage production system.

Procedures

This field experiment was conducted in 2004 on a Crete silt loam soil. The

experimental area had been managed in a ridge-tillage system since 1984. Potassium deficiencies had been observed in this area before the initiation of the study. Soil test results showed that initial pH was 6.5 and organic matter was 2.5%; Bray-1 P and exchangeable K in the top 6 inches of soil were 26 and 280 ppm, respectively. Treatments consisted of the liquid fertilizer Trisert-K+ applied at 2.5 gal/a at the V5 (early vegetative) or R3 (early pod) stage of growth; Trisert-K+ applied at 5 gal/a at R3; 2.5 gal/a of Trisert-K+ applied at both V5 and R3; starter applied Trisert-K+; starter Trisert-K+ in combination with 2.5 gal/a Trisert-K+ applied at R3; 2.5 gal/a Trisert-K+ applied at V5, R3, and R4; and Trisert-K+ applied preplant broadcast. An untreated check plot also was included. Trisert-K+ is a chlorine-free, clear liquid solution containing 5% nitrogen (N), 20% K_2O, and 13% sulfur (S). Each gallon of Trisert-K+ contains 0.58 lb N, 2.34 lb K_2O, and 1.55 lb S. Starter fertilizer was applied 2 inches to the side and 2 inches below the seed at planting. Foliar fertilizer was applied with a backpack sprayer at a total spray volume of 20 gal/a. Broadcast applications were made 5 days before planting. The experiment was furrow irrigated. The Roundup Ready® soybean variety Asgrow 3303 was planted on May 6, 2004, at the rate of 12 seed/foot. The V5 application was on 5 June, the R3 application was on 8 July, and the R4 application was on Aug 17.

Results

All K fertilizer treatments improved soybean yields and whole-plant K concentration over the untreated check plot, except for the broadcast application (Table 13). Seed yields were maximized with either starter application of Trisert-K+ in combination with foliar application of either 2.5 or 5 gal/a of Tisert-K+ applied at R3 stage or with two foliar applications of Trisert-K+ at 5 gal/a applied at the V5 stage and again at R3. Three foliar applications of Trisert-K+ did not improve yields over yields with two applications. Seed yield was 5 bu/a greater when starter fertilizer was combined with a single foliar application of Trisert-K+ at the R3 stage than when starter was applied alone. Broadcast application of fertilizer containing K was not as effective as application of starter fertilizer, in combination with foliar application.

Table 13. Potassium fertilizer application effects on soybean yield, Scandia, Kansas, 2004.

Treatment	Yield, bu/a	Whole-plant K at Early Pod, %
Trisert-K+ (2.5 gal/a at V5)	75.7	3.12
Trisert-K+ (5 gal/a at V5)	81.6	3.32
Trisert-K+ (2.5 gal/a at R3)	84.9	3.54
Trisert-K+ (5.0 gal/a at R3)	85.6	3.48
Trisert-K+ (2.5 gal/a at V5+R3)	89.3	3.57
Trisert-K+ (5gal/a at V5+R3)	91.8	3.66
Starter Trisert-K+ (5 gal/a)	85.3	3.20
Starter Trisert-K+ plus Trisert-K+ (2.5 gal/a at R3)	90.7	3.59
Starter Trisert-K+ plus TrisertK+ (5 gal/a at R3)	92.9	3.67
Preplant Broadcast KTS	83.1	3.08
Trisert-K+ (2.5 gal/a at V5+R3+R4)	91.5	3.72
Untreated check	69.5	2.82
LSD (0.05)	2.5	0.75

CONTROLLED-RELEASE UREA FOR IRRIGATED CORN PRODUCTION

W.B. Gordon

Summary

No-till production systems are being used by an increasing number of producers in the central Great Plains because of several advantages that include reduction of soil erosion, increased soil water-use efficiency, and improved soil quality. But the large amount of residue left on the soil surface can make nitrogen (N) management difficult. Surface applications of urea-containing fertilizers are subject to volatilization losses. Leaching can also be a problem on course-textured soils when N is applied in one preplant application. Slow-release, polymer-coated urea products are beginning to become available for agricultural use. The polymer coating allows the urea to be released at a slower rate than uncoated urea. This experiment compares urea, a controlled-release polymer-coated urea (ESN), and ammonium nitrate at 3 N rates (80, 160, and 240 lbs/a) for production of corn. Split applications (1/2 preplant + 1/2 at V4 stage) at the 160 lb/a N rate also were included for urea, ammonium nitrate, ESN, UAN broadcast and banded, and urea plus the urease inhibitor Agrotain. The V4-stage application of all the materials was applied in a surface band. Only the preplant applications were broadcast. The study was conducted on a farmer's field on a Muir silt loam soil. The field was furrow irrigated. The ESN product resulted in greater corn yields than urea did at all N rates. Corn yields on plots treated with ammonium nitrate or ESN were essentially the same at all but the lowest N rate. Yields were above normal in 2004, and yields increased with increasing N rate, regardless of the N source. Applying 160 lb/a N in two split applications did not improve yields over applying all N preplant. Applying UAN broadcast was not as effective as applying in a dribble band. Applying urea with the urease inhibitor was more effective than using urea alone. The polymer-coated urea product has the potential to make surface application of N in no-till systems more efficient.

Introduction

Conservation-tillage production systems are being used by an increasing number of producers in the Great Plains because of several inherent advantages. These advantages include reduction of soil-erosion losses, increased soil water-use efficiency, and improved soil quality. The large amount of residue left on the soil surface in no-till systems can make N management difficult. Surface application of N fertilizers is a popular practice with producers. When urea-containing N fertilizers are placed on the soil surface they are subject to volatilization losses. Nitrogen immobilization can also be a problem when N fertilizers are surface applied in high-residue production systems. Nitrogen leaching can be both an agronomic and environmental problem on course-textured soils. Polymer-coated urea has the potential to make N management more efficient when surface applied in no-till systems.

Procedures

This experiment was conducted on a farmer's field in the Republican River valley on a Muir silt loam soil. Soil pH was 7.1, organic matter was 2.1%, Bray-1 P was 69 ppm, and exchangeable K was 469 ppm. The corn hybrid DeKalb C60-19 was planted without tillage into corn stubble on April 18, 2004, at the rate of 28,000 seeds/a. Nitrogen was applied on the soil surface immediately after planting. Split applications consisted of 1/2 of the N applied immediately after planting and 1/2

applied at the V4 stage. Preplant treatments were all broadcast, and VF4 treatments were banded. Treatments consisted of controlled-release polymer-coated urea (ESN), urea, or ammonium nitrate applied at 3 rates (80, 160, and 240 lbs/a). A no-N check plot also was included. Additional treatments were split applications of ESN, urea, ammonium nitrate, UAN (28% N) broadcast and applied in a dribble band, and urea plus the urease inhibitor, Agrotain, at the 160 lb/a N rate. The experimental area was adequately irrigated throughout the growing season. Plots were hand harvested on November 8, 2002.

Results

Application of the ESN controlled-release urea product resulted in greater corn yield at all rates of N than application of urea did (Table 14). Yields achieved with ESN application were equal to those of ammonium nitrate, except at the lowest N rate. The lower yields with urea indicate that volatilization of N may have been a significant problem. Splitting applications of N did not improve corn yields with any of the materials. Weather conditions were ideal in 2004, and yields were above normal. Yields increased with increasing N rate up to 240 lb/a. Applying UAN in a dribble band was more effective than broadcasting, and applying urea with a urease inhibitor was more effective than urea alone.

Results of this study suggest that slow-release, polymer-coated urea can improve N use efficiency, compared with urea and UAN, when surface applied in no-till conditions.

Table 14. Effects of nitrogen source and rate on corn grain yield and earleaf N, Scandia, Kansas, 2004.

N Source	N Rate, lb/a	Yield, bu/a	Earleaf N, %
	0-N check	154	1.77
ESN	80	189	2.19
	160	208	2.30
	240	250	2.48
Urea	80	176	2.00
	160	192	20.8
	240	230	2.22
Ammonium nitrate	80	200	2.21
	160	212	2.34
	240	249	2.44
ESN	80+ 80 split	206	2.35
Urea	80+80 split	190	2.15
Ammonium nitrate	80+80 split	209	2.37
28% UAN broadcast		193	2.19
28% UAN dribble		203	2.30
Urea + Agrotain	80+ 80 split	209	2.34
LSD (0.05)		8	0.07

IMPROVING EFFICIENCY OF PHOSPHORUS FERTILIZERS

W.B. Gordon

Summary

Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or HPO_4^{-2}, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of limited water solubility. Crop recovery of applied P fertilizer can be quite poor during the season of application. Specialty Fertilizer Products has developed and patented a dicarboxylic co-polymer, AVAIL®, that can be used as a coating on granular phosphate fertilizer or mixed into liquid phosphate fertilizers. The polymer is reported to sequester antagonistic cations out of the soil solution, thus keeping P fertilizer in a more available form for plant uptake. To evaluate the effectiveness of the AVAIL® product, experiments were conducted at the North Central Kansas Experiment Field during 2001 through 2004 in which mono-ammonium phosphate (MAP, 11-52-0) coated with AVAIL® was used on both corn and soybean. In 2004, AVAIL® also was evaluated in liquid ammonium polyphosphate fertilizer (10-34-0) applied as a starter for corn production. Treatments in the corn experiment consisted of applying MAP at rates to give 20, 40, or 60 lb/a P_2O_5, either treated with AVAIL® or untreated. A no-P check plot also was included. The soybean experiment consisted of applying either treated or untreated MAP at rates to give 30 or 60 lb/a P_2O_5. A no-P check was again included. The phosphate fertilizer was banded beside the row in both the corn and soybean experiments. The liquid starter experiment consisted of a no-starter check and a 30-30-5 treatment, applied alone or with AVAIL® at a 2% rate. Fertilizer was placed 2 inches to the side and 2 inches below the seed at planting. Soil-test P values were in the "medium" category in all experiments. When averaged over years and P rates, the AVAIL®-treated MAP increased corn grain yield by 18 bu/a over the yields with untreated MAP. Tissue P concentration was greater in the AVAIL®-treated plots than in untreated plots at both the 6-leaf stage and at mid-silk. When averaged over years and P rates, soybean yield was improved by 9 bu/a by the use of AVAIL®-treated P fertilizer. In 2004, liquid starter fertilizer mixed with a 2% solution of AVAIL® increased corn grain yield by 13 bu/a over the untreated starter treatment. Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL® increased P uptake and yield of corn and soybean.

Introduction

Phosphorus occurs in soils mainly as inorganic P compounds, but also as low concentrations of P in the soil solution. Most soils contain relatively small amounts of total P, and only a small fraction of the total P is available to plants. Most inorganic P compounds in soils have very low solubility. Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or HPO_4^{-2}, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of very limited water solubility. Crop recovery of applied P fertilizer can be quite poor during the season of application. Specialty Fertilizer Products has developed and patented a dicarboxylic co-polymer that can be used as a coating on granular phosphate fertilizer or mixed into liquid phosphate fertilizers. The registered trade name of the new product is AVAIL®. The polymer is reported to sequester antagonistic cations out of the soil solution, thus keeping P fertilizer in a more available form for plant

uptake. The objective of this research was to evaluate the use of AVAIL® with phosphorus fertilizer for corn and soybean production.

Procedures

Experiments were conducted during 2001 through 2004 at the North Central Kansas Experiment Field on a Crete silt loam soil. The corn experiment consisted of applying granular MAP (11-52-0) at rates to give 20, 40, or 60 lb P_2O_5/a, either treated with 2% AVAIL® or untreated. A no-P check plot also was included. The MAP fertilizer was sub-surface banded at planting. Soil-test values at the experimental site were 2.8% organic matter, 6.2 pH, and 22 ppm Bray-1 P. A liquid-fertilizer starter test was conducted with corn in 2004. Treatments consisted of liquid starter (30-30-5), applied with or without 2% AVAIL®. A no-starter check also was included. The fertilizer was placed 2 inches to the side and 2 inches below the seed at planting.

The soybean experiment consisted of applying granular MAP at rates to give 30 or 60 lb P_2O_5/a, either with or without AVAIL®, plus a no-P check. As in the corn experiment, the MAP was applied in a sub-surface band at planting. Soil-test values were 2.5% organic matter, 6.7 pH, and 23 ppm Bray-1 P. Because MAP contains nitrogen, and rates were calculated on the basis of P content, N in the form of ammonium nitrate was added so that all treatments received the same amount of N. All experiments were irrigated.

Results

When averaged over years and P rates, the AVAIL®-treated MAP increased corn grain yield by 18 bu/a over the yields with untreated MAP (Table 15). The AVAIL®-treated MAP gave greater grain yield at all rates of applied P. Ear leaf P concentration at silking was greater in the AVAIL®-treated plots than in the untreated plots. The use of AVAIL® with P fertilizer resulted in improved plant P uptake. When AVAIL® was applied with liquid starter fertilizer, yields were increased by 13 bu/a over yields with the untreated starter (Table 17). Phosphorus uptake in the AVAIL®-treated plots was greater than that in the untreated plots at both the 6-leaf stage and at silking. When averaged over years and P rates, plots treated with MAP plus AVAIL® had soybean yields 9 bu/a more than plots treated with MAP alone (Table 18). Phosphorus uptake at the full-bloom stage was increased by the use of AVAIL® applied with MAP (Table 19). Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL® with P fertilizer increased plant P uptake and yield of corn and soybean.

Table 15. Corn yield response to phosphorus and AVAIL®.

Treatment	2001	2002	2003	Average
lb/a P_2O_5		bu/a		
20 untreated	188 B*	142 D	182 D	171 D
40 untreated	191 B	169 C	188 C	182 CD
60 untreated	190 B	173 BC	195 BC	186 BC
20 + AVAIL®	194 B	173 BC	210 B	192ABC
40 + AVAIL®	195 B	190 AB	210 A	198AB
60 + AVAIL®	209 A	194 A	210A	204A
Check	174 C	120 E	169A	154 E
LSD (0.05)	9	17	10	12

* Means separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 16. Applied phosphorus and AVAIL® effects on corn ear leaf P concentration.

Treatment	2001	2002	2003	Average
lb/a P2O5		bu/a		
20 untreated	0.229 D*	0.229 E	0.238 D	0.232 D
40 untreated	0.239 C	0.247 CD	0.248 C	0.245 C
60 untreated	0.251 B	0.257 B	0.255 B	0.254 B
20 + AVAIL®	0.236 C	0.240 D	0.244 C	0.240 C
40 + AVAIL®	0.257 A	0.253 BC	0.258 B	0.256 B
60 +AVAIL®	0.261 A	0.274 A	0.265 A	0.267 A
Check	0.199 E	0.212 F	0.204 E	0.205 E
LSD (0.05)	0.005	0.007	0.006	0.006

* Means separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 17. AVAIL® in liquid starter fertilizer, 2004.

Treatment	Yield	V6 P uptake	Ear Leaf P
	bu/a	lb/a	%
No starter	223	1.45	0.232
Starter	247	1.98	0.267
Starter + 2% AVAIL®	260	2.39	0.302
LSD (0.05)	8	0.20	0.013

Table 18. Soybean yield response to phosphorus and AVAIL®.

Treatment	2002	2003	2004	Average
lb/a P_2O_5		bu/a		
30 untreated	62 C*	41 C	69 C	58 C
60 untreated	62 C	48 B	74 B	61 B
30 + AVAIL®	70 B	57 A	78 A	68 A
60 +AVAIL®	73 A	58 A	79 A	70 A
Check	52 D	32 D	60 D	48 D
LSD (0.5)	2	3	1	2

*Means separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 19. Applied phosphorus and AVAIL® effects on whole-plant P uptake at full bloom.

Treatment	2002	2003	2004	Average
lb/a P_2O_5		lb/a		
30 untreated	6.51 C	7.37 D	9.64 C	7.84 B
60 untreated	6.86 BC	8.02 C	10.84 B	8.57 B
30 + AVAIL®	8.56 AB	9.16 B	13.13 A	10.28 A
60 + AVAIL®	10.20 A	10.18 A	12.91 A	11.09 A
Check	4.17 D	4.67 E	5.37 D	4.64 C
LSD (0.05)	1.15	0.91	0.45	0.83

TABLE OF CONTENTS

EXPERIMENT FIELD PERSONNEL

William F. Heer, Agronomist-in-Charge

SOUTH CENTRAL KANSAS EXPERIMENT FIELD

Hutchinson

Introduction

The South Central Kansas Experiment Field at Hutchinson was established in 1951 on the U.S. Coast Guard Radio Receiving Station located southwest of Hutchinson. The first research data were collected with the harvest of 1952. Before 1952, data for the South Central area of Kansas were collected at three locations (Kingman, Wichita/Goddard, and Hutchinson). The current South Central Field location is approximately 3/4 miles south and east of the old Hutchinson location on the Walter Peirce farm.

Research at the South Central Kansas Experiment Field is designed to help the area's agriculture develop to its full agronomic potential by using sound environmental practices. The principal objective is achieved through investigations of fertilizer use, weed and insect control, tillage methods, seeding techniques, cover crops and crop rotations, variety improvement, and selection of hybrids and varieties adapted to the area, as well as alternative crops that may be beneficial to the area's agriculture production.

Experiments deal with problems related to soil tilth and to production of wheat, grain and forage sorghum, oat, alfalfa, corn, soybean, cotton, rapeseed/canola, and sunflower. Breeder and foundation seed of wheat, oat, and canola varieties/hybrids are produced to improve seed stocks available to farmers. A large portion of the research program at the field is currently dedicated to wheat and canola breeding and germplasm development.

In March of 2004, the Kansas State University Foundation took possession of approximately 300 acres of land southwest of Partridge, Kansas. This land was donated to the Foundation by George V. Redd and Mabel E. Bargdill for use in developing and improving plants and crops. The acreage is in two parcels. One parcel of approximately 140 acres lies south of Highway 61 and west of county road Centennial. It is currently in CRP and will remain there until the contract runs out. The second parcel, a full quarter, is currently in Foundation wheat, production wheat, and grain sorghum. Both parcels will be worked into the research activities of the South Central Experiment Field.

Soil Description

A new soil survey was completed for Reno County and has renamed some of the soils on the Hutchinson Field. The new survey overlooks some of the soil types present in the older survey, and it is believed that the descriptions of the soils on the Field as follows is more precise. The Hutchinson Field has approximately 120 acres classified as nearly level to gently sloping Clark/Ost loams with calcareous subsoils. This soil requires adequate inputs of phosphate and nitrogen fertilizers for maximum crop production.

The Clark soils are well drained and have good water-holding capacity. They are more calcareous at the surface and less clayey in the subsurface than the Ost. The Ost soils are shallower than the Clark, having an average surface layer of only 9 inches. Both soils are excellent for wheat and grain sorghum production. Large areas of these soils are found in southwestern and southeastern Reno County and in western Kingman County. The Clark soils are associated with the Ladysmith and Kaski soils common in Harvey County, but are less clayey and contain more calcium carbonate.

Approximately 30 acres of Ost Natrustolls Complex, with associated alkali slick spots, occur on the north edge of the Field. This soil

requires special management and timely tillage, because it puddles when wet and forms a hard crust when dry. A 10-acre depression on the south edge of the Field is a Tabler-Natrustolls Complex (Tabler slick-spot complex). This area is unsuited for cultivated crop production and has been seeded to switchgrass. Small pockets of the Tabler-Natrustolls are found throughout the Field.

The soils on the Redd-Bargdill land are somewhat different from those on the current Field. The south quarter (CRP) has mostly Shellabarger fine sandy loams with 1 to 3% slopes. There are also some Farnums on this quarter. The new classification has these soils classified as Nalim loam. The north quarter was previously all classified as Tabler clay loam; the new survey has the soils classified as Funmar-Taver, Funmar, and Tever loams.

2003-2004 Weather Information

From 1997-2000 precipitation was above average. In 2001, a below-normal amount of precipitation was recorded at the Field. The precipitation was slightly (0.946 inches) above normal in 2002 and 1.06 inches below normal in 2003. The U.S. Department of Commerce National Oceanic and Atmospheric Administration National Weather Service rain gauge (Hutchinson 10 S.W. 14-3930-8) collected 32.96 inches of precipitation in 2004, 3.14 inches more than the 30-year (most recent) average of 29.82 inches. It should be noted that the 30-year average has been increasing in the past few years.

As with all years, distribution within the year and the rainfall intensity are the determining factors in the usefulness of the precipitation. In 2004, March, June, and July received above-normal precipitation of 1.93, 2.59, and 4.06 inches, respectively. Because of the timing of the spring rains and cool temperatures, the wheat and other fall crops (canola) did well. This was not true for the summer crops, as can be seen in the data tables. Had it not been for the late freeze, the summer crops would not have yielded well. This was a result of the cool temperatures in August and September that slowed crop development.

A frost-free growing season of 204 days (April 13 - November 3, 2004) was recorded. This is 21 days more than the average frost-free season of 183 days (April 19 - October 17) and four days more than in 2003.

Table 1. Precipitation at South Central Kansas Experiment Field, Hutchinson (10 S.W. 14-3930-8), Kansas.

Month	Rainfall (inches)	30-yr avg* (inches)	Month	Rainfall (inches)	30-yr avg (inches)
2003			April	1.29	2.93
September	1.83	3.00	May	3.29	4.22
October	3.65	2.51	June	6.78	4.19
November	0.05	1.39	July	7.39	3.33
December	1.44	0.97	August	2.39	3.23
2004			September	1.67	2.73
January	0.51	0.68	October	2.64	2.47
February	0.45	1.09	November	1.81	1.35
March	4.53	2.60	December	0.21	0.95
			2004 Total	32.96	29.82

* Most recent 30 years.

CROP PERFORMANCE TESTS AT THE SOUTH CENTRAL FIELD

William F. Heer and Kraig L. Roozeboom

Introduction

Performance tests for winter wheat, grain sorghum, alfalfa, canola, sunflower, oat, and spring wheat were conducted at the South Central Kansas Experiment Field. Off-site tests for irrigated corn, soybean, and grain sorghum also were conducted. Results of these tests can be found in the following publications, which are available at the local county extension office or online at http://www.ksu.edu/kscpt.

2004 Kansas Performance Tests with Winter Wheat Varieties. KAES Report of Progress, SRP 930.

2004 National Winter Canola Variety Trial. KAES Report of Progress, SRP 937.

2004 Kansas Performance Tests with Grain Sorghum Hybrids. KAES Report of Progress, SRP 933.

2004 Kansas Performance Tests with Sunflower Hybrids. KAES Report of Progress , SRP 936.

2004 Kansas Performance Tests with Alfalfa Varieties. KAES Report of Progress, SRP 935.

2004 Kansas Performance Tests with Summer Annual Forages. KAES Report of Progress, SRP 938.

2004 Kansas Performance Tests with Spring Small Grains. KAES Report of Progress, SRP 931.

EFFECTS OF NITROGEN RATE AND PREVIOUS CROP ON GRAIN YIELD IN CONTINUOUS WHEAT AND ALTERNATIVE CROPPING SYSTEMS IN SOUTH-CENTRAL KANSAS

William F. Heer

Summary

The predominant cropping systems in South-Central Kansas have been continuous wheat and wheat-grain sorghum-fallow. With continuous wheat, tillage is performed to control diseases and weeds. In the wheat-sorghum-fallow system, only two crops are produced every three years. Other crops (corn, soybean, sunflower, winter cover crops, and canola) can be placed in these cropping systems.

To determine how winter wheat (and alternative crop) yields are affected by these alternative cropping systems, winter wheat was planted in rotations following the alternative crops. Yields were compared with yields of continuous winter wheat under conventional (CT) and no-till (NT) practices. Initially, the CT continuous wheat yields were greater than those from the other systems. Over time, however, wheat yields following soybean have increased, reflecting the effects of reduced weed and disease pressure and increased soil nitrogen. But CT continuous winter wheat seems to out-yield NT winter wheat, regardless of the previous crop.

Introduction

In South-Central Kansas, continuous hard red winter wheat and winter wheat - grain sorghum - fallow are the predominant dry - land cropping systems. The summer fallow period following sorghum is required because the sorghum crop is harvested in late fall, after the optimum planting date for wheat in this region. Average annual rainfall is only 29 inches/yr, with 60 to 70% occurring between March and July. Therefore, soil moisture is often not sufficient for optimum wheat growth in the fall. No-tillage (NT) systems often increase soil moisture by increasing infiltration and decreasing evaporation. But higher grain yields associated with increased soil water in NT have not always been observed.

Cropping systems with winter wheat following several alternative crops would provide improved weed control, through additional herbicide options and reduced disease incidence, by interrupting disease cycles, and would allow producers several options under the 1995 Farm Bill. But the fertilizer nitrogen (N) requirement for many crops is often greater under NT than under CT. Increased immobilization and denitrification of inorganic soil N and decreased mineralization of organic soil N have been related to the increased N requirements under NT. Therefore, evaluation of N rates on hard red winter wheat in continuous wheat and in cropping systems involving "alternative" crops for the area have been evaluated at the South Central Field.

The continuous-winter-wheat study was established in 1979 and was restructured to include a tillage factor in 1987. The first of the alternative cropping systems, in which wheat follows short-season corn, was established in 1986 and modified in 1996 to a wheat-cover crop-grain sorghum rotation. The second cropping system (established in 1990) has winter wheat following soybean. Both cropping systems use NT seeding into the previous crop's residue. All three systems have the same N rate treatments.

Procedures

The research was conducted at the KSU South Central Experiment Field, Hutchinson. Soil was an Ost loam. The sites had been in

wheat before the start of the cropping systems. The research was replicated five times in a randomized-block design with a split-plot arrangement. The main plot was crop, and the subplot was six N rates (0, 25, 50, 75, 100, and 125 lbs/a). Nitrogen treatments were broadcast applied as NH_4NO_3 before planting. Phosphate was applied in the row at planting. All crops were produced each year of the study. Crops are planted at the normal time for the area. Plots are harvested at maturity to determine grain yield, moisture, and test weight.

Continuous Wheat

These plots were established in 1979. The conventional tillage treatments are plowed immediately after harvest then worked with a disk as necessary to control weed growth. The fertilizer is applied with a Barber metered screw spreader before the last tillage (field cultivation) on the CT and before seeding of the NT plots. The plots are cross-seeded in mid-October to winter wheat. Because of an infestation of cheat in the 1993 crop, the plots were planted to oat in the spring of 1994. The fertility rates were maintained, and the oat was harvested in July. Winter wheat has been planted in mid-October each year since the fall of 1994. New herbicides have aided in the control of cheat in the no-till treatments.

Wheat after Corn/Grain Sorghum Fallow

In this cropping system, winter wheat was planted after a short-season corn had been harvested in late August to early September. This early harvest of short-season corn allows the soil-profile water to be recharged (by normal late-summer and early-fall rains) before planting of winter wheat in mid- October. Fertilizer is applied with the Barber metered screw spreader in the same manner as for the continuous wheat. In 1996, the corn crop in this rotation was dropped, and three legumes (winter pea, hairy vetch, and yellow sweet clover) were added as winter cover crops. Thus, the rotation became a wheat-cover crop-grain sorghum-fallow rotation. The cover crops replaced the 25, 75, and 125 N treatments in the grain sorghum portion of the rotation. Yield data can be found in Field Research 2000, KSU Report of Progress 854.

Wheat after Soybean

Winter wheat is planted after soybean has been harvested in early- to mid- September in this cropping system. As with the continuous-wheat plots, these plots are planted to winter wheat in mid-October. Fertilizer is applied with the Barber metered screw spreader in the same manner as for the continuous wheat. Since 1999, a Group-III soybean has been used. This delays harvest from late August to early October. In some years, this effectively eliminates the potential recharge time before wheat planting.

Wheat after Grain Sorghum in Cover Crop/Fallow - Grain Sorghum - Wheat

Winter wheat is planted into grain sorghum stubble harvested the previous fall. Thus, the soil profile water has had 11 months to be recharged before planting of winter wheat in mid-October. Nitrogen fertilizer is applied at a uniform rate of 75 lbs/a with the Barber metered screw spreader in the same manner as for the continuous wheat.

Winter wheat is also planted after canola and sunflower to evaluate the effects of these two crops on the yield of winter wheat. Uniform nitrogen fertility is used; the data is not presented. The yields for wheat after these two crops is comparable to wheat after soybean.

Results

Continuous Wheat

Grain yield data for plots in continuous winter wheat are summarized by tillage and N rates in Table 3. Data for years before 1996 can be found in Agronomy Field Research 2000, KSU Report of Progress 854. Conditions in 1996 and 1997 proved to be

excellent for winter wheat production in spite of the dry fall of 1995 and the late-spring freezes in both years. Excellent moisture and temperatures during the grain-filling period resulted in decreased grain-yield differences between the conventional and no-till treatments within N rates. Conditions in the springs of 1998 and 1999 were excellent for grain filling in wheat, but the differences in yield between conventional and no-till wheat still expressed themselves (Table 3). In 2000, the differences were larger up to the 100 lb/a N rate. At that point, the differences were similar to those of previous years. The wet winter and late spring of the 2003-2004 harvest year allowed for excellent tillering, grain fill, and yields (Table 2).

Wheat after Soybean

Wheat yields after soybean also reflect the differences in N-rate. When comparing the wheat yields from this cropping system with those where wheat followed corn, however, the effects of residual N from soybean production in the previous year can be seen. This is especially true for N rates between 0 and 75 lb in 1993 and between 0 to 125 lb in 1994 (Table 3). Yields in 1995 reflect the added N from the previous soybean crop, with yield-by-N-rate increases similar to those of 1994. The 1996 yields for spring wheat reflect the lack of response to nitrogen fertilizer for the spring wheat. Yields for 1997 and 1998 both show the yield leveling off after the first four increments of N. As with the wheat in the other rotations in 1999, the ideal moisture and temperature conditions allowed the wheat yields after soybean to express the differences in N rate up to 100 lb N/ac. In the past, those differences stopped at the 75 lb N/ac treatment. When compared with yields in continuous wheat, the yield of rotational wheat is starting to reflect the presence of the third crop (grain sorghum) in the rotation. Wheat yields were lower in 2000 than in 1999. This is attributed to the lack of timely moisture in April and May and the hot days at the end of May. This heat caused the plants to mature early, and also caused low test weights. In 2004, there was not as much cheat as in 2003; thus, the yields were much improved (Table 3). Yields in 2004 indicate that the wheat is showing a 50- to 75-lb N credit from the soybean and rotational effects. As the rotation continues to cycle, the differences at each N rate will probably stabilize after four to five cycles, with a potential to reduce fertilizer N applications by 25 to 50 lb/a where wheat follows soybean.

Wheat after Grain Sorghum/Cover Crop

The first year that wheat was harvested after a cover-crop grain sorghum planting was 1997. Data for the wheat yields from 1997 to 2004 are in Table 4. Over these eight years, there does not seem to be a definite effect of the cover crop (CC) on yield. This is most likely due to the variance in CC growth within a given year. In years like 1998 and 1999, in which sufficient moisture and warm winter temperatures produced good CC growth, the additional N from the CC seems to carry through to the wheat yields. With the fallow period after the sorghum in this rotation, the wheat crop has a moisture advantage over the wheat after soybean. Cheat was the limiting factor in this rotation in 2003. A more aggressive herbicide control of cheat in the cover crops has been started, and the 2004 yields reflect the control of cheat. Management of the grasses in the cover-crop portion of this rotation seems to be the key factor in controlling the cheat grass and increasing yields.

Other Observations

Nitrogen application significantly increased grain N contents in all crops. Grain phosphate content did not seem to be affected by increased N rate.

Loss of the wheat crop after corn can occur in years when fall and winter moisture is limited. This loss has not occurred in

continuous winter wheat, regardless of tillage, or in the wheat after soybean. Corn will have the potential to produce grain in favorable years (cool and moist) and to produce silage in nonfavorable (hot and dry) years. In extremely dry summers, extremely low grain sorghum yields can occur. The major weed-control problem in the wheat-after-corn system is with the grasses. This was expected, and work is being done to determine the best herbicides and time of application to control grasses.

Soybean and Grain Sorghum in Rotations

Soybean was added to intensify the cropping system in the South Central area of Kansas. They have the ability, being a legume, to add nitrogen to the soil system. For this reason, the nitrogen is not applied during the time when soybean is planted in the plots for the rotation. This gives the following crops the opportunity to use the added N and allows checking yields against yields for the crop in other production systems. Yield data for soybean following grain sorghum are given in Table 5. Soybean yields are affected more by weather for the given year than by the previous crop. In three out of the nine years, there was no effect of the N rate applied to the wheat and grain sorghum crops in the rotation. In the two yrs that N application rate did affect yield, it was only at the lesser N rates. This is a similar affect that is seen in a given crop. The yield data for the grain sorghum after wheat in the soybean-wheat-grain sorghum rotation are in Table 6. As with the soybean, weather is the main factor affecting grain sorghum yield. The addition of a cash crop (soybean), thus intensifying the rotation (cropping system), will reduce the yield of grain sorghum in the rotation; compare soybean-wheat-grain sorghum vs. wheat-cover crop-grain sorghum in Tables 6 and 7. More uniform yields are obtained in the soybean-wheat-grain sorghum rotation (Table 6) than in the wheat-cover crop-grain sorghum rotation (Table 7).

It is hoped that these rotations will be continued after the Field personnel are removed from the Field and it becomes a satellite Field. Other systems studies at the Field are a wheat-cover crop (winter pea)-grain sorghum rotation with N rates (data presented in Report of Progress 854, 2000), and a date-of-planting, date-of-termination cover-crop rotation with small grains (oat) and grain sorghum.

Table 2. Wheat yields by tillage and nitrogen rate in a continuous-wheat cropping system, Hutchinson, Kansas.

	Yield (bu/a)																	
N	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Rate [1]	CT[2]	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT
0	46	23	47	27	52	19	49	36	34	15	50	11	26	8	54	9	66	27
25	49	27	56	45	61	37	67	51	46	28	53	26	34	9	56	9	68	41
50	49	29	53	49	61	46	76	61	52	28	54	35	32	8	57	22	65	40
75	49	29	50	46	64	53	69	64	50	34	58	36	34	7	57	42	63	37
100	46	28	51	44	55	52	66	61	35	33	54	34	35	5	56	35	64	43
125	45	25	48	42	56	50	64	58	31	32	56	36	32	5	57	38	63	31
LSD* (0.01)	NS	NS	8	8	5	5	13	13	14	14	10	10	6	NS	NS	18	NS	9

[1] Nitrogen rate in lb/a.
[2] CT=conventional; NT=no-tillage.
* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

Table 3. Wheat yields after soybean in a soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)													
Rate	1991	1992	1993	1994	1995	1996[1]	1997	1998	1999	2000	2001	2002[2]	2003	2004
lb/a														
0	51	31	24	23	19	35	13	21	31	26	12	9	31	40
25	55	36	34	37	26	36	29	34	46	37	16	10	48	46
50	55	37	41	47	34	36	40	46	59	46	17	9	59	48
75	52	37	46	49	37	36	44	54	66	54	17	7	65	46
100	51	35	45	50	39	36	45	55	69	55	20	8	67	43
125	54	36	46	52	37	36	47	57	68	50	21	8	66	40
LSD* (0.01)	NS	4	6	2	1	1	4	3	7	5	7	4	3	5
CV (%)	7	6	9	5	7	2	9	4	5	7	23	24	4	6

[1] Spring wheat yields.
[2] Yields severely reduced by hail.
* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

Table 4. Wheat yields after grain sorghum in a wheat-cover crop-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)							
Rate	1997	1998	1999	2000	2001	2002[1]	2003	2004
lb/a								
0	17	25	26	4	45	10	9	47
HV[2]	43	50	39	16	45	10	5	36
50	59	52	50	21	41	8	4	35
WP[2]	43	51	66	21	41	9	8	37
100	52	56	69	26	39	5	5	32
SC[2]	53	54	70	22	42	6	6	36
LSD* (0.01)	21	12	5	5	5	3	NS	8
CV (%)	26	14	6	16	6	20	70	12

[1] Yields severely reduced by hail.
[2] HV=hairy vetch, WP=winter pea, SC=sweet clover.
* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

Table 5. Soybean yields after grain sorghum in soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)								
Rate[1]	1996	1997	1998	1999	2000	2001	2002	2003	2004
lb/a									
0	16	26	22	33	25	7	22	5	53
25	17	29	23	35	21	8	22	6	50
50	18	30	23	36	23	9	22	6	50
75	20	29	24	36	24	8	21	7	51
100	22	31	25	37	21	9	21	7	51
125	20	25	24	34	22	8	22	7	49
LSD* (0.01)	3	7	NS	NS	NS	NS	ns	1.4	5
CV (%)	10	12	6	12	15	13	7	17	6

[1] N is not applied to the soybean plots in the rotation.
* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

Table 6. Grain sorghum yields after wheat in a soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)								
Rate	1996	1997	1998	1999	2000	2001	2002	2003	2004
lb/a									
0	32	13	57	52	55	15	34	10	86
25	76	29	63	67	56	15	41	10	112
50	93	40	61	82	54	13	43	9	129
75	107	41	60	84	49	9	43	8	136
100	106	65	55	77	50	7	46	8	141
125	101	54	55	82	49	7	47	9	142
LSD* (0.01)	8	13	NS	13	NS	NS	8	NS	9
CV (%)	5	18	10	9	10	58	11	24	4

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

Table 7. Grain sorghum yields after cover crop in cover crop-grain sorghum-wheat rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)								
Rate	1996	1997	1998	1999	2000	2001	2002[1]	2003	2004
lb/a									
0	73	26	69	81	68	17	22	21	92
HV[2]	99	36	70	106	54	17	21	16	138
50	111	52	73	109	66	13	25	15	135
WP[2]	93	35	72	95	51	19	23	17	138
100	109	54	67	103	45	12	25	14	136
SC[2]	94	21	72	92	51	19	19	19	94
LSD* (0.01)	13	14	NS	21	16	6	NS	5	19
CV (%)	8	22	13	12	16	21	20	22	9

[1] Yields affected by hot, dry conditions in July and bird damage.
[2] HV=hairy vetch, WP=winter pea, SC=sweet clover.
* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

EFFECTS OF TERMINATION DATE OF AUSTRIAN WINTER PEA WINTER COVER CROP AND NITROGEN RATES ON GRAIN SORGHUM AND WHEAT YIELDS

William F. Heer and Rhonda R. Janke

Summary

The effects of the cover crop most likely were not expressed in the first year (1996) grain sorghum harvest (Table 8). Limited growth of the cover crop (winter peas), due to weather conditions, produced limited amounts of organic nitrogen. Therefore, the effects of the cover crop were limited and varied when compared with those of fertilizer N. The winter pea plots were planted after the wheat crop for 1998 was harvested in June, and were terminated the following spring, before the 1999 grain sorghum plots were planted. The N rate treatments were applied and the grain sorghum was planted on June 11, 1999. Winter wheat was again planted on the plots in October of 2000 and harvested in June of 2001. Winter pea was planted in September of 2001 and terminated in April and May of 2002. Grain sorghum was planted in June and harvested in October of 2002. During 2003, this area was in sorghum fallow and the plots were fertilized and planted to wheat in October of 2003 for harvest in 2004.

Introduction

There has been a renewed interest in the use of winter cover crops as a means of soil and water conservation, as a substitute for commercial fertilizer, and for the maintenance of soil quality. One of the winter cover crops that may be a good candidate is winter pea. Winter pea is established in the fall, over-winters, produces sufficient spring foliage, and is returned to the soil before planting of a summer annual. Because it is a legume, there is a potential for adding nitrogen to the soil system. With this in mind, research projects were established at the South Central Experiment Field to evaluate the effect of winter pea and its ability to supply N to the succeeding grain sorghum crop, compared with commercial fertilizer N, in a winter wheat-winter pea-grain sorghum rotation.

Procedures

The research is being conducted at the KSU Research and Extension South Central Experiment Field, Hutchinson. Soil in the experimental area is an Ost loam. The site had been in wheat before starting the cover-crop cropping system. The research used a randomized-block design and was replicated four times. Cover-crop treatments consisted of fall-planted winter peas with projected termination dates in April and May, and no cover crop (fallow). The winter pea is planted into wheat stubble in early September at a rate of 35 lb/a in 10-inch rows with a double disk opener grain drill. Before termination of the cover crop, above-ground biomass samples are taken from a one-square- meter area. These samples are used to determine forage yield (winter pea and other), and forage nitrogen and phosphate content for the winter pea portion. Fertilizer treatments consist of four fertilizer N rates (0, 30, 60, and 90 lb N/a). Nitrogen treatments are broadcast-applied as NH_4NO_3 (34-0-0) before planting of grain sorghum. Phosphate is applied at a rate of 40 lbs P_2O_5 in the row at planting. Grain sorghum plots are harvested to determine grain yield, moisture, test weight, and grain nitrogen and phosphate content. The sorghum plots are fallowed until the plot area is planted to wheat in the fall of the following year. The fertilizer treatments are also applied before planting of wheat. Wheat was planted in this rotation in October of 2003 for harvest in 2004.

Results

Winter Pea and Grain Sorghum

Winter pea cover crop and grain sorghum results were summarized in the Agronomy Field Research 2000 Report of Progress 854, pages 139-142. The grain sorghum yields were similar to the wheat yields in the long- term N-rate study. The first increment of N resulted in the greatest change in yield, and the yields tended to peak at the 60-lb N rate treatment, regardless of the presence or lack of winter pea. Grain sorghum yields for 2002 are presented in Table 8. These yields reflect the later planting date (June 22). The growing season in 2002 favored the later-planted summer crops. The crops emerged after the June 15 hail storm and were not as mature for the August wind storm; thus, they had less lodging and stock damage, resulting in less secondary tillering and sucker heads. This allowed the main head to fill and produce quality grain.

Winter Wheat

The fall of 2000 was wet, after a very hot, dry August and September. Thus, the planting of wheat was delayed until November 24, 2000. With the wet fall, the temperatures were also warm, allowing the wheat to tiller into late December. January and February both had above-normal precipitation, which carried the wheat through a dry March. April, May, and June were slightly below normal in both precipitation and temperature. The wheat plots were harvested on June 29, 2001. Wheat yields reflect the presence of the winter pea treatments, as well as the reduced yields in the grain sorghum for the no-pea treatment plots. Test weight of the grain was not affected by pea or fertilizer treatment, but was affected by the rainfall at harvest time. This is also true for the percentage of nitrogen in the seed at harvest. A concern with the rotation is weed pressure. The treatment with April-termination pea plus 90 lb/ac N had significantly more weeds in it than any of the other treatments had. Except for this treatment, there were no differences noted for weed pressure. Grain yield data are presented in Table 9. With the earlier planting for the 2004 crop, the wheat should have had a better chance to tiller, but the fall was wet and cold, limiting fall growth.

As this rotation continues and the soil system adjusts, it will reveal the true effects of the winter cover crop in the rotation. In the dry (normal) years, the soil water (precipitation) during the growing season most likely will not be as favorable as it was in 1999, and the water use by the cover crop will be the main influence on the yield of the succeeding crop.

Table 8. Winter pea cover-crop and termination-date effects on grain sorghum after winter wheat-cover crop -- sorghum yield, South Central Field, Hutchinson, Kansas .

		Flag leaf		Grain								
		1996		1996			1999			2002		
Date	N Rate[1]	N	P	N	P	Yield	N	P	Yield	N	P	Yield
	lb/a			%		bu/a	%		bu/a	%		bu/a
April[2] N/pea	0	2.5	0.38	1.6	0.26	86.5	1.1	0.32	72.6	1.5	0.38	78.4
	30	2.7	0.44	1.6	0.27	93.9	1.2	0.29	90.9	1.6	0.40	87.5
	60	2.8	0.43	1.7	0.27	82.6	1.5	0.32	106.4	1.8	0.40	82.8
	90	2.8	0.44	1.7	0.25	90.4	1.7	0.34	101.8	1.8	0.35	92.5
April[2] /pea	0	2.4	0.40	1.5	0.29	80.2	1.3	0.31	93.5	1.6	0.37	79.9
	30	2.7	0.39	1.6	0.26	85.7	1.3	0.32	97.4	1.7	0.38	91.1
	60	2.7	0.38	1.7	0.27	90.0	1.5	0.33	105.1	1.8	0.40	87.5
	90	2.9	0.41	1.8	0.23	83.8	1.8	0.32	97.9	2.0	0.37	77.2
May[3] N/pea	0	2.1	0.39	1.4	0.30	81.4	1.1	0.34	40.5	1.6	0.41	56.4
	30	2.4	0.39	1.5	0.28	88.1	1.1	0.32	66.6	1.7	0.40	71.6
	60	2.6	0.40	1.6	0.27	90.7	1.2	0.30	93.3	1.8	0.40	71.4
	90	2.6	0.40	1.6	0.26	89.6	1.4	0.31	105.9	1.9	0.40	82.6
May[3] /pea	0	2.3	0.40	1.4	0.29	85.0	1.2	0.31	92.4	1.7	0.39	74.8
	30	2.5	0.40	1.5	0.31	92.4	1.3	0.31	97.7	1.8	0.38	81.5
	60	2.6	0.38	1.6	0.26	92.9	1.5	0.30	112.3	1.9	0.36	86.8
	90	2.7	0.41	1.6	0.25	90.5	1.5	0.32	108.7	1.8	0.39	90.3
LSD (P=0.05)		0.2	0.02	0.1	NS	8.9	0.2	0.04	16.0	0.14	0.05	14.0

[1] Nitrogen applied as 34-0-0 after pea termination, before planting grain sorghum on June 17, 1996, June 11, 1999, and June 22, 2002.
[2] Early April termination. Actual termination May 16, 1996, April 21, 1999, and April 13, 2002.
[3] Early May termination. Actual termination June 4, 1996, May 19, 1999, and May 25, 2002.

Table 9. Winter pea cover-crop and termination-date effects on winter wheat after grain sorghum in a winter wheat-winter pea cover crop-grain sorghum rotation, South Central Field, Hutchinson, Kansas, 2001.

Termination Date	N Rate[1]	Grain Yield 2001	Grain Yield 2004	Grain N 2001	Grain N 2004	Grain P 2001	Grain P 2004	Plant Height 2001	Plant Height 2004	Lodging 2004	Weeds 2001
	lb/a	bu/a		%				inch		%	rating[2]
April[3] N/pea	0	37	58	2.32	1.73	0.38	0.38	26	31	0	3
	30	40	56	2.43	1.94	0.36	0.36	28	29	3.8	5
	60	39	51	2.30	2.23	0.38	0.34	30	30	17.5	4
	90	37	44	2.24	2.27	0.38	0.35	30	29	35.0	7
April[3] /pea	0	39	58	2.38	1.89	0.35	0.38	26	29	3.8	3
	30	42	55	2.33	1.97	0.37	0.34	27	32	8.8	4
	60	36	50	2.22	2.23	0.40	0.33	29	31	37.5	7
	90	37	47	2.18	2.46	0.37	0.32	28	30	60.0	10
May[4] N/pea	0	38	57	2.30	1.79	0.37	0.36	26	30	1.3	3
	30	38	53	2.32	2.13	0.37	0.34	26	30	32.5	5
	60	34	46	2.42	2.30	0.35	0.35	30	30	46.3	7
	90	38	44	2.24	2.37	0.35	0.35	30	30	50.0	8
May[4] /pea	0	42	60	2.37	1.91	0.40	0.36	26	30	3.8	4
	30	37	50	2.38	2.19	0.38	0.35	28	30	27.5	6
	60	35	45	2.38	2.33	0.37	0.33	29	30	42.5	9
	90	37	45	2.34	2.42	0.38	0.34	28	30	42.5	10
LSD (P=0.05)		5	6	0.18	0.12	0.03	0.03	2	1	24	3

[1] Nitrogen applied as 34-0-0 before planting winter wheat.
[2] Visual rating 1= few to 10=most. Insufficient weeds were present in 2004 to rate.
[3] Early April termination.
[4] Early May termination. There was minimal lodging in 2001.

TABLE OF CONTENTS

PRECIPITATION MAPS: CAN THEY SUPPORT A REGIONAL WATER BALANCE?

R.M. Aiken, D.J. Inloes, and J.M.S. Hutchinson

Summary

Precipitation drives agricultural productivity in semiarid regions, potentially adding $20/acre in value of grain production for each inch of crop water use exceeding a yield (or break-even) threshold. Storm Total Precipitation (STP) images, derived from radar systems reporting base reflectivity, provide an independent measure of water in the atmosphere that is likely to fall as precipitation. Comparisons with ground observations indicate rank correlations as large as 0.8. A metric for information content of STP images is proposed: the product of rank correlation and the fraction of sites correctly classified as precipitation, relative to ground observation reports. A review of potential techniques to extract further information from STP images and to combine information from ground observations suggests that base reflectivity provides a feasible means of mapping precipitation, with a specified degree of uncertainty.

Introduction

Precipitation drives land productivity and the agricultural economy of semiarid regions. Grain yields of rain-fed and irrigated crops tend to increase, after a yield threshold is met, with water available during the growing season (Nielsen, 1995; Khan, et al. 1996). Knowledge of precipitation timing, amounts, and location can support land management and enhance agricultural economies.

Networks of cooperative observer sites, coordinated by NOAA, provide daily precipitation observations. But each observation site represents 400 square miles, on average, for the Goodland, Kansas, Weather Forecast Office (WFO). It is commonly recognized that precipitation can vary dramatically within a 400-square-mile area. Information about precipitation amounts at smaller spatial scale would improve knowledge of water available to cropping systems.

Base reflectivity, derived from National Weather Service (NWS) radar systems, indicates the quantity of water in the atmosphere that is likely to fall as precipitation. The NWS operates more than 100 of these stations in the continental United States, each covering an area of 150-mile radius. The objective of this research was to evaluate the utility of base reflectivity to represent precipitation input to Agricultural Geographic Information Systems that calculate a soil water balance for regions corresponding to NWS WFO service areas.

Procedures

Ground observations (from 1999 to 2003) reported at 160 sites covered by the Goodland, Kansas, WFO were provided by the High Plains Climate Center (HPCC). Observers were instructed to report daily observations at 7:00 a.m. local time. Precipitation events representing a range of growing-season weather conditions (April through September) were identified from ground observations. Criteria included number of sites reporting precipitation, average precipitation amounts, and number of daily sequential events. Storm Total Precipitation (STP) images, derived from AWIPS, processing of Level II data, were provided by WFO officials as .jpg (24-byte) graphics files for 50 events occurring during the 1999 to 2003 period, April through October. Duration of events averaged 1 hr 13 min and terminated before 7:00 a.m. local time.

Precipitation amounts in each STP image were represented by three integer values (range of 0 to 255) corresponding to red (R), green (G) and blue (B) layers composing the

color image. A color key, common to most images, indicated the range of precipitation amounts corresponding with a set of RGB values. Each pixel in a STP image corresponded with approximately 70 acres of land. STP images were cropped to standard extent and georegistered onto a state-plane base map (Lambert Conformal Projection) by using ESRI ArcGIS 8.3 protocols. Coordinates of county line intersections were compared for the base map and images. Potential accuracy was determined to be within 6 x 10^{-5} decimal degrees (~ 10 m). A database of ground observations, corresponding to the 55 STP images of precipitation events, was linked to the ArcGIS system. This database included coordinates, provided by the HPCC, which identified the location of each observation site. Visual Basic script was developed to extract RGB values from STP images at coordinates corresponding to observation sites. The RGB values were associated with precipitation amounts by using bounding values.

Precipitation reports from ground sites and corresponding image pixels were compared for each observation location. For locations classified as precipitation sites, Spearman's Rank Correlation was performed to evaluate the degree of association between the STP categorical data and the ground observation ordinal data. The midpoints of the classified data range, from STP images, were also regressed on ground observations to provide an indication of relative precipitation scales for the two information sources. Finally, a metric for information content of an STP image was calculated as

$$InfoContent = \rho_S \left(\frac{P_T}{P_T + P_F + NP_F} \right)$$

where ρ_S is the Spearman Rank Correlation coefficient, P_T is the number of sites classified as precipitation, P_F is the number of false precipitation sites, and NP_F is the number of sites falsely classified as non-precipitation sites.

Results

A representative event is shown in Figure 1. Precipitation reported at ground observation sites is represented by a '+', scaled to the reported amount. Precipitation amounts decoded from the corresponding pixel of the STP image are depicted by a green circle, also scaled to the median amount for the category. Thus, when the '+' and the circle symbols are identical in size, the ground observation and data from the image are in agreement.

Opportunities to improve information retrieval from STP images exist. Error may be introduced by georegistration positioning error. The color-rendering process used to generate the STP images resulted in combinations of RGB values not included in the image color key, resulting in incomplete classification of precipitation amounts. Expanding the color range beyond the color key decreased classification failure, but increased ambiguity in classification. The RGB classification could be altered to improve separation among precipitation classes. Combining ground information with STP images for composite precipitation mapping represents another opportunity to improve information retrieval from STP images. This is likely to reduce bias in precipitation mapping. Further, it is possible that information in pixels adjacent to an observation site provide information pertinent to that site. To the degree that spatial correlation exists, the information contained in neighboring pixels may improve the accuracy of classification and subsequent mapping.

Acknowledgments

This work was partly supported through the USDA/ARS Cooperative Agreement, Sustaining Rural Economics Through New Water Management Technologies.

References

Khan, A.H., L.R. Stone, O.H. Buller, A.J. Schlegel, M.C. Knapp, J.-I Perng, H.L. Manges, and D.H. Rogers. 1996. Educational software for illustration of drainage, evapotranspiration and crop yield. J. Nat. Resour. Life Sci. Educ. 25:170-174.

Nielsen, D. C. 1995. Water use/yield relationships for Central Great Plains crops. Conservation Tillage Fact Sheet #2-95. USDA-ARS, Akron, Colorado.

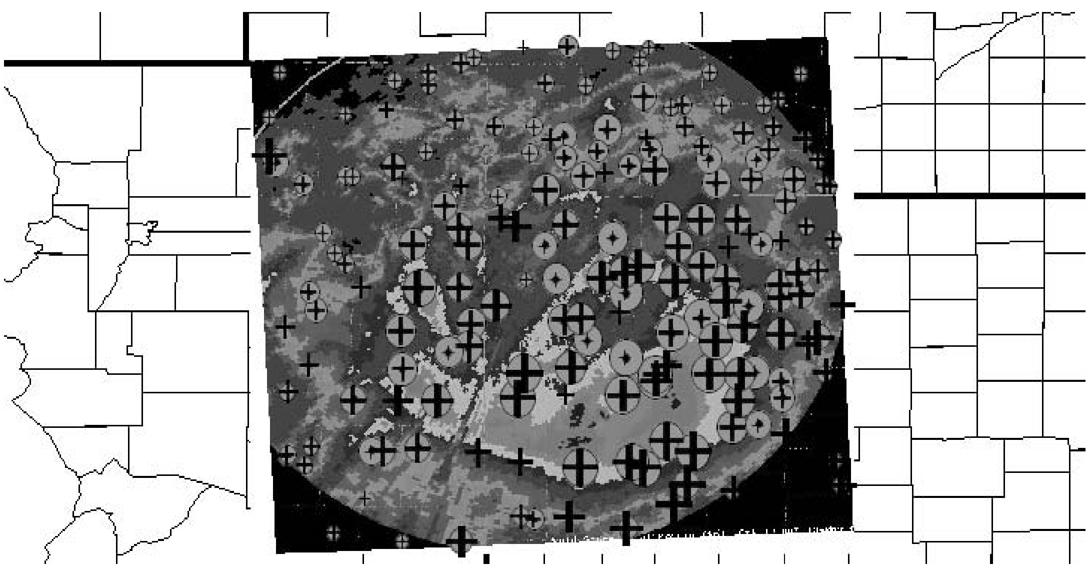


Figure 1. A representative precipitation event, depicting ground observation sites (+) and STP image data (circle). When the + and the circle are the same size, the observation and the STP data are in agreement.

DRYLAND STRIP-TILL PRODUCTION

B.L.S. Olson and R. Aiken

Summary

Interest in strip tillage has risen over the past few years. Questions about whether strip tillage is beneficial on dryland fields is a major concern for producers evaluating this new process. To provide answers to some of the questions producers have, a field study was initiated in the fall of 2003. The objectives of this research were to compare no-till with strip-till fertilizer treatments applied in the fall, winter, and spring. Results from the first year would suggest some benefit to strip tillage over no-till for corn and sunflower, whereas there was no difference among treatments for grain sorghum. For corn, there was variability in the yield from the strip-till treatments: the winter strip-till treatment yielded 21 bushels more than the no-till did, but neither the fall strip-till or spring strip-till treatments yielded more than no-till. With sunflower, the spring and winter strip-till treatments yielded more than no-till. Far-reaching conclusions should not be drawn from results from one year. Instead, these studies will be duplicated next year to see if the results are similar. But these results do provide valuable information on dryland strip-till production in western Kansas on fields with higher-than-normal average rainfall (April to September 2004 - 20.51 inches, Average - 17.79 inches).

Introduction

Strip tillage is a tillage process by which a six- to ten-inch strip of ground is tilled. The basic configuration consists of a coulter, disks, and a sub-surface knife for injecting fertilizer. Questions from farmers about whether dryland strip tillage is a viable production option in northwestern Kansas have arisen over the past few years. Some of the benefits to strip tillage may include warming of the ground in the spring, which provides an ideal environment for seedling crops, and destruction of compaction zones, which are prevalent in western Kansas fields. Because the ground is worked, however, moisture loss could negate any benefit that strip tillage could provide on dryland fields. Therefore, the objectives of this research were to compare no-till to strip-till fertilizer treatments applied in the fall, winter, and spring.

Procedures

Research was initiated on a field of wheat stubble half a mile east of Quinter, Kansas, in the fall of 2003. Previous cropping history indicates the field had been in no-till for the previous five years. A fall-applied strip-till treatment of 50 lbs/acre of N applied as 28% UAN was strip-tilled on December 1, 2003. On January 23, 50 lbs/acre of N applied as anhydrous ammonia was strip-tilled for the winter treatment. For the spring treatment, 50 lbs/acre of N applied as 32% UAN was strip-tilled on April 19, 2004. At planting, an additional 25 lbs/acre of N was applied as urea in a 2x2 arrangement (two inches over from the planted row and two inches in the soil) for all strip-till treatments. For the no-till treatment, 75 lbs/acre of N was applied as urea in a 2x2. All treatments had a total of 75 lbs/acre of N applied. Treatments were applied by using an 8-row strip-till machine. Plot size was eight 30-inch rows wide by 600 feet long. Treatments were randomized across three replications for each crop. Pioneer 33B49 corn was planted on April 28, 2004, at 16,600 seeds/acre. NC+ 5B89 grain sorghum was planted on May 28 at 51,800 seeds/acre. DeKalb DKF 3880 CL sunflower was planted on May 28 at 17,300 seeds/acre. Appropriate pest management measures were taken to

control weeds and head moth in the sunflower. Plots were harvested on October 9.

It was surprising that the site had higher-than-normal average rainfall for the period of April to September (2004 - 20.51 inches, Average - 17.79 inches). The higher-than-average rainfall, along with the cooler-than-normal temperatures for June and July, allowed for adequate moisture to be available to meet the needs of the crops, even though the crops were planted on eighteen inches of subsoil containing available moisture.

Root measurements were taken on eight randomly selected plants from each plot after grain harvest. Roots were extracted carefully from the soil from the winter strip-till treatment for corn and grain sorghum and the spring strip-till treatment for sunflower. Roots were then washed, tagged, and air dried.

Root scores were obtained by evaluating all of the roots from the plot. For corn and grain sorghum, root mass was assessed on a scale of 1 to 5, with 1 equal to greatest root mass and 5 equal to least root mass. Straightness of root mass was gauged on a scale of 1 to 5, with 1 equal to very straight and 5 equal to significant turning. For sunflower, taproot mass was assessed on a scale of 1 to 5, with 1 equal to greatest taproot mass and 5 equal to least taproot mass. Straightness of taproot was gauged on a scale of 1 to 5, with 1 equal to very straight and 5 equal to significant turning. Lateral roots were scored on a scale of 1 to 5, with 1 equal to abundant lateral roots and 5 equal to sparse lateral roots, whereas secondary roots were evaluated on a scale of 1 to 5, with 1 equal to abundant and 5 equal to sparse. The average root score was a compilation of all scores of the roots combined.

Results

Results from the first year would suggest some benefit to strip tillage over no-till for corn and sunflower; for grain sorghum, however, there was no difference among treatments. For corn, there was variability in the yield from the strip-till treatments. The winter strip-till treatment was 21 bushels more than yield from the no-till, but neither the fall strip-till or spring strip-till treatments yielded more than no-till (Table 1). There was no difference in plants per acre between the treatments. Evaluation of the extracted roots showed no difference in root scores from the strip-till treatments, which had similar root mass, straightness of roots, and amounts of lateral and secondary roots, compared with no-till.

In grain sorghum, there was no difference in grain yield (Table 2). End-of-season plant population could not be measured due to the amount of tillering that occurred over the growing season. Root measurements were taken, with root mass and straightness of the root mass greater in the strip-till treatment (Table 4).

With sunflower, two of the three strip-till treatments yielded more than no-till did (Table 3). The numbers of plants per acre were higher in these treatments than in no-till. Larger numbers of seedling survival may be one reason strip-till yielded more. Another reason for the higher yields for the strip-till treatments could be better root development (Table 5). Roots examined from the spring-applied strip-till treatment were straighter, with more lateral growth, than those extracted from the no-till treatment. Although the field had been in no-till for five years before the study, root growth was still impeded, which, in turn, likely affected yield.

Far-reaching conclusions should not be drawn from results from one year. Instead, these studies will be duplicated next year to see if the results are similar. But these results do provide valuable information on dryland strip-till production in western Kansas on fields with higher-than-normal average rainfall (April to September 2004 - 20.51 inches, Average - 17.79 inches).

Table 1. Corn yield, Quinter, Kansas, 2004.

Treatments	Test weight	Moisture %	Population (plts/a)	Bu/a adj. 15.5% moisture	
Winter strip tillage	59.9	14.6	16,843	114	a
Spring strip tillage	59.2	14.3	16,988	101	b
Fall strip tillage	59.4	14.3	16,408	100	b
No-till	59.8	14.3	15,682	93	b
LSD (0.05)	NS	NS	NS	8.6	

Table 2. Grain sorghum yield, Quinter, Kansas, 2004.

Treatments	Test weight	Moisture %	Bu/a adj. 14.0% moisture	
Fall strip tillage	52.9	20.8	107	a
Winter strip tillage	51.8	21.1	106	a
No-till	52.5	19.7	104	a
Spring strip tillage	51.1	20.2	104	a
LSD (0.05)	NS	NS	NS	

Table 3. Sunflower yield, Quinter, Kansas, 2004.

Treatments	Test weight	Moisture %	Oil %	Population (plts/a)	Lb/a adj. 10.0% moisture	
Spring strip tillage	27.3	9.6	38.5	15682	2422	a
Winter strip tillage	28.7	9.3	37.8	12923	2392	a
Fall strip tillage	28.6	9.2	38.4	13649	2127	b
No-till	29.0	9.0	38.2	11180	2090	b
LSD (0.05)	NS	NS	NS	779.7	256.1	

Table 4. Grain sorghum root scores, Quinter, Kansas, 2004.

Treatments	Root Mass	Root Mass Straightness	Lateral Roots	Secondary Roots
Strip tillage	1.3	1.3	1.3	1.3
No-till	4.0	3.0	2	2
LSD (0.05)	1.85	0.93	NS	NS

Table 5. Sunflower root scores, Quinter, Kansas, 2004.

Treatments	Root Mass	Root Mass Straightness	Lateral Roots	Secondary Roots
Strip tillage	3.3	1.7	1.7	2.0
No-till	3.0	3.7	3.0	3.0
LSD (0.05)	NS	1.6	0.9	NS

EFFECT OF TILLAGE ON SOIL WATER RECHARGE AND CROP PRODUCTION

A. Schlegel, R. Aiken, and L. Stone

Summary

The impact of deep tillage (chisel plow or paratill) on soil water recharge during fallow (wheat harvest to sunflower planting) was compared with shallow tillage (sweep plow) or no tillage. Averaged across 6 site years, soil water recharge tended to be slightly less with deep tillage than with surface or no-till, but the differences were less than an inch (4.1, 4.5, 4.9, and 5.1 inches for chisel plow, paratill, sweep plow, and no-till, respectively). Sunflower yields were adversely affected by dry growing conditions and differed widely among site years. Averaged across 4 site years, sunflower yields were highest with no-till (980 lb/a), followed by paratill (841 lb/a), sweep plow (823 lb/a), and chisel plow (805 lb/a). Crop water use also tended to be greater with no-till (12.3 inches) than after tillage (10.1, 10.3, and 10.7 inches for chisel plow, paratill, and sweep plow, respectively).

Introduction

Soil compaction is a topic of renewed interest for producers in Kansas. Compacted zones in soil can be caused by heavy equipment traffic on wet soils (e.g., combine or grain cart) and extend below normal tillage depths. Compaction in the surface soil can be caused by repeated tillage operations, commonly called a tillage pan. Deep tillage is often recommended to alleviate compaction, but there is little information on the impact of deep tillage on soil water storage and subsequent crop production. The objectives of this research were to evaluate the effect of several tillage tools on soil water storage and crop production.

Procedures

The study was initiated after wheat harvest in 2001. Four tillage practices (chisel, paratill, sweep plow, and no-till) were initiated after wheat harvest at three locations (the Sunflower Demonstration site near Goodland and at the Kansas State University Research-Extension Centers near Colby and Tribune). Soil water was measured after tillage after wheat harvest, in the spring at sunflower emergence, and in the fall at harvest. Yields for 2002 are reported for the Colby site only, because drought resulted in crop failure at Tribune and drought, aggravated by poor stands, resulted in crop failure at Goodland. Sunflower yields for 2003 are reported for all sites. The study was continued at Colby in 2004.

Results

<u>2002 Crop Season</u>

Soil water recharge was less for the chisel-plow treatment at both Colby (4-ft profile) and Goodland (10-ft profile), whereas paratill had the least recharge at Tribune. Recharge was greatest for paratill at the Goodland and Colby sites, whereas recharge was greater with sweep plow at Tribune (8-ft profile). Recharge efficiency at Colby (water stored divided by accumulated precipitation) ranged from 29% to 37%, as 12.16 inches of precipitation were recorded from July 13, 2001, through June 10, 2002. In contrast, at Tribune, recharge efficiency ranged from 22% for paratill to 46% for sweep plow, but precipitation during fallow was only 3.28 inches (August 21, 2001, to May 31, 2002). At Colby, available water in the 10-ft profile was 3 inches greater for no-till than for paratill at crop emergence. Soil water at harvest was similar for all tillage treatments at Colby.

Crop water use (WU) was greatest for no-till at Colby. The greater water use occurred during vegetative growth—54% greater than vegetative water use for paratill. These tillage treatments also had greatest leaf area (LAI) at flowering. Greatest yield occurred for paratill. Oil contents were similar for all tillage treatments. Low yield for the chisel-plow treatment may be due to impaired root development and limited soil water depletion (0.84 inches) during seed fill, compared with that of paratill (1.34 inches), sweep plow (1.60 inches), and no-till (2.25 inches).

2003 Crop Season

Soil water recharge was greater for no-till and sweep plow at Colby (10-ft profile) but greatest for chisel plow treatment at Goodland (10-ft profile); paratill had the least recharge at Colby and Goodland. Recharge efficiency at Colby ranged from 23% to 40%, as 19.79 inches of precipitation were recorded from July 26, 2002, through July 1, 2003. Recharge efficiency at Goodland ranged from 39% to 53%, as an average of 14.91 inches of precipitation was recorded at the Goodland WSO and Goodland 19SW stations from July 29, 2002, through June 11, 2003. At Colby, available water in the 10-ft profile was 2.5 inches greater for no-till than for paratill at crop emergence. Soil water at harvest was similar for all tillage treatments at Colby.

At Tribune, soil water recharge was about 1 inch greater with sweep plow or paratill than with no-till or chisel, but soil water in the profile at planting was 8.0 inches for no-till, compared with 7.0 inches for sweep plow, 6.4 inches for paratill, and 5.3 inches for chisel, reflecting the difference in previous-harvest soil water content. Recharge efficiency ranged from 25 to 31%, with no differences between tillage treatments. Precipitation from July 15, 2002, to July 8, 2003, was 19.93 inches; rainfall from July 8, 2003, to sunflower harvest (October 17, 2003) was only 2.27 inches. The abnormally dry summer increased variability while reducing sunflower yield. At harvest, there was essentially no available water left in the profile (<1 inch in 8 ft profile) for any tillage treatment.

Crop water use was greatest for no-till at Colby. This tillage treatment also had greatest leaf area at flowering, biomass productivity, and seed yield. Oil contents were similar for all tillage treatments. At Goodland, crop water use, biomass productivity, and seed yield were greatest for the chisel-plow treatment. Oil content and leaf area were similar for all tillage treatments. At Tribune, water use was greatest for no-till and least for chisel plow. Sunflower seed yield and water use efficiency (WUE) were less with paratill than with other tillage treatments.

2004 Crop Season

Soil water recharge was greater for no-till at Colby (8-ft profile); chisel plow had the least recharge. Recharge efficiency ranged from 34% to 53%, as 11.96 inches of precipitation were recorded from July 7, 2003, through June 24, 2004. Available water in the 8-ft profile was 1.8 inches greater for no-till than for the average of other tillage treatments at crop emergence. Soil water at harvest was similar for all tillage treatments.

Crop water use, leaf area, and seed yield were greatest for no-till. Sunflower seed yield and water use were similar for the other tillage treatments. Oil contents were similar for all treatments. Full expression of tillage effects will likely require more favorable growing conditions.

Acknowledgments

This research was supported in part by the National Sunflower Association. This study benefitted from the capable technical support of Ralph Wolf, Larry Dible, Chris Erickson, Alicia Leavitt and Ivy Ramsey.

Table 1. Soil water recharge, water use, and sunflower productivity in 2002.

Implement	Soil Water Recharge (in)			Results in NWREC, Colby				
	Colby	Goodland	Tribune	WU	Yield	Oil	LAI @ R 5.5	Straight Taproots
				in	lbs/a	%	m^2/m^2	%
No-till	4.20	3.55	1.20	15.72	1340	41.0	2.15	90
Sweep Plow	4.40	3.92	1.50	12.24	1292	41.6	1.99	65
Chisel Plow	3.46	2.56	0.99	10.88	897	42.5	1.79	25
Paratill	4.43	4.36	0.73	11.72	1521	41.9	2.33	60

Table 2. Soil water recharge, water use, and sunflower productivity in 2003.

Implement	Soil Water Recharge (in)			Results at NWREC, Colby			
	Colby	Goodland	Tribune	WU	Yield	Oil	LAI@ R 5.5
				in	lbs/a	%	m^2/m^2
No-till	7.96	7.19	5.01	13.29	1247	32.8	2.38
Sweep Plow	7.27	6.48	6.16	11.41	815	32.5	1.29
Chisel Plow	4.55	7.91	5.02	10.33	1028	32.4	1.85
Paratill	5.39	5.76	6.10	10.83	917	31.2	1.84

Implement	Results at SWREC, Tribune			Results at Goodland			
	WU	Yield	WUE	WU	Yield	Oil	LAI@ R 5.5
	in	lb/a	lb/in	in	lbs/a	%	m^2/m^2
No-till	9.58	851	91	8.25	248	35.2	0.55
Sweep Plow	8.88	881	100	8.16	250	35.0	0.66
Chisel Plow	7.80	812	102	9.23	448	34.7	0.74
Paratill	8.41	560	67	7.85	336	35.2	0.70

Table 3. Soil water recharge, water use, and sunflower productivity in 2004.

Implement	Recharge	WU	Yield	Oil	LAI @ R 5.5
		in	lb/a	%	
No-till	6.38	14.69	1215	33.8	3.35
Sweep Plow	4.77	12.96	879	32.7	3.00
Chisel Plow	4.02	12.17	951	33.8	2.84
Paratill	5.02	12.77	893	33.6	2.49

PRECISION MOBILE DRIP IRRIGATION VERSUS DROP-NOZZLE IRRIGATION

B.L.S. Olson, D. Rogers, and F. Lamm

Introduction

Precision mobile drip irrigation is an irrigation system in which drip hoses are attached to a center-pivot sprinkler and are dragged on top of the ground. The placement of water by the hoses on the ground could potentially increase irrigation efficiency, compared with a standard drop-nozzle system. In addition, problems associated with wet wheel tracks should be reduced. But drag hoses lying on the ground could cause more management concerns for farmers. One example would be animal damage to the drip hoses, which disrupts even water distribution. The objectives of this study were to compare yield from corn irrigated by using precision mobile drip irrigation (PMDI) with that from sprinkler irrigation with drops (drop-nozzle). The second objective was to discern if the emitters have a reduction in water flow over the season due to clogging. Figure 1 is a sprinkler with the drag hoses attached.

Procedures

The study was initiated on a center-pivot sprinkler located seven miles north and three miles west of Hoxie, Kansas. Three spans, spans 4, 5, and 7, of an eight-span center-pivot sprinkler were divided into two sections. Each section had either the PMDI system installed or the standard drop-nozzle system. With this configuration, three replications of each method were achieved, for a total of six plots. The center-pivot sprinkler is nozzled to apply 300 gpm. Drag-hose spacing on the PMDI system was 60 inches, whereas the spacing on the drop-nozzle system was 120 inches. The entire flow to the center pivot was screen filtered to 50 mesh.

The farmer strip-tilled the field the previous fall and applied 75 lbs/acre of N as anhydrous ammonia and 7-25-0 lbs/acre as 10-34-0. The field was planted on May 2, 2004, with Mycogen 2E685 corn treated with Cruiser at 26,000 seeds/acre, with 50 lbs/acre of N as 32% UAN applied in a 2x2 placement (two inches from the planted row and two inches in the soil). Appropriate pest management measures were taken to control weeds and insects.

Water flow from emitters at the end and 5, 10, and 15 inches from the end of two drag hoses from each plot were captured for one minute on May 26, August 4, and September 13, 2004. Water flow for the entire drag hose was also collected for the two drag hoses, along with the water flow from two drop-nozzles on the same span.

Corn yield was collected in two ways. First, samples were hand harvested from forty feet of each plot. Samples were then dried, threshed and weighed, and yield was calculated on a bu/acre basis. Yield was also collected at harvesting by using a Green Star yield monitoring system for the entire field.

Results

Weather conditions over the summer brought supplemental rainfall, which allowed for respectable yields to be achieved at the site. When comparing hand-harvest yields, there was no significant difference between the PMDI treatment at 233 bu/acre and the drop-nozzle treatment at 236 bu/acre. When looking at the field map (Figure 2) generated by the yield monitor, no discernable pattern was evident between the two systems.

The average emitter output over the summer declined from 214 ml/min on May 24 to 209 ml/min on August 4 to 180 ml/min on September 13. Output from the emitters decreased by an average of 16% through the summer. Variation of the amount of water collected from emitters also increased over the summer (Figure 3). Output from the nozzles from spans 4, 5, and 7 also decreased from an average of 2.51 gpm on May 26 to

2.48 gpm on August 4 to 2.28 gpm on September 13 (Figure 4). The average reduction in flow was 9%. The 9% reduction in flow indicates that the overall pumping capacity of the well was reduced. The additional 7% reduction in flow rate from the emitters can not be accounted for. With these results in mind, this study will be repeated 2005 to determine if results are similar.

Acknowledgments

Appreciation is expressed to DLS Farms, for their cooperation in evaluating these irrigation methods.

Figure 1.

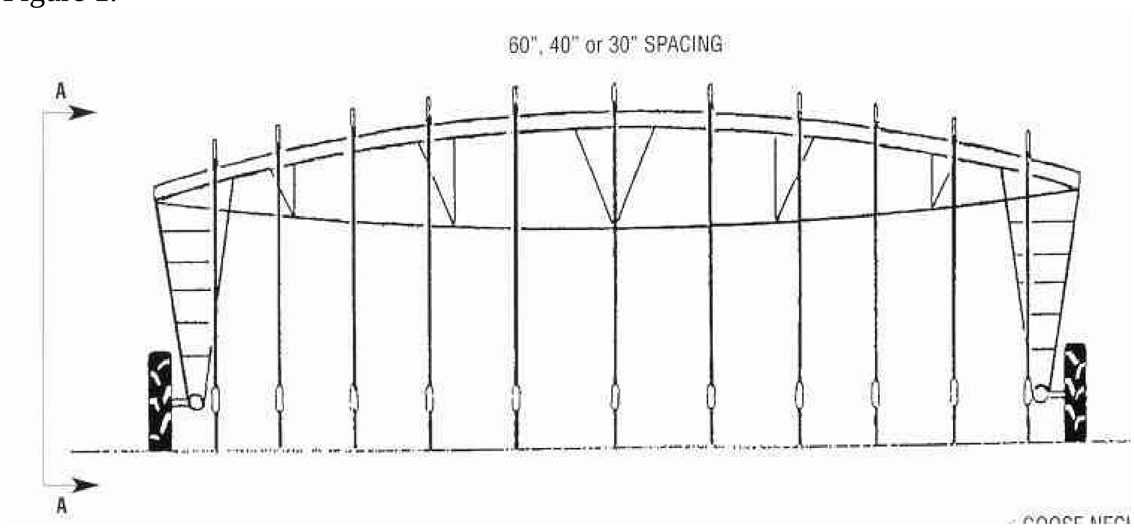


Figure 2.

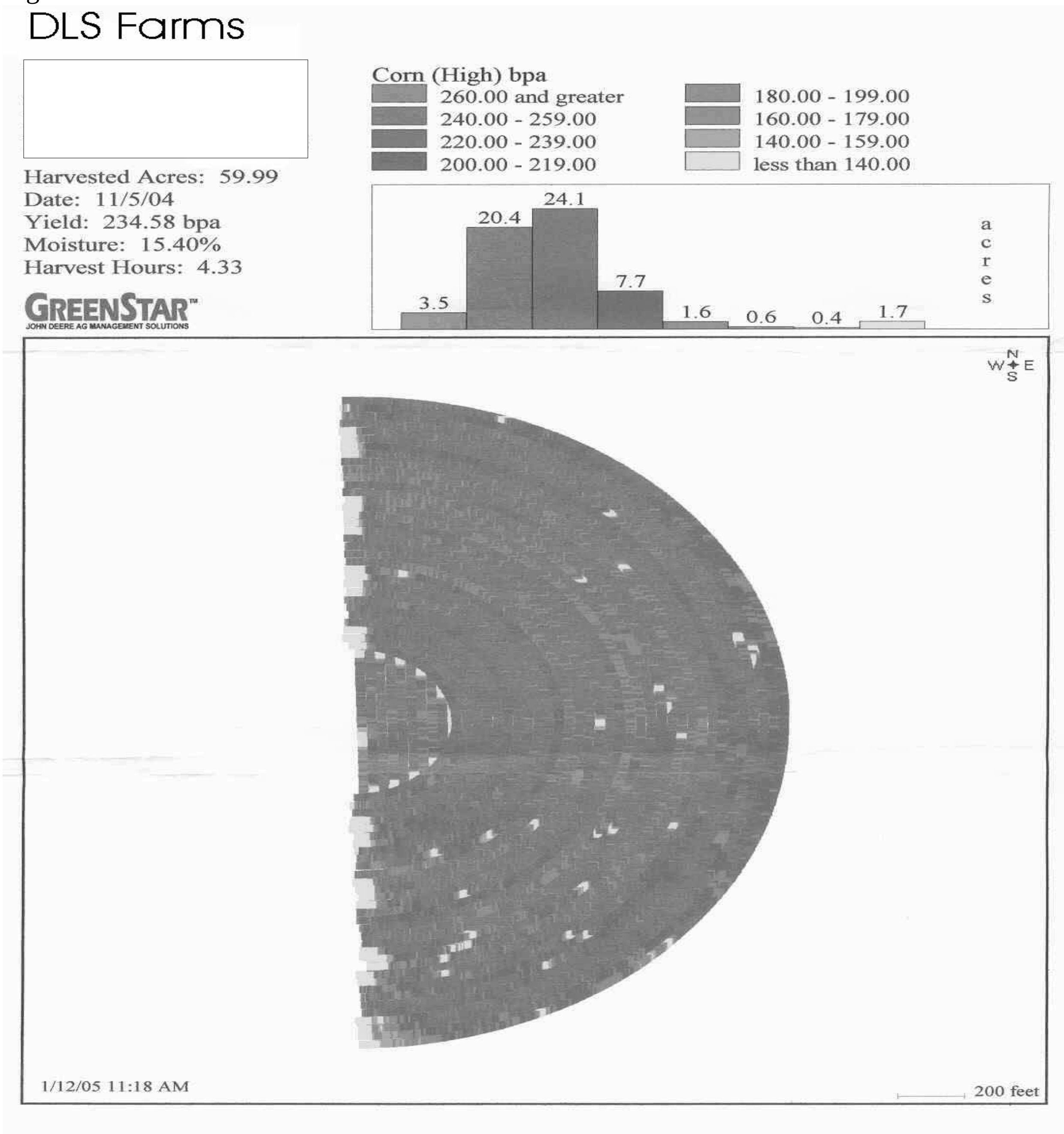

DLS Farms
Corn (High) bpa
260.00 and greater
240.00 - 259.00
220.00 - 239.00
200.00 - 219.00
180.00 - 199.00
160.00 - 179.00
140.00 - 159.00
less than 140.00
Harvested Acres: 59.99
Date: 11/5/04
Yield: 234.58 bpa
Moisture: 15.40%
Harvest Hours: 4.33
3.5
20.4
24.1
7.7
1.6
0.6
0.4
1.7
acres
N
W
E
S
1/12/05 11:18 AM
200 feet

Figure 3.

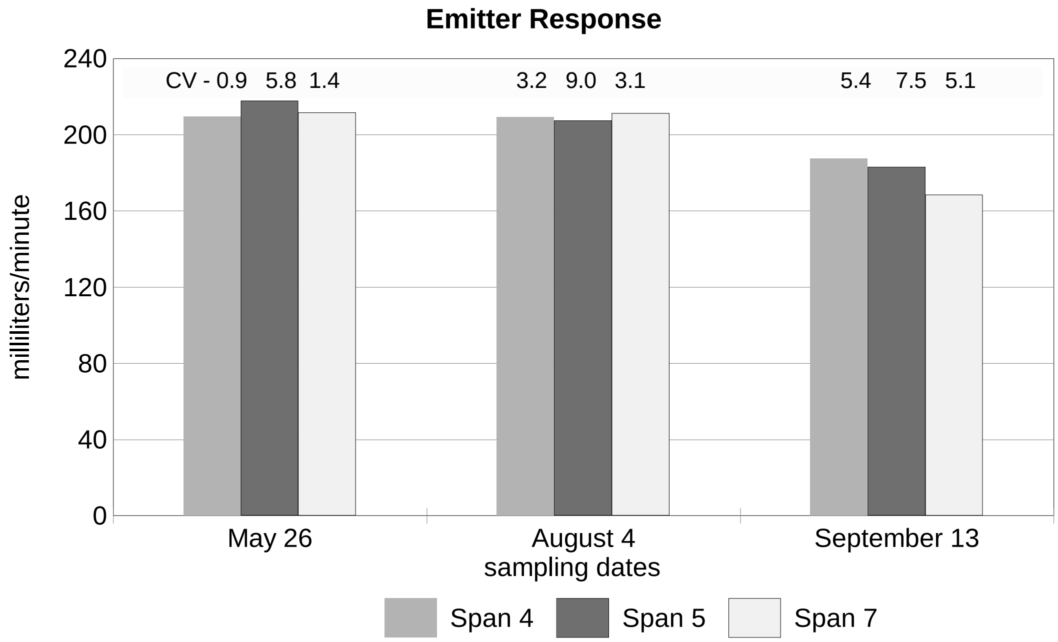
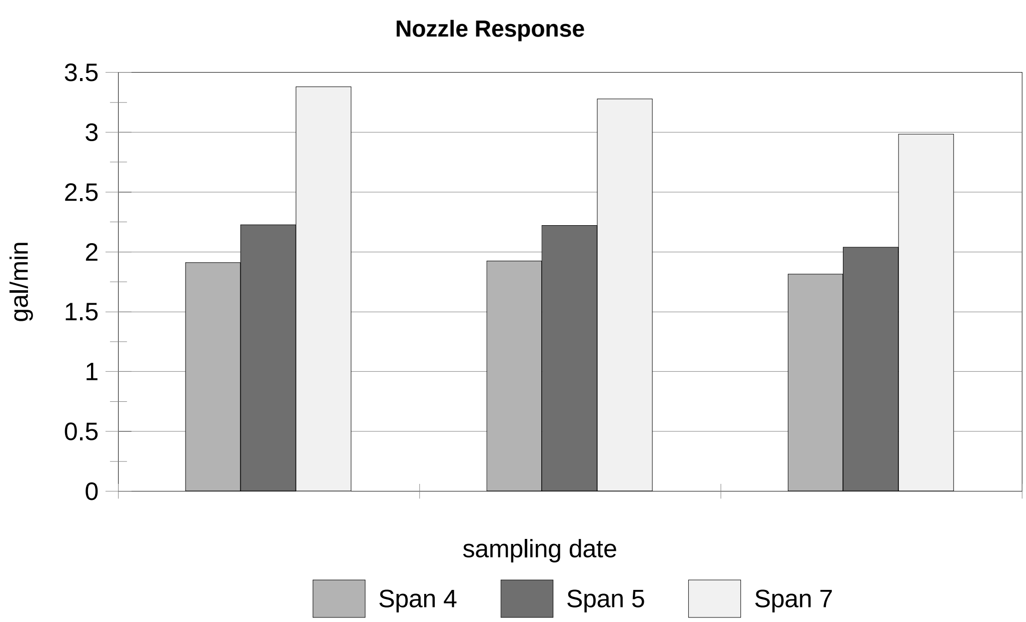


Figure 4.



SUNFLOWER DEVELOPMENT, YIELD, AND WATER USE: MID-OLEIC AND HIGH-OLEIC ISOHYBRIDS

R. M. Aiken and R. D. Stockton

Summary

Are mid-oleic and high-oleic oilseed sunflower hybrids as productive as conventional oilseed hybrids, with limited or sufficient water supply? Three oilseed hybrids, similar except for oleic content (conventional, mid-oleic, or high-oleic), and a standard conventional oilseed (Mycogen SF 187) were grown in 2002 and 2003 under a range of water rates. Crop development, water use, biomass productivity, yield, and seed quality were determined for all treatments. Crop development was similar for all hybrids and rates of water use. Canopy development was limited by available water before flowering (R5). Yield response to seasonal water use was similar to that in other reports (160 lb/ai) for dryland conditions, but decreased as water became more available.

Introduction

Advanced knowledge of sunflower genetics led to hybrids differing in the oleic fraction of fatty acids. Mid-oleic (55% to 75%) and high-oleic (> 77%) oils are suited to health-promoting cooking oils with improved stability for commercial applications. But there is limited information on water requirements of isohybrids that differ primarily in oleic content. Our research objectives were to compare development, seed yield and quality, and water use, in semi-arid cropping systems, of oilseed sunflower isohybrids that differ primarily in oleic oil content.

Procedures

Oilseed sunflower seed was planted (30" rows, 23,000 seeds/acre) into disked and harrowed soil (Keith silt loam), bedded up to 60" centers on June 11, 2002, and June 17, 2003. Soil fertility was supplemented at planting by banding 80 lb/acre N and 30 lb/acre P_2O_5 adjacent and below the seed furrow. The pre-emergence herbicides sulfentrazone (Spartan, 3 oz/acre) and pendimethalin (Prowl 3.3EC, 3 pt/acre) were applied after planting.

Experimental treatments included cultivar and supplemental water. Cultivars included Mycogen SF 187, an established conventional hybrid, and three Mycogen isohybrids, differing primarily in oleic acid content—Conventional (Conv.), NuSun, and High Oleic (H. Ol.). Supplemental water treatments in 2002 were full profile, with either no supplemental water or 3" added at R1, R5, and R7 growth stages. Supplemental water treatments in 2003 were partial profile, with either no supplemental water or 3" added at R1 and R6 growth stages. Flood irrigation was controlled by dikes to prevent runoff from experimental plots.

Growth-stage observations were noted weekly; stand counts (two rows, 17' 5") were noted at mid-vegetative stage and at harvest. Crop water use (soil water extraction plus precipitation and irrigation from emergence to R5.5 and from R5.5 to R9) was determined for all plots. Soil water was determined weekly for cultivar SF 187 in 2002.

Plots were hand-harvested (two rows, 17' 5") for seed and total biomass; the plots were also machine-harvested. Seed was analyzed for moisture content, test weight, weight of 200 seeds, oil content, and oleic fraction (refractometer). Maximum seed set and seed size were determined for four plants from each of duplicate plots that were thinned to a stand of 6,000 pl/A at V8 growth stage in 2002.

Results

Stand establishment was similar for all treatments in 2002 (Table 1), but was

improved by irrigation in 2003 (Table 2). Plant development rates were similar for all cultivars adapted to the Central High Plains in both years. Maximum leaf area occurred during bloom for SF 187 in 2002 (Figure 1). In 2002, leaf area at R5 ranged among cultivars from 3.8 to 5.5 m^2/m^2, with limited response to irrigation (see Table 1). In 2003, leaf area at R5 ranged from 1.0 to 4.1 m^2/m^2, with a substantial response to irrigation (Table 2).

Available water was adequate for full transpiration through early reproductive development in 2002 (R3, on August 8, Figure 1), but available water was less than 50% of soil water-holding capacity for the rest of the growing season. Water use averaged 28.0" for full irrigation and 21.5" for rain-fed crop. Water use was limited by precipitation and limited irrigation in 2003 (Table 2). Combining the 2002 and 2003 results illustrates a similar productive response of all cultivars to available soil water (Figure 2). The initial seed-yield response to seasonal water use is similar to that reported by Nielsen (1995) of 160 lb/ai, but yields increased more slowly as seasonal use of water increased. Factors that may contribute to the limited yield response could include insect pests (Charlet et al., 2002), restrictive soil layers (Schlegel et al., 2002), soil water deficiencies during seed fill (Aiken, 2001) and lack of root aeration during flowering (Unger, 1990).

Acknowledgments

This research was supported, in part by the National Sunflower Association. This study benefited from the capable technical support of Ralph Wolf, Larry Dible, Chris Erickson, Alicia Leavitt, and Ivy Ramsey.

References

Aiken, R.M. 2001. Available soil water, sunflower canopy development and productivity. Proceedings of the 24th Sunflower Research Workshop. National Sunflower Association. Fargo, North Dakota.

Charlet, L.D., R.M. Aiken, R.R. Meyer, and A. Gebre-Amlak. 2002. Management strategies for the sunflower stem weevil 2001. 2002 High Plains Sunflower Research. National Sunflower Association. Fargo, North Dakota.

Nielsen, D.C. 1995. Water use/yield relationships for central Great Plains crops. Conservation Tillage Fact Sheet #2-95. USDA-ARS, Akron, Colorado.

Schlegel, A., R. Aiken, and L. Stone. 2002. Alleviation of soil compaction in dryland cropping systems. 2002 High Plains Sunflower Research. National Sunflower Association. Fargo, North Dakota.

Unger, 1990. Sunflower. *In* Irrigation of agricultural crops, B.A. Stewart and D.R. Nielsen (eds.). American Society of Agronomy (ASA-CSSA-SSSA), Madison, Wisconsin.

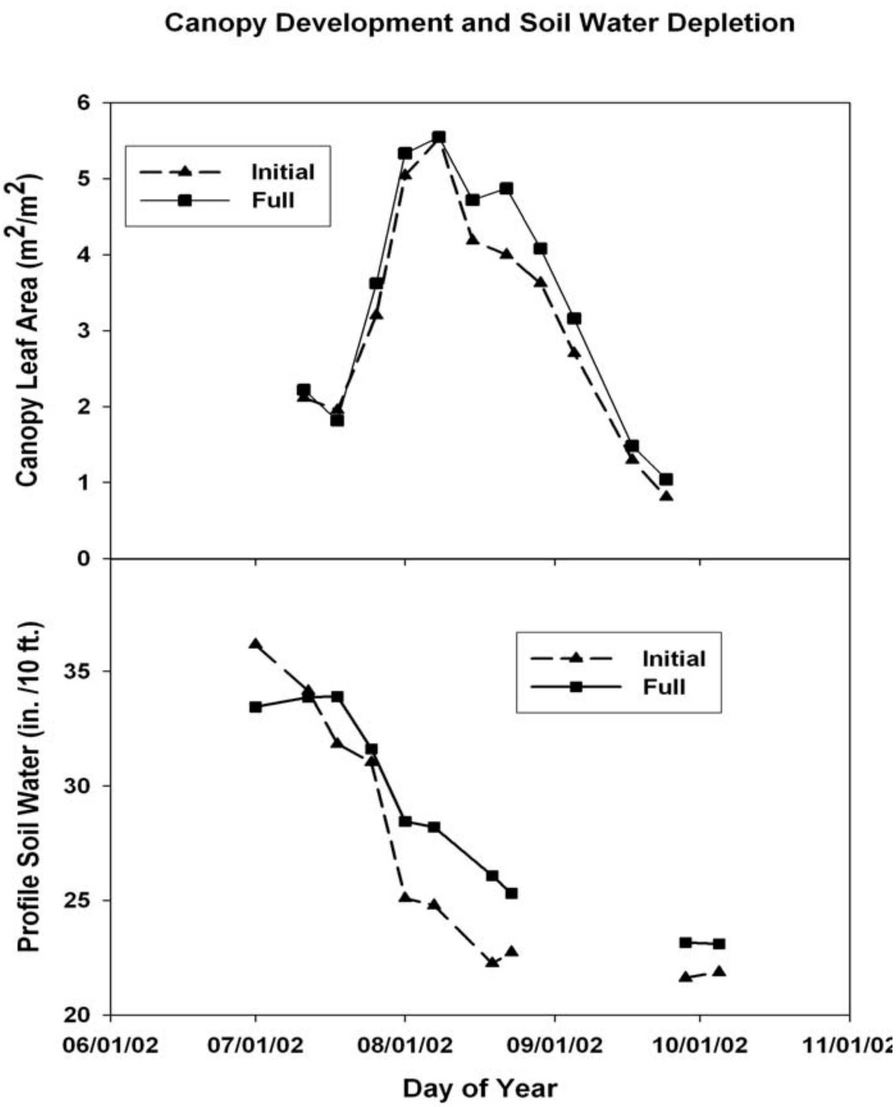


Figure 1. Changes in sunflower canopy leaf area and soil water for a conventional oilseed hybrid (Mycogen SF 187) grown in 2002 with full initial soil water profiles and either no supplemental irrigation (Initial) or 3” applied at R1, R5 and R7 growth stages (Full).

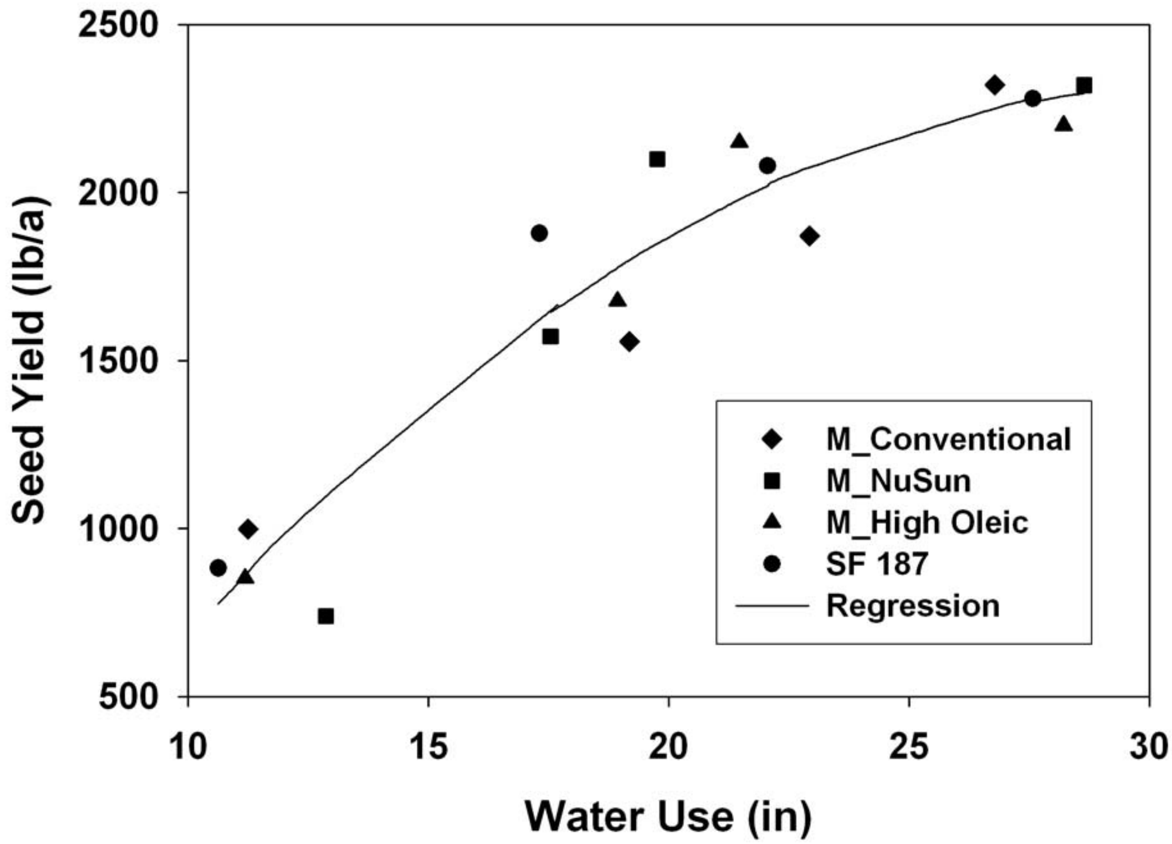


Figure 2. Seed yield response to seasonal water use for three oilseed isohybrids, differing primarily in oleic content (conventional, NuSun, and high-oleic). The regression curve indicates decreasing yield response as water becomes more available.

MANAGEMENT STRATEGIES FOR THE SUNFLOWER STEM WEEVIL

L.D. Charlet and R.M. Aiken

Summary

The sunflower stem weevil can increase harvest losses due to stalk breakage, which can be most severe during drought stress or when high winds occur as plants are drying before harvest. Stem weevil also has been implicated in the transmission of Phoma black stem and charcoal stem rot. Field research evaluated effects of insecticides and timing strategies, over a range of planting periods, on oilseed sunflower yield, weevil densities, weevil parasitoids, longhorned beetle, and larvae of a root-boring moth. Insecticide treatments improved seed yields and reduced populations of stem weevil and root-boring moth larvae for all planting dates in 2002, but not in 2003, when lack of available water and the presence of sunflower moth likely reduced yield potential. A seed treatment reduced stem weevil numbers in 2003, but not in 2002, when a lower rate was applied.

Introduction

The sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte), is a pest of cultivated sunflower and has previously caused yield losses in North Dakota (Charlet et al. 1985, 1997). Since 1993, damage has been reported and populations have been increasing in eastern Colorado, western Kansas, and Nebraska (Armstrong, 1996; Charlet, 2000). Adult sunflower stem weevils emerge from overwintered stalks in mid-to-late June in the northern plains. Females lay their eggs at the base of sunflower stalks. Larvae feed apically in the stems until early August and then descend to the lower portion of the stalk or root crown by late August and excavate overwintering chambers by chewing cavities into the stem cortex. If the larval population in a plant is large, the stem, weakened by tunneling, pith destruction, or overwintering chambers, will break, causing a loss of the entire head before harvest (Rogers and Serda, 1979; Rogers and Jones, 1982; Charlet, 1987b). Stalk breakage due to the sunflower stem weevil is most severe during drought stress or when high winds occur as plants are drying before harvest (Charlet, 1996). The sunflower stem weevil also has been implicated in the transmission of Phoma black stem and charcoal stem rot (Charlet and Gulya, 1984).

This project investigated the timing of chemical treatments with different planting dates on irrigated sunflower. Parasitoids were also studied to determine their effectiveness as biological control agents of the weevil. Because there seems to be an increasing incidence of the sunflower longhorned beetle, *Dectes texanus* LeConte, in sunflower fields within the central plains, evaluation was included for this sunflower pest to determine if the management tactics also reduced its levels. This pest can also cause lodging of sunflower stalks before harvest, and result in losses to the producer. The incidence of a root-boring moth, *Pelochrista womonana* (Kearfott) (Lepidoptera: Tortricidae), has increased, and with it, the number of larvae occurring in the lower stalk and root crown in sunflower from the central Great Plains also have increased. This insect was previously noted as a pest of sunflower in the southern plains (Rogers et al., 1979; Rogers, 1985), so its incidence in the stalks was determined.

Insecticides have been tested against the sunflower stem weevil in both North Dakota (Charlet et al., 1985) and, recently, in the central plains, although in the latter trial's results were not always consistent (Charlet, 2000). More recent trials have shown mixed results, and in some instances weevil densities were not reduced enough to prevent lodging. This was especially true in confection sunflower. Models for degree-day prediction of weevil emergence have been developed for

both the northern and central Great Plains (Charlet, 1987a; Armstrong, 1996), but have not been used for timing of insecticide treatment. Research objectives were to evaluate the effect of insecticides and different timing strategies, over a range of planting periods, on oilseed sunflower yield, weevil densities, weevil parasitoids, longhorned beetle, and larvae of a root-boring moth.

Procedures

Field plots were established at the Northwest Research—Extension Center near Colby, Kansas. All plots included three planting dates. Trials included insecticide application timing based on both plant growth stage and the use of degee-day models for weevil emergence to determine which is most effective. The treatments included a foliar insecticide application of Furadan (carbofuran) at a rate of 1 pt. per acre at growth stage V8 and at either growth stage V12 or to coincide with 581 degree days (base of 6˚C beginning 1 January). A seed treatment of the product Cruiser (thiamethoxam) at a rate of 400g AI per 100 kg of seed also was included in the trials. All treatments included untreated controls and were replicated four times. The degree of control was measured by comparing the percentage of plant lodging and the number of weevil larvae per stalk.

The species of parasitoids present and degree of parasitism of the sunflower stem weevil larvae was determined by rearing the larvae recovered from the different trials. Comparisons could then be made of the degree of biological control of the weevil and whether there was a neutral or negative impact of the various management techniques on the parasitoids of the weevil. All trials included evaluation of their impact on beetle densities. Because the sunflower longhorned beetle overwinters in the stalk, the dissection of the stalks also can determine the effect of the different treatments on the population of this pest.

Results

Insecticide treatments improved seed yields for all planting dates in 2002 (Table 1), but not in 2003 (Table 2); in 2003, supplemental irrigation (4.6” total) was likely inadequate for crop requirements. Large populations of sunflower moth also contributed to lower seed yields. Greatest seed yield in 2002 (Table 1) was obtained for the first planting date, with Furadan application at 581 GDD (base 6 ºC); but seed yields for other planting dates and insecticide applications were similar. Least seed yield was harvested for untreated plots at the first planting date. Lodging was near 100% for these early untreated plots. Greatest seed yield in 2003 (Table 3) was obtained for the third planting date; least yield resulted from the initial planting dates. Treatment effects on parasitoids in 2003 are under laboratory analysis.

Application of Furadan reduced stem weevil populations for all three planting dates in 2002 (Table 3). In 2003, the Furadan applied at V8 was only effective in reducing weevil numbers in the stalk at the first planting date (Table 4). It is possible that inconsistent results are due to limited soil moisture content, which can prevent uptake and movement of the carbofuran within the plant, reducing the product efficacy in killing larvae feeding in the plant. The seed treatment reduced weevil numbers within most of the planting dates in 2003 (Table 4). The seed treatment was less effective in 2002 (Table 3). Part of the reason could be an increase in the amount of chemical applied to the seed in 2003.

The numbers of root-boring moth larvae decreased with both Furadan treatments in all planting dates in 2002 (Table 3), but not 2003 (Table 4); the number of larvae decreased with delay in planting date in both years. Significant differences in longhorned beetles were not evident among treatments (Tables 3 and 4).

Individual plants were tagged, and the seed yield in grams per head was measured. The stalks from these same plants were also tagged so that the number of weevils within the stem could be correlated with the yield from that head. Regression analysis of the yield and weevil numbers revealed no correlation between the two variables (R^2 = 0.17). Thus, it seems that the weevil density in the stalk is not the major factor in determining seed yield. The same analysis was also made for each planting date, but the results were the same.

Acknowledgments

This research was supported, in part, by the National Sunflower Association. This study benefited from the capable technical support of Theresa Gross, Ralph Wolf, Larry Dible, Chris Erickson, Alicia Leavitt, and Ivy Ramsey.

References

Armstrong, J. S. 1996. Development of a degree-day based prediction model for adult sunflower stem weevil, *Cylindrocopturus adspersus*, emergence. Proceedings of the 18th Sunflower Research Workshop, National Sunflower Association, Fargo, North Dakota. pp. 49-51.

Charlet, L. D. 1987a. Emergence of the sunflower stem weevil, *Cylindrocopturus adspersus* (Coleoptera: Curculionidae), relative to calendar date and degree-days in the northern Great Plains. J. Kansas Entomol. Soc. 60: 426-432.

Charlet, L. D. 1987b. Seasonal dynamics of the sunflower stem weevil, *Cylindrocopturus adspersus* LeConte (Coleoptera: Curculionidae), on cultivated sunflower in the northern Great Plains. Can. Entomol. 119: 1131-1137.

Charlet, L. D. 1994. Seasonal abundance and impact of the sunflower stem weevil parasitoid, *Nealiolus curculionis* (Hymenoptera: Braconidae) in the Northern Great Plains. Biol. Control 4: 26-31.

Charlet, L. D. 1996. The biology and management of the sunflower stem weevil: past, present, and future. Proceedings of the 9th Great Plains Sunflower Insect Workshop, National Sunflower Association, Fargo, North Dakota. pp. 44-53.

Charlet, L. D. 2000. Management of the sunflower stem weevil, *Cylindrocopturus adspersus*, in the central Plains. Proceedings of the 22nd Sunflower Research Workshop, National Sunflower Association, Fargo, North Dakota. pp. 1-9.

Charlet, L. D., and T. J. Gulya, Jr. 1984. Stem weevil: biology and interaction with premature ripening. Proceedings of the Sunflower Research Workshop. National Sunflower Association, Bismarck, North Dakota. pp. 18-19.

Charlet, L. D., G. J. Brewer, and B. Franzmann. 1997. Insect pests, pp. 183-261. *In*. Sunflower technology and production. A. Schneiter [ed.], Agron. Ser. 35. American Society of Agronomy, Madison, Wisconsin.

Charlet, L. D., C. Y. Oseto, and T. J. Gulya. 1985. Application of systemic insecticides at planting: effects on sunflower stem weevil (Coleoptera: Curculionidae) larvae numbers, plant lodging, and seed yield in North Dakota. J. Econ. Entomol. 1347-1349.

Rogers, C. E. 1985. Bionomics of *Eucosma womonana* Kearfott (Lepidoptera: Tortricidae), a root borer in sunflowers. Environ. Entomol. 14: 42-44.

Rogers, C. E., and O. R. Jones. 1979. Effects of planting date and soil water on infestation of sunflower by larvae of *Cylindrocopturus adspersus*. J. Econ. Entomol. 72: 529-531.

Rogers, C. E., and J. G. Serda. 1982. *Cylindrocopturus adspersus* in sunflower: overwintering and emergence patterns on the Texas high plains. Environ. Entomol. 11: 154-156.

Rogers, C. E., T. E. Thompson, and O. R. Jones. 1979. *Eucosma womonana* Kearfott (Lepidoptera: Oleuthreutidae): a new pest of sunflower in the southern Plains. J. Kansas Entomol. Soc. 52: 373-376.

Table 1. Seed yields† at NWREC, Colby, Kansas, 2002.

	May 10	May 28	June 6
Untreated	173	2414	2094
Furadan 581 GDD (base 6 ºC)	3399	3045	3044
Furadan V8 to V10	2750	2856	3114
Water Use (in)	30.53	26.72	27.77

†Seed yields adjusted to 10% moisture content, lb/a; Triumph 652.

Table 2. Seed yields† at NWREC, Colby, Kansas, 2003.

	May 13	June 2	June 24
Untreated	1252	1756	1882
Furadan 581 GDD (base 6 ºC)	1325	1535	1967
Furadan V8 to V10	1312	1663	1746
Water Use (in)	19.78	17.59	20.05

†Seed yields adjusted to 10% moisture content, lb/a; Triumph 652.

Table 3. Mean number of sunflower stem weevils, sunflower long-horned beetles, and sunflower root-boring moth larvae in stalks, compared by insecticide treatments and timings for each of three planting dates at Colby, Kansas, 2002.

Planting Date	Treatment and Timing	No. Stalks	Mean Number of Larvae ± SE		
			C. adspersus	D. texanus	P. womonana
May 10	Control	20	43.1 ± 5.0a	0.3 ± 0.1a	5.8 ± 1.0a
	Furadan @ 581 DD	18	11.1 ± 2.2b	0.2 ± 0.1a	1.3 ± 0.3b
	Furadan @ V8-10	19	10.1 ± 1.6b	0.3 ± 0.1a	2.5 ± 0.4b
	Cruiser seed treatment	20	46.2 ± 4.2a	0.4 ± 0.1a	6.8 ± 0.8a
May 28	Control	16	43.8 ± 5.5a	0.3 ± 0.1a	3.2 ± 0.6a
	Furadan @ 581 DD	20	3.2 ± 0.9c	0.3 ± 0.1a	1.1 ± 0.3b
	Furadan @ V8-10	20	7.4 ± 2.5c	0.1 ± 0.1a	0.9 ± 0.3b
	Cruiser seed treatment	16	30.3 ± 4.9b	0.4 ± 0.1a	3.9 ± 1.0a
June 6	Control	20	23.5 ± 4.4a	0.4 ± 0.1a	2.0 ± 0.4a
	Furadan @ 581 DD	20	3.9 ± 0.9c	0.2 ± 0.1ab	0.4 ± 0.2b
	Furadan @ V8-10	20	3.0 ± 0.7c	0.1 ± 0.1b	0.5 ± 0.2b
	Cruiser seed treatment	20	15.5 ± 1.9b	0.2 ± 0.1ab	2.3 ± 0.5a

Means followed by the same letter in a column within each planting date are not significantly different at $P < 0.05$.

Table 4. Mean number of sunflower stem weevils, sunflower long-horned beetles, and sunflower root-boring moth larvae in stalks, compared by insecticide treatments and timings for each of three planting dates at Colby, Kansas, 2003.

Planting Date	Treatment and Timing	No. Stalks	Mean Number of Larvae ± SE		
			C. adspersus	D. texanus	P. womonana
May 13	Control	20	47.5 ± 5.9a	0.4 ± 0.1a	2.5 ± 0.5a
	Furadan @ 581DD; 2 June	20	43.7 ± 5.2ab	0.5 ± 0.1a	2.5 ± 0.5a
	Furadan @ V8-10; 17 June	20	34.1 ± 6.3b	0.4 ± 0.1a	3.3 ± 0.8ab
	Cruiser seed treatment	20	18.0 ± 2.7c	0.6 ± 0.1a	4.5 ± 1.0b
June 2	Control	20	8.9 ± 2.2a	0.6 ± 0.1a	2.4 ± 0.4a
	Furadan @ 581DD; 2 June	20	6.9 ± 1.8a	0.4 ± 0.1a	1.8 ± 0.4a
	Furadan @ V8-10; 11 July	20	6.0 ± 1.3a	0.4 ± 0.1a	1.7 ± 0.4a
	Cruiser seed treatment	20	6.8 ± 1.7a	0.6 ± 0.1a	2.4 ± 0.4a
June 24	Control	20	1.4 ± 0.7a	0.1 ± 0.1a	0.2 ± 0.1a
	Furadan @ 581DD; 2 June	20	0.5 ± 0.2ab	0.1 ± 0.1a	0.2 ± 0.1a
	Furadan @ V8-10; 18 July	20	0.6 ± 0.2ab	0.2 ± 0.1a	0.3 ± 0.1a
	Cruiser seed treatment	20	0.1 ± 0.1b	0.1 ± 0.1a	0.3 ± 0.1a

Means followed by the same letter in a column within each planting date are not significantly different at $P < 0.05$.

DEVIL'S CLAW CONTROL IN SUNFLOWER

B.L.S. Olson and D.E. Peterson

Summary

Devil's claw has been a difficult weed to control in sunflower because there are few herbicides labeled for the crop. With the advent of imazamox-tolerant sunflower, imazamox, sold as Beyond, could be applied to sunflower and potentially control devil's claw. Research was initiated to evaluate devil's claw control with imazamox, and a comparison of adjuvants to be used with imazamox, a nonionic surfactant (NIS) or crop oil concentrate (COC), was incorporated into the study. A two-year study was started in the spring of 2003 in northwestern Kansas, with two sites in each year that had naturally occurring infestations of devil's claw. Visual control ratings for devil's claw and other weeds present in the field were taken at the 2-, 8-, and 12- to 14-true-leaf stage of the devil's claw. Weed-control ratings were consistent with application timing having the greatest effect, regardless of the weed. Early treatments provided 90% control for devil's claw and tumble pigweed and 83% control for puncturevine. A 30% reduction in control was typically observed with later treatment applications. Residual weed control from the early application treatments was not an issue because of the lack of rainfall, which inhibited later weed emergence. No difference between NIS and COC was observed when ratings were taken on devil's claw, puncturevine, tumble pigweed, or on sunflower yield. No injury was observed on the sunflower from the various imazamox applications. Ratings were taken every two weeks, however, and any visual symptoms would have likely disappeared by that time. The Clearfield sunflower system seems to have potential for controlling many troublesome weeds like devil's claw that occur in High Plains sunflower production.

Introduction

Devil's claw is a difficult broadleaf weed to control in sunflower. In 2002, the multi-state National Sunflower Association field survey identified devil's claw as a troublesome weed in High Plains sunflower production. In previous years, a post-emergence herbicide application to control broadleaf weeds was not possible because there were few herbicide options. Post-emergence grass control was possible by using herbicides such as sethoxydim or clethodim, but broadleaf weed control could only be achieved through pre-emergence applications of herbicides such as sulfentrazone, pendimethalin, trifluralin, or S-metolachlor. At best, these herbicides provide only suppression of devil's claw.

With the advent of Clearfield sunflower, possible control of devil's claw could be achieved through a post-emergence application of imazamox. Clearfield sunflower is tolerant to an application of imazamox, which is sold as Beyond. The tolerance this sunflower has to imazamox was actually transferred from a wild sunflower that was growing abundantly in a soybean field north of Topeka, Kansas, through the efforts of Kansas State University faculty and USDA-ARS personnel.

Therefore, the objectives of this research were: 1) evaluate the control of devil's claw by Beyond, 2) determine if devil's claw control is lost if Beyond application is delayed, 3) determine if delaying the Beyond application affects sunflower yield.

Procedures

The study was initiated in the spring of 2003 in northwestern Kansas, where two sites were established for two years on fields with naturally occurring infestations of devil's claw. These sites are distinguished as Site 1,

Site 2, Site 3, and Site 4. A pre-emergence application of pendimethalin at 1,387 g ai/ha (Prowl at 3 pt/acre) was applied to Site 1 on June 4, 2003, and to Site 2 on May 28, 2003, to suppress grasses and some broadleaf weeds. In 2003, early-season rains delayed planting at both sites until June 20. An experimental Clearfield NuSun sunflower hybrid from Croplan Genetics (EXPCL 346CL) was acquired and planted with a final stand of 50,400 seeds/ha (20,400 seeds/acre) at both locations. A burndown application of glyphosate 1,121 g ai/ha (Roundup Original 32 oz/acre) was applied on June 22.

In 2004 on May 29, DeKalb DKF3880 CL was planted at Site 3 and 4 at 42,500 seeds/ha (17,200 seeds/acre). Pendimethalin at 1,387 g ai/ha and glyphosate at 1,121 g ai/ha was applied to Site 3 on June 4 and to Site 4 on June 2. Moisture was poor after planting, causing a two-week delay in sunflower emergence. Extremely dry conditions continued at Site 4, to the point that the site was abandoned with no useable data collected.

Application treatments for imazamox consisted of applying imazamox at 35 g ai/ha (Beyond at 4 oz/acre) and UAN at 1% v/v with either non-ionic surfactant (NIS) at 0.25% v/v or crop oil concentrate (COC) at 1% v/v. Treatments were applied when the devil's claw were at the 2-leaf (July 3, 2003 and June 30, 2004), 8-leaf (July 17 in 2003 and 2004), and 12- to 14-true leaf (July 30, 2003, and August 3, 2004) stage. A control treatment of no herbicide was also included. Treatments were applied by using a 6-tip CO2 backpack sprayer with XR110015, applying 93.5 L/ha (10 gal/acre). Treatments were applied to four 76.2-cm (30-inch) row plots, 30.5 m (100 ft) long in 2003 and to four 76.2-cm (30-inch) row plots, 9.1 m (30 ft) long in 2004. Visual injury ratings were taken every two weeks by using a scale of 0 equaling no injury and 100% equaling plant death.

Each site had four replications, and visible control, crop response, and sunflower yield values were analyzed and separated by using Fisher's Protected Least Significant Difference at the 0.05 level.

Site 1 was not harvested due to drought, but weed-control ratings were taken of devil's claw and tumble pigweed. At Site 2, one replication was not harvested due to sparse devil's claw pressure, but the other replications were hand harvested, and weed-control ratings were taken of devil's claw and puncturevine. At Site 3, devil's claw was the only predominant weed, whereas Site 4 was completely abandoned due to dry conditions.

Results

Weed-control ratings were consistent with application timing having the greatest affect on sunflower yield and weed-control rating, regardless of the weed (Table 1). Residual weed control from early-application treatments was not an issue due to the lack of rainfall, which inhibited later weed emergence. Imazamox applications on older devil's claw typically caused stunting and yellowing of the leaves, but the weeds did grow out of the injury after a few weeks.

No difference between NIS and COC was observed when ratings were taken on devil's claw, puncturevine, tumble pigweed, or on sunflower yield. There was typically only a 2 to 5% difference in control observed when comparing the effect of NIS and COC at the same application timing on a particular weed.

No injury was observed on the sunflower from the various imazamox applications. Ratings were taken every two weeks, however, and any visual symptoms would have likely disappeared by that time.

Applying Beyond to Clearfield sunflower has shown great promise in controlling devil's claw and troublesome weeds that occur in High Plains sunflower production if the herbicide is applied when the weeds are small.

Table 1. Weed-control ratings at two weeks after imazamox treatment (2WAT), and harvest (H) and sunflower yields.

Herbicide*	Rate	Devil's Claw Stage	Devil's Claw Site 1, 2, 3 at 2WAT	Devil's Claw Site 1, 2, 3 at H	Tumble Pigweed Site 1 at H	Puncturevine Site 2 at H	Yield Site 2 and 3	
	g ai/ha	# of leaves	- - - - - - - - - - % control			- - - - - - - - - -	kg/ha	(lb/a)
Imazamox	35	2	90	92	91	83	502	(448)
Imazamox	35	8	62	57	39	47	427	(381)
Imazamox	35	12	40	37	30	35	225	(201)
Control			0	0	0	0	191	(171)
LSD (0.05)			4.5	3.6	9	11	93.2	(83.2)

CORN CANOPY TEMPERATURE AS A STRESS INDEX WITH LIMITED SUBSURFACE DRIP IRRIGATION

R. Aiken and F. Lamm

Summary

Corn canopy temperature, when compared with air temperature and humidity, can indicate stress conditions that may reduce yield potential. Canopy temperature and available soil water were measured for corn under deficit and full subsurface drip irrigation under drought conditions in a pre-irrigated deep silt-loam soil. Infrared thermometers indicated similar heat-stress degree days and canopy-to-ambient temperature gradients for corn under limited and full irrigation. Energy-balance calculations indicated that canopy temperatures of the irrigated crop were equivalent to stomatal resistance ranging from 100 to 200 s m^{-1}. Results are consistent with 3% yield reduction, 7% less seasonal water use, and a 30% reduction in irrigation water application for limited irrigation crop, compared with results for full irrigation.

Introduction

Deficit irrigation can limit corn productivity (Stewart et al., 1975; Musick and Dusek, 1980; Eck, 1986). Active corn canopies tend to be cooler than atmospheric conditons, but corn under water stress tends to be warmer, even warmer than the surrounding air. So canopy temperature (in relation to air temperature) provides a measuer of crop water stress, when adjusted for humidity effects (Jackson, 1982). Plant growth processes can be impaired when canopy temperatures exceed a threshold (Burke and Oliver, 1993). The objective of this research was to use remote sensing of canopy temperature to quantify the duration and intensity of crop water stress for corn under deficit irrigation.

Procedures

The corn crop was established under intensive management for high yields. Irrigation was by alternate-row subsurface drip irrigation (60-inch spacing, 12-m depth; Lamm et al., 1990). Canopy temperatures were measured by infrared thermocouple thermometers (Exergen IRtc.03, germanium lens, 12 inches above canopy, NE and –45° orientation relative to horizon, shielded). Heat-stress degree days (HSDD, °Cd), computed from apparent canopy temperature (T_c) and heat threshold (T_h = 28 °C, or 82 °F, Evett, et al., 2000), were averaged over 12-min intervals.

$$HSDD = \frac{1}{24}\sum^{120} 0.2 \bullet \left(T_c - T_h\right) \qquad [1]$$

The difference between crop canopy and air temperature ($T_c - T_a$) was computed for each observation. This difference was compared with vapor pressure deficit, a measure of atmospheric humidity. A solution to the Penman-Monteith energy balance was also used to simulate $T_c - T_a$, varying stomatal resistance and using weather data.

Results

Available soil water in the surface 8 ft of a deep silt loam soil is depicted for four subsurface drip irrigation regimes during the 2002 to 2004 corn growing seasons (Figure 2). Irrigation was scheduled at daily-to-weekly frequencies to match evaporative demand, limited by irrigation capacities of 0.15 inches daily (equivalent to 1.05 inches weekly) or 0.30 inches daily (full irrigation). Soil water deficits resulted from limited irrigation capacity (0.15 inches daily) in the drought conditions of 2002 and 2003.

Daily variation in the apparent canopy-ambient thermal gradient ($T_c - T_a$) is depicted for four subsurface drip irrigation regimes during August 14, 2002 (Figure 3). The selected day represents active crop canopies during mid-grain fill and a range of soil water deficit conditions (Fig. 2). A Penman-Monteith type energy balance solution for $T_c - T_a$ is depicted for comparison. Solutions assume stomatal resistance (r_s) of 100 or 200 s m^{-1}. Irrigated crop canopies maintained similar canopy temperatures, equivalent to r_s of 100 or 200 s m^{-1}.

Heat-stress units (Eq. 1) were defined by the duration and degree that canopy temperature exceeded a threshold temperature [i.e., 28 ^oC (Evett et al., 2000; Burke and Oliver, 1993)]. Cumulative heat stress is depicted for replicated plots of four irrigation regimes during 2002 to 2004 maize growing seasons (Figure 4). Cumulative heat stress, averaged over years, was 31% and 25 % of the non-irrigated treatment for limited and full irrigation capacities, respectively.

The apparent canopy-ambient thermal gradient was normalized by the humidity factor (vapor pressure deficit) for four subsurface drip irrigation regimes during 2002 to 2004 corn growing seasons (Figure 5) for clear mid-day periods when wind speed exceeded 9 mph. Linear regression indicated that the canopy under full irrigation capacity (0.30 inches, daily) maintained slightly cooler conditions than did canopy under limited irrigation capacity (0.15 inches, daily; coefficients not shown). Warmer canopy conditions for non-irrigated crop during the drought conditions of 2002, 2003 and periods of 2004 indicate significant crop water stress.

Acknowledgments

This research was supported, in part, by the Kansas Corn Commission. Technical assistance of Mark Golemboski, Bob Schwindt, Sue Draper, Alicia Leavitt, Chris Erickson, Nathen Harter, Ivy Ramsey, and Dana Inloes is appreciated.

References

Burke, J.J., and M.J. Oliver. 1993. Optimal thermal environments for plant metabolic processes (*Cucumis satifus, L.*): Light-harvesting chlorophyll a/b pigment-protein complex of photosystem II and seedling establishment in cucumber. Plant Phys. 102:295-302.

Eck, H.V. 1986. Effects of water deficits on yields, yield components, and water use efficiency of irrigated corn. Agron. J. 78:1035-1040.

Evett, S.R., T.A. Howell, A.D. Schneider, D.R. Upchurch, and D.F. Wanjura. 2000. Automatic drip irrigation of corn and soybean. Proceedings: 4th National Irrigation Symposium. American Society of Agricultural Engineers, St. Joseph, Michigan. pp. 401-408.

Jackson, R.D. 1982. Canopy temperature and crop water stress. *In* Advances in Irrigation, D. Hillel (ed.) 1:43-85.

Lamm, F.R., H.L. Manges, D.H. Rogers, W.E. Spurgeon, and M.H. Farmer. 1990. Design and installation of a drip irrigation system for research purposes. ASAE Paper No. 90-2530. American Society of Agricultural Engineers, St. Joseph, Michigan.

Musick, J.T., and D.A. Dusek. 1980. Irrigated corn yield response to water. Trans. ASAE 23(1):92-98, 103.

Stewart, J.I, R.D. Misra, W.O. Pruitt, and R.M. Hagan. 1975. Irrigating corn and grain sorghum with a deficit water supply. Trans. ASAE 18:270-280.

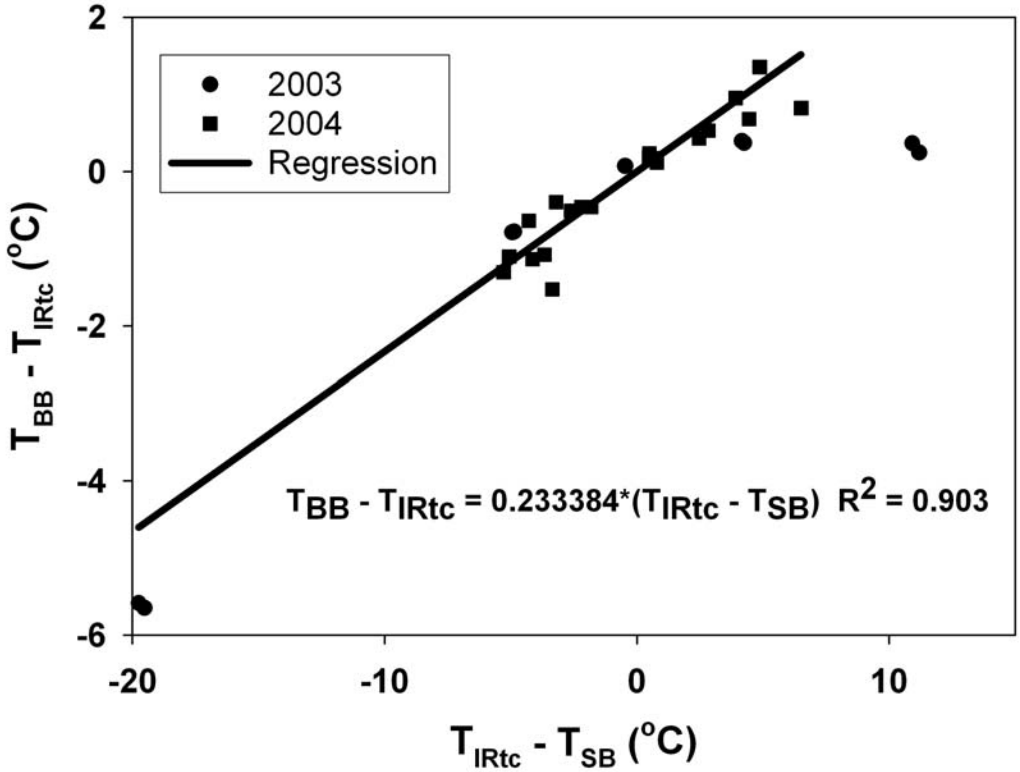


Figure 1. Infrared thermometers were calibrated to improve measurement accuracy. Calibration data from 2003 and 2004 are compared with a relationship developed from 2004 data.

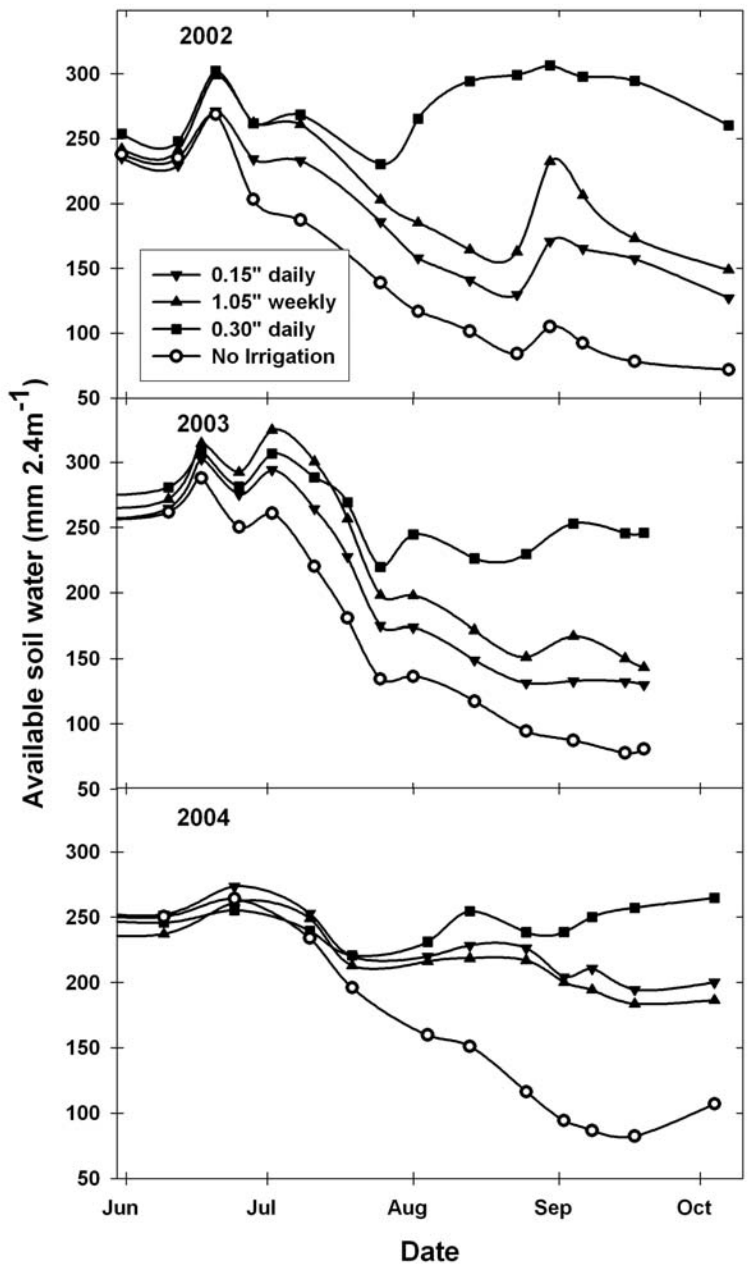


Figure 2. Seasonal trends in available soil water during 2002 to 2004 cropping seasons reflect differences in four irrigation treatments for corn under subsurface drip.

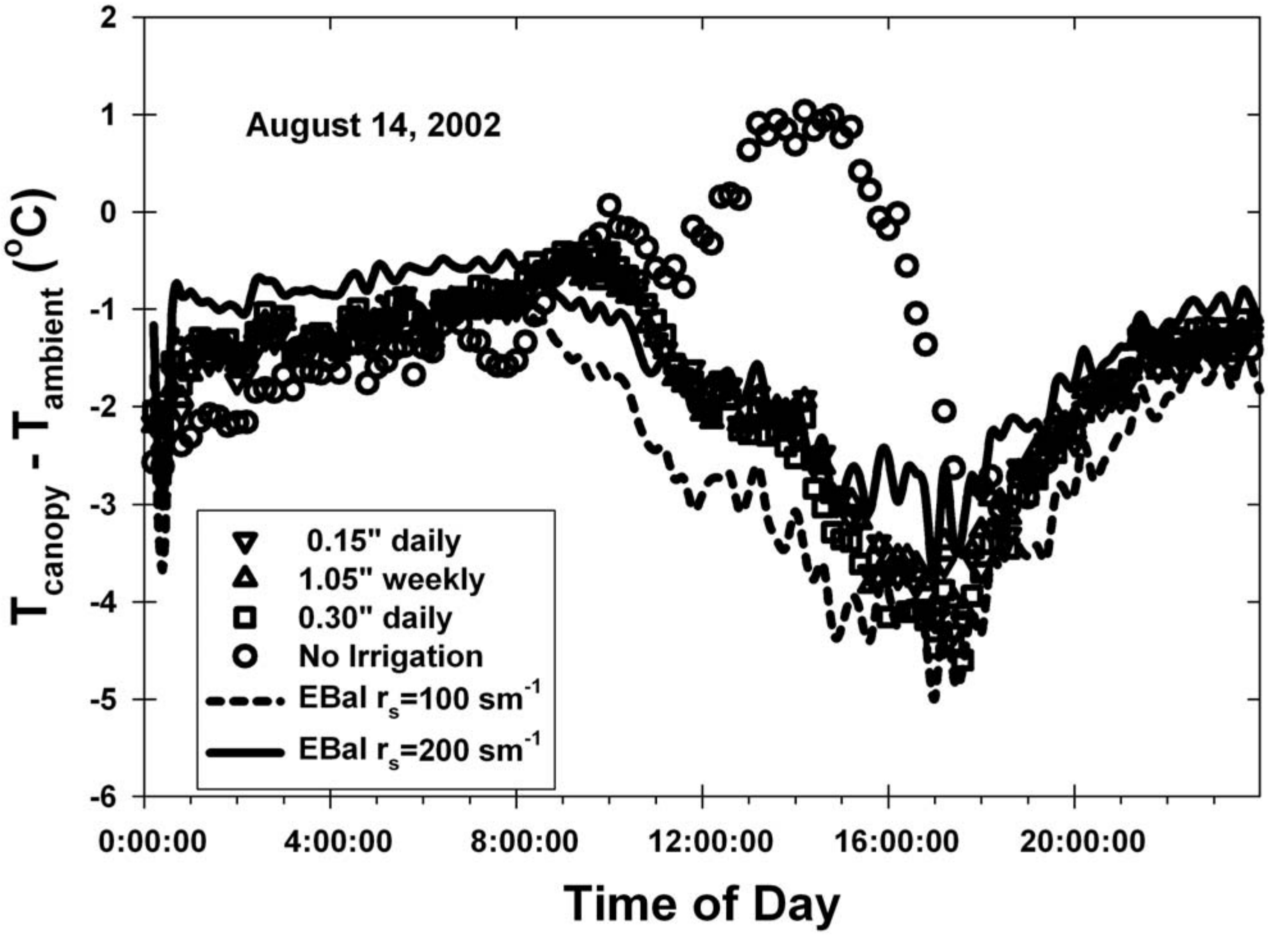


Figure 3. Daily variation in the difference between canopy and air temperature are presented for four irrigation treatments. Full crop canopies were active on this day during the mid-grain fill period.

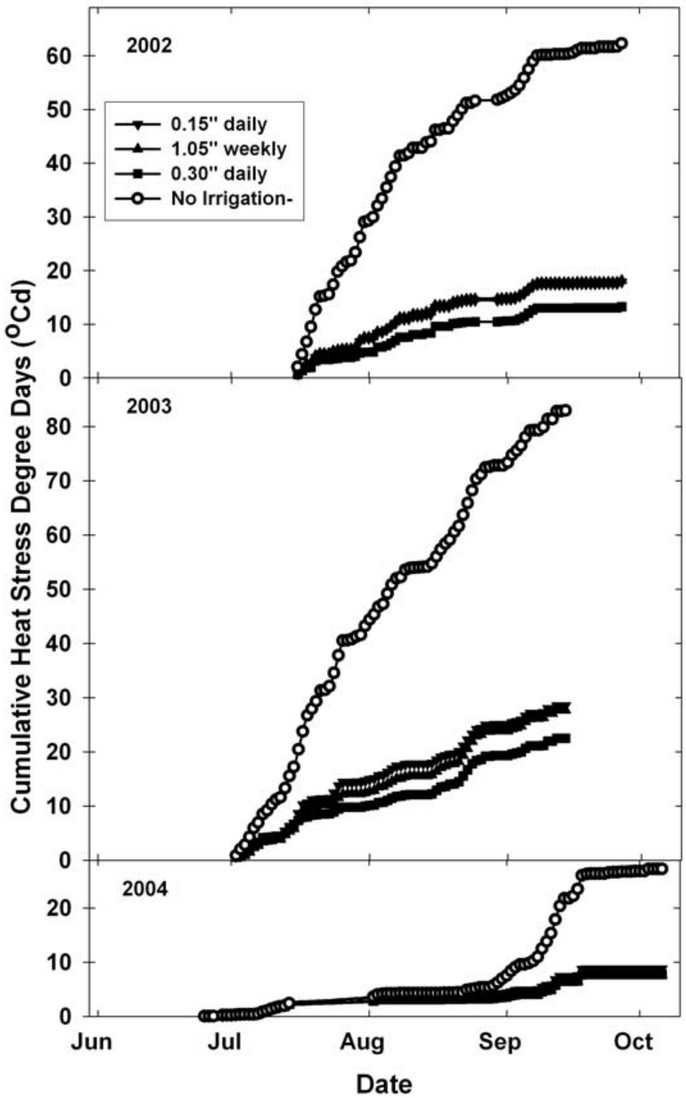


Figure 4. Heat stress was calculated from canopy temperatures that exceeded a threshold temperature (28 °C or 82 °F, Eq. 1). Cumulative heat-stress degree days are presented for corn under four irrigation regimes, using subsurface drip irrigation.

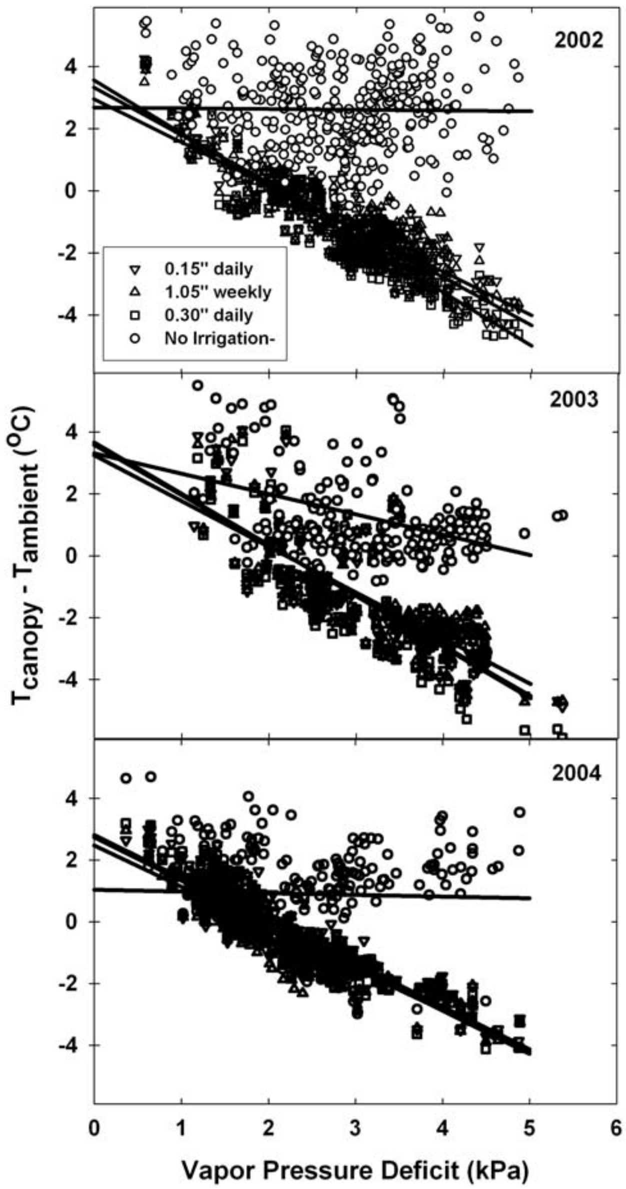


Figure 5. The difference between canopy and air temperature increases with dry conditions (increasing vapor pressure deficit) when available soil water is sufficient to meet crop water requirements. The canopy-air temperature difference is presented for corn, under four subsurface drip irrigation regimes in 2002 to 2004.

Notes

Notes

K-State Research and Extension publications are available online at:
www.oznet.ksu.edu

Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan 66506

SRP 956 December 2005