FIELD RESEARCH 2011

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KANSAS STATE UNIVERSITY AGRICULTURAL EXPERIMENT STATION AND COOPERATIVE EXTENSION SERVICE

FIELD
RESEARCH
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Contents

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East Central Kansas Experiment Field

Introduction

The research program at the East Central Kansas Experiment Field is designed to keep area crop producers abreast of technological advances in agronomic agriculture. Specific objectives are to (1) identify the top-performing varieties and hybrids of wheat, corn, soybean, and grain sorghum; (2) establish the amount of soil loosening and crop residue cover needed for optimum crop production; (3) evaluate weed and disease control practices using chemical, no chemical, and combination methods; and (4) test fertilizer rates, timing, and application methods for agronomic 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 over slowly, permeable clay subsoil. The soil is derived from old alluvium. Water intake is slow, averaging less than 0.1 in./hour when saturated. This makes the soil susceptible to water runoff and sheet erosion.

2010 Weather Information

Precipitation during 2010 totaled 36.26 in., which was very close to the 35-year average (Table 1). However, rainfall during the growing season months of April, June, July, and September was above average. April and June rainfall was more than 1 in. above average and July and September rainfall was more than 2 in. above average. Precipitation for August was 1.54 in. below average. The corn planting season overall was delayed by rainy weather with several replants necessary. The coldest temperatures during 2010 occurred in January with 10 days in single digits. The overall coldest day was -7.9°F on January 10. The summer had 60 days with temperatures exceeding 90.0°F. August was very hot. The hottest 5-day period was August 9 to 13, when temperatures averaged 101.7°F. The overall hottest day was August 13, when the temperature reached 103.5°F. The last freezing temperature in the spring was March 29 (average, April 18), and the first killing frost in the fall was October 29 (average, October 21). There were 213 frost-free days, which is more than the long-term average of 185.

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

Month	2010	35-year avg.	Month	2010	35-year avg.
	------------- in. -------------			------------- in. -------------	
January	0.55	1.03	July	5.49	3.37
February	1.47	1.32	August	2.05	3.59
March	1.48	2.49	September	5.86	3.83
April	4.81	3.50	October	1.91	3.43
May	4.56	5.23	November	1.54	2.32
June	6.38	5.21	December	0.18	1.45
Annual total				36.26	36.78

Impact of Planting at Different Distances from the Center of Strip-till Fertilized Rows on Early Growth and Yield of Corn

K.A. Janssen

Summary

Corn growers who have automatic guidance systems technology such as GPS and auto-steer can plant corn directly on top of previously established strip-tilled fertilized rows, but this might not always be the best location for planting. The objective of this study was to determine the effects of planting corn at different distances from strip-tilled fertilized rows. The locations evaluated were planting directly on top of the strip-tilled fertilized rows and 3.75, 7.5, and 15 in. off the center of the rows. Planting corn on top of freshly tilled strip-tilled fertilized rows negatively impacted yield when plant population was adversely affected. Planting at distances greater than 3.75 in. from strip-tilled fertilized rows reduced early season corn growth, uptake of nutrients, and yield. The best location for planting was within 3.75 in. of the strip-tilled fertilized rows and where the seedbed was firm and moist for planting.

Introduction

Corn growers who have automatic guidance systems technology, such as GPS and auto-steer, have the capability to plant corn in precise locations relative to previously established strip-tilled fertilized rows. Depending on the amount of time that has elapsed between the strip-till fertilizer operation and planting and the rate and forms of fertilizers applied, the best location for planting may not be directly on top of the strip-tilled fertilized rows. For example, strip-tilled fertilized rows could have air pockets under the row, might be dry or cloddy, or could have excessive levels of fertilizer salts or free ammonia. On the other hand, planting too far away from the strip-tilled fertilized rows might reduce benefits from residue management, including warmer loosened soil and rapid root-to-fertilizer contact. The objective of this study was to determine the effects of planting corn at various distances from the center of previously established strip-tilled fertilized rows on fine textured soils in eastern Kansas.

Procedures

Field experiments were conducted on an Osage silty clay loam soil at a field site near Lane, KS, in 2006 and 2008 and on a Woodson silt loam soil at the East Central Kansas Experiment Field at Ottawa, KS, in 2009 and 2010. The planting distances evaluated were directly on top of the strip-tilled fertilized rows and 3.75, 7.5, and 15 in. off the center of the rows. The experiment was designed as a randomized complete block with three to four replications. Plot size ranged from 0.03 to 0.55 acres depending on the site year. The strip-till fertilization application was performed 1 day before planting in 2006, 2 weeks before planting in 2008, 2.5 months before planting in 2009, and 22 days before planting in 2010. Fertilizer was applied at a standard rate, (120-30-10 lb/a). The fertilizer source was a mixture of dry urea, diammonium phosphate, and muriate of potash. Depth of the strip-till fertilizer application was 5 to 6 in. below the row. The planting treatments were evaluated for effects on plant population, early season corn growth, nutrient uptake, and grain yield.

Results

In 2006 and 2008, plant populations were higher for corn planted 3.75 in. off the center of the strip-tilled fertilized rows compared to planting directly on top of the rows (Figure 1). This was expected in 2006 because the strip-till fertilization operation was performed only 1 day before planting and the soil was loose and had air pockets under the row. In 2008, with 2 weeks between the strip-tillage operation and planting, plant population was still increased by planting just slightly off the strip-tilled fertilized rows. No differences in plant populations occurred in 2009, when the strip-till operation was performed 2.5 months before planting. In 2010, when soil was waterlogged and soil temperatures were cold after planting, plant populations were best when planting was directly on the row or 3.75 in. off the center of the rows. Planting 7.5 and 15 in. off the center of the rows significantly decreased plant population.

Early season corn growth at the V2- to V3- and V6- to V7-leaf growth stages tended to be better for corn planted directly on top of the strip-tilled fertilized rows (Figures 2A and 2B). Planting corn 7.5 in. from the center of the strip-tilled fertilized rows reduced early season growth of corn at the V6- to V7-leaf growth stage 20% on average, and planting 15 in. away reduced early season growth 43%. Uptake of plant nutrients (i.e., nitrogen, phosphorus, and potassium) followed a pattern generally similar to that for plant growth (data not shown).

In 2006, corn planted directly on top of the strip-tilled fertilized rows yielded 8% less than that of corn planted 3.75 in. off the center of the rows (Figure 3). This was a result of 1,637 fewer plants/a. In 2008, corn planted 3.75 in. off the center of the strip-tilled fertilized rows had the highest plant population and the highest numerical grain yield. In 2009, when the strip-till operation was performed 2.5 months before planting and the strip-tilled seedbed had plenty of time to settle and become firm, there were no differences in plant population and no differences in yield between planting directly on the strip-tilled rows and 3.75 in. off the rows. In 2010, with very wet soil conditions and cold temperatures after planting, significant reductions in plant populations and early corn growth occurred with planting distances 7.5 and 15 in. from the center of the rows compared to planting directly on or 3.75 in. off the row. Planting 7.5 in. off the center of the strip-tilled fertilized rows reduced plant population 2,616 plants/a, and 15 in. off 6,800 plants/a. Early growth was reduced 38 and 53%, respectively. Interestingly, these effects had only a small impact on yield (15%) because under these conditions nitrogen fertilizer also was lost.

These results suggest that the best location for planting strip-till corn will vary depending on the condition of the strip-tilled fertilized seedbed and the amount of time between planting and when the strip-till fertilizer operation was performed. The best location for planting will need to be assessed for each field situation and year. Corn should be planted in a moist, firm seedbed to obtain best stands and within 3.75 in. of strip-tilled fertilized rows to ensure quick contact between corn roots and fertilizer.

Additional years of testing are needed to determine if these guidelines also might apply to strip-tilled fertilized corn planted on course-textured soils and when higher rates of fertilizer and other sources of nitrogen are applied.

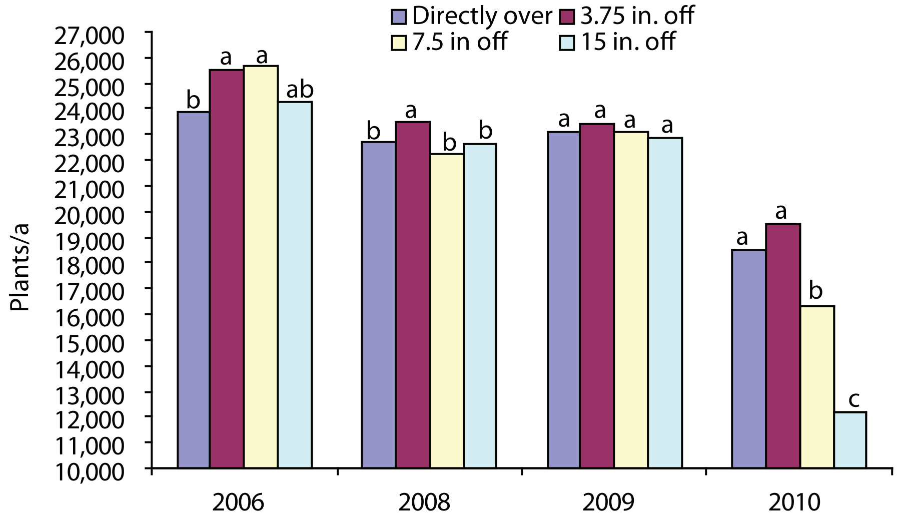

Figure 1. Impact of planting at different distances from the center of strip-tilled fertilized rows on corn plant population.

Means with the same letter within years are not significantly different at $P<0.05$.

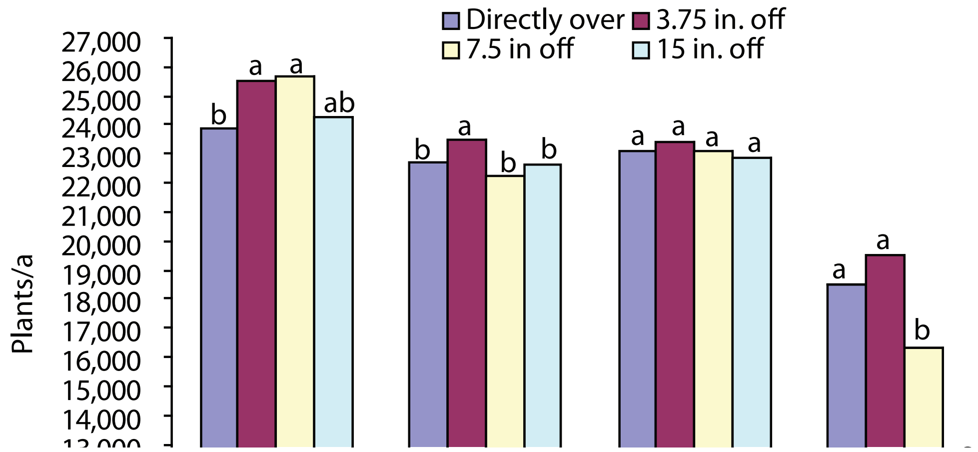

Figure 2. Impact of planting at different distances from the center of strip-tilled fertilized rows on corn growth at the (A) V2- to V3- and (B) V6- to V7-leaf growth stages.

Means with the same letter within years are not significantly different at $P<0.05$. No plant samples were collected at the V2- to V3-leaf corn growth stage in 2010.

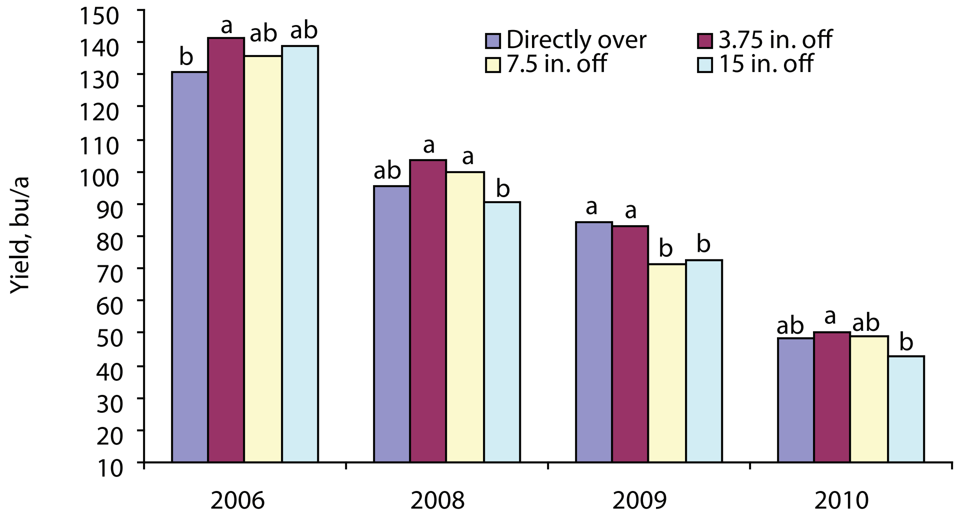

Figure 3. Impact of planting at different distances from the center of strip-tilled fertilized rows on corn grain yield.

Means with the same letter within years are not significantly different at $P<0.05$.

Harvey Country Experiment Field

Introduction

Research at the Harvey County Experiment Field dealt 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 was designed to directly benefit agricultural industries in the area. The focus was primarily on wheat, grain sorghum, and soybean, but research also was conducted on alternative crops such as corn and sunflower. Investigations included variety and hybrid performance tests, chemical weed control, reduced tillage/no-tillage systems, crop rotations, cover crops, fertilizer use, planting practices, and disease and insect resistance and control. This Experiment Field was closed at the end of the 2009 growing season because of the retirement of the Agronomist-in-Charge and severe budget cuts associated with major shortfalls in Kansas tax revenues.

Soil Description

The Harvey County Experiment Field consisted of two tracts. The headquarters tract (North Unit), 75 acres immediately west of Hesston on Hickory Street, is all Ladysmith silty clay loam with 0 to 1% slope. The South Unit, 4 miles south and 2 miles west of Hesston, comprised 142 acres of Ladysmith, Smolan, Detroit, and Irwin silty clay loams as well as Geary and Smolan silt loams. All have a 0 to 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 runoff 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.

2008-2009 Weather Information

October rainfall totaled more than an inch above normal and contributed to a delay in wheat planting in some instances. November precipitation was near or slightly above normal and aided fall wheat establishment. December, January, and February were substantially drier, with a total shortfall of 2.05 and 2.17 in. below normal at the North and South Units, respectively. In March the total precipitation was close to that of the long-term average for the month at the North Unit, but 0.51 in. below normal at the South Unit. Fall mean monthly temperatures tended to be slightly cooler than normal. January and March temperatures were near normal, but the mean temperature for February was 4.2°F warmer than usual. Coldest temperatures of 10°F or less occurred on 7 days in December, 5 days in January, and 2 days in February. Only one of these in late January dropped below zero (-1°F).

During the spring, monthly precipitation varied considerably, with April totals that averaged 2.94 in. above normal for the two locations. On the other hand, May was 2.17 and 1.72 in. drier than usual at the North and South Units. June brought improvement in the moisture outlook, with totals that were 0.19 and 0.54 in. above normal at the respective locations. Mean monthly temperatures in April and May were 3.3°F and 1.8°F below normal, but June was slightly warmer than usual, with a temperature 1.3°F above average. The last spring frost occurred 7 days earlier than normal on April 10.

The summer months brought substantially above-average rainfall in July and September but well below normal rainfall in August. Rainfall totals for the three summer months were similar for the two locations, with an average of 1.16 in. above normal. Mean temperatures during the summer and early fall were notably cooler than usual. For the July-September period, average departure was -5.3°F; in October the average temperature was 9.8°F below normal.

During the growing season, only 2 days in late June and 1 day in mid-July had temperatures at or above 100°F. The first frost of the fall occurred on October 3, but initial freezing temperatures were observed 1 week later, 11 days earlier than normal. In all, the season was quite favorable for row crops.

Table 1. Monthly precipitation totals, Harvey Co. Experiment Field, Hesston, KS[1]

Month	North unit	South unit	Normal	Month	North unit	South unit	Normal
	--------------- in. --------------				--------------- in. --------------		
2008				2009			
October	4.07	4.28	2.95	January	0.04	0.03	0.79
November	1.57	1.93	1.68	February	0.38	0.33	1.08
December	0.41	0.35	1.01	March	2.64	2.20	2.71
				April	5.77	5.79	2.84
				May	2.66	3.11	4.83
				June	4.91	5.26	4.72
				July	5.44	5.25	3.59
				August	2.24	2.04	3.88
				September	3.97	4.29	2.99
12-month total					34.1	34.86	33.07
Departure from 30-year normal at North Unit					1.03	1.79	

[1] Two reports were based on field research conducted at the North unit: *No-Till Crop Rotation Effects on Wheat, Corn, Grain Sorghum, Soybean, and Sunflower*; and *Soil Response to Wheel Traffic and Intensive Cropping Systems in No-Till*. Cover crop research described in remaining reports was conducted at the South Unit.

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 11 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 began in 2004. In 2009, highest wheat yields occurred in rotations in which wheat followed soybean or sunflower, averaging 57.2 bu/a. Wheat following corn produced 7.9 bu/a less. From 2004 through 2009, wheat performed best after soybean, with a top yield of 56.7 bu/a, producing 6.8 and 8.2 bu/a less following corn and sunflower, respectively. Inclusion of [GS] or [SB] in the rotation had no meaningful effect on wheat.

Corn yield in 2009 was highest after wheat, with an average of 141.1 bu/a. Statistically comparable results were obtained for corn after soyean. Corn yields were intermediate following [SB] and lowest after grain sorghum. Long-term corn production followed a similar trend, but with little difference between soybean and [SB] as antecedent crops.

Grain sorghum production was greatest in rotations in which it followed wheat or [SB], averaging 140.5 and 133.4 bu/a, respectively. Grain sorghum yields were intermediate following soybean and lowest following grain sorghum or [GS]. However, during the 6-year period, yields of grain sorghum were nearly identical after soybean vs. [SB]. Similarly, grain sorghum yields after grain sorghum were comparable to those after [GS]. Six-year average yields of grain sorghum after wheat, soybean or [SB], and sorghum or [GS] were 112.4, 105.5, and 90.8 bu/a. Double-crop grain sorghum produced 41.8 bu/a in 2009 and an average of 68.3 bu/a during 2004-2009 without significant rotation effect.

Soybean produced an average yield of 48.8 bu/a in 2009 and 42.5 bu/a over the 6-year period without significant main effect of preceding crop. Double-crop soybean yields ranged from 32.3 to 37.5 bu/a in 2009, with no significant differences among rotations. Long-term [SB] yields in the W-[SB]-C-SB and W-[SB]-GS-SB rotations averaged 21.0 bu/a whereas [SB] in W-[SB]-GS-SF trended slightly higher at 24.5 bu/a.

Sunflower produced the highest yield of 1,857 lb/a in the rotation without double crops. Rotations with [SB] and [GS] resulted in sunflower yields that averaged 250 lb/a less. Long-term sunflower yields followed a similar trend, with relatively small differences among treatment means, especially between rotations with [SB] and [GS].

Introduction

The number of acres devoted to no-till crop production in the United States has risen steadily in recent years, most notably since 2002. According to the Conservation

Technology Information Center, no-till was used on 62.4 million acres, nearly 23% of the cropland in 2004. At that time, Kansas ranked seventh in the nation with 4.2 million acres of no-till annual crops, representing 21.2% of planted acres. Anecdotal information suggests that no-till annual crop acreages have continued to increase. 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 all contribute to no-till adoption by growers. Crop rotation reduces pest control costs, enhances yields, and contributes significantly to successful no-till crop production. Selecting appropriate crop rotations provides adequate diversity of crop types to facilitate realization of these benefits and 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 profitability and reliability of these systems. This experiment includes 10 three-year rotations. Nine of these involve 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. [SB] and [GS] 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 2000. Lime was applied according to soil test recommendations and incorporated by light tillage in late fall of that year. Detailed soil sampling was done in early April 2001, just before establishment of the cropping systems. Average soil test values at that time included pH 6.2, organic matter 2.7%, available phosphorus (P) 46 lb/a, and exchangeable potassium (K) 586 lb/a. Selected plots were sampled for the determination of soil chemical and physical properties following the conclusion of the 2009 growing season. (See *Soil Response to Wheel Traffic and Intensive Cropping Systems in No-Till* on page 16.)

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. The experiment uses a randomized complete block design with four replications of 31 annual treatments representing each crop in each rotation.

Wheat

Wheat planting was delayed by wet weather in October of 2008. Plots to be planted to wheat were sprayed with Roundup WeatherMax in early November to control late-emerged weeds. Overley wheat was planted into corn, soybean, and sunflower stubble on November 4 in 7.5-in. rows at 90 lb/a with a John Deere 1590 no-till drill with single-disk openers. Wheat was fertilized with 120 lb/a N and 32 lb/a P_2O_5 as preplant broadcast 46-0-0 and as in-furrow 18-46-0 at planting. No herbicides were used on wheat in any of the cropping systems. Wheat was harvested on June 26, 2009.

Corn

Wheat plots to be planted to corn were sprayed with Roundup PowerMax in July and Roundup WeatherMax in late September and November of 2008. Corn planting also was delayed significantly by wet weather. Two spring preplant herbicide applications were required to control weeds. These involved Roundup WeatherMax alone or in combination with very low rates of 2,4-D and Clarity as well as Dual II Magnum. Subsequently, weeds were controlled with a single postemergence application of Roundup PowerMax. A White no-till planter with double-disk openers on 30-in. centers was used to plant Pioneer 35P10 RR with Cruiser insecticide at approximately 19,000 seeds/a on May 19, 2009. All corn was fertilized with a blend of 10-34-0 and 28-0-0 providing 30 lb/a N and 30 lb/a P_2O_5, banded 2 in. from the row at planting. Corn after wheat, [SB], and grain sorghum received an additional 95 lb/a N, and corn after soybean received 65 lb/a N as 28-0-0 injected in a band 10 in. on either side of each row in June. Corn was harvested on September 30, 2009.

Grain Sorghum

Wheat plots to be planted to grain sorghum were treated the same as corn during the preceding summer and fall. Soybean and grain sorghum plots to be planted to grain sorghum were treated in April with Roundup WeatherMax plus very low rates of Clarity and 2,4-D_{LVE}. All plots to be planted to sorghum were sprayed with Roundup WeatherMax in May. Roundup WeatherMax plus AAtrex 4L plus Dual II Magnum were applied shortly after grain sorghum planting to manage existing weeds as well as provide residual weed control. Sorghum Partners KS 585 with Concep III safener and Cruiser insecticide was planted at approximately 42,000 seeds/a in 30-in. rows with 30 lb/a N and 30 lb/a P_2O_5 banded 2 in. from the row on June 5. Sorghum after wheat, grain sorghum, [GS], and [SB] received an additional 60 lb/a of N, and grain sorghum after soybean received 30 lb/a of N as 28-0-0 injected in a band 10 in. on either side of each row in early July. Sorghum was harvested on October 28, 2009.

Double-crop grain sorghum plots received an application of Roundup PowerMax just before planting. Pioneer 87G57 with Concep III safener and Cruiser insecticide was planted on June 30 with the same procedures used for grain sorghum. An additional 30 lb/a N were injected in July. Postemergence application of AAtrex 4L plus COC was made with drop nozzles on August 10. Double-crop grain sorghum was harvested on November 6, 2009.

Soybean

Weed control procedures for wheat and row crop plots to be planted to soybean were similar to those for grain sorghum prior to planting. Asgrow AG3802 RR soybean was planted at 120,000 seeds/a in 30-in. rows on May 22. During the season, two applications of Roundup were required for satisfactory weed control. Soybean was harvested on October 7, 2009.

Double-crop soybean had a preplant application of Roundup PowerMax. Asgrow AG3802 RR soybean was planted as a double crop at 120,000 seeds/a in 30-in. rows on June 30. One additional Roundup application was required in late July. Double-cropped soybean was harvested on November 6, 2009.

Sunflower

All sunflower plots were sprayed with Roundup WeatherMax plus very low rates of Clarity and 2,4-D_{LVE} in April, and with Roundup PowerMax alone just before planting. Dual II Magnum was applied preemergence after planting. Triumph s672 sunflower was planted on June 24 at 28,000 seeds/a with 30-30-0 fertilizer banded 2 in. from the row. An additional 40 lb/a N as 28-0-0 was injected in a band 10 in. on either side of each row in July. Baythroid XL at 2.8 oz/a was applied in August for control of head-clipper weevils. Sunflower was harvested on October 2, 2009.

Results

Wheat

Near-normal rainfall in November followed planting, with a total of 1.39 in. during the first 4 weeks. Although delayed somewhat, wheat emergence and stand establishment were excellent in all crop rotations. Wheat heading was somewhat later than usual. No differences in the incidence of wheat diseases were observed among the rotations. Also, no significant differences occurred in wheat maturity among the rotations (Table 1). Plant heights were relatively uniform across the rotations, with no significant differences. Plant N concentration was highest in wheat following corn and soybean, averaging 1.5%, about 40% greater than after sunflower. Highest wheat yields occurred in rotations where wheat followed soybean or sunflower, averaging 57.2 bu/a. The yield advantage was 7.9 bu/a vs. wheat after corn. However, six-year average yields were highest for wheat after soybean at 56.7 bu/a, with a yield decline of 6.8 and 8.2 bu/a following corn and sunflower, respectively. Double-cropping with soybean or grain sorghum in selected rotations did not meaningfully influence wheat yield. Grain test weights averaged 0.45 lb/bu more in wheat after soybean than in wheat after corn and sunflower. Grain protein levels averaged 10.4% for wheat after corn and soybean compared to 9.2% for wheat after sunflower. In general, antecedent crop effects were much more significant than overall rotation effects in determining wheat performance.

Corn

The first significant rainfall of 0.52 in. coincided with corn emergence one week after planting. Final corn populations averaged 20,147 plants/a (Table 2), with no crop rotation effects. Corn reached the half-silking stage 55 to 57 days after planting, earliest in corn after wheat and latest in corn after grain sorghum. Leaf N averaged 2.58% without rotation effect. No lodging occurred. Number of ears/plant and grain test weights were not affected by crop rotation. Corn yields were highest at 141.1 bu/a following wheat and lowest at 114.6 bu/a after grain sorghum in 2009. Double-cropping with soybean after wheat appeared to reduce corn yield by nearly 13 bu/a. Corn after soybean produced grain yield comparable to corn after wheat. Six-year average corn yields tended to be highest following wheat, intermediate following soybean or [SB], and lowest following grain sorghum in the GS-C-SB rotation.

Grain sorghum

During the first 10 days after grain sorghum planting, rainfall totaled 2.46 in. Emergence occurred 5 days after planting. Final populations ranged from 33,700 to 37,200 plants/a, tending to be highest after wheat or soybean and lowest after [SB], [GS], and sorghum (Table 2). On average, grain sorghum reached half-bloom stage at 66 days after planting. Grain sorghum after wheat, soybean and [SB], however, reached this stage 3 to 4 days earlier than after sorghum and [GS]. Leaf N levels ranged from 2.52% to 3.04% among rotations, with the highest mean values in grain sorghum after wheat and [SB] and lowest mean values in grain sorghum following grain sorghum and [GS]. Grain sorghum production ranged from 93.5 to 141.3 bu/a. Yields were highest following wheat and [SB], intermediate following soybean, and lowest after grain sorghum and [GS].

Atypically, grain sorghum after soybean in 2009 produced a yield 14.3 bu/a less than grain sorghum following [SB]. Double-cropped soybean vs. no double-crop did not significantly reduce grain sorghum yields. However, [GS] vs. no double-crop reduced grain sorghum yields by an average of 33.3 bu/a. In 2009, grain sorghum in monoculture produced 14.2 bu/a less than in rotations where it followed [GS]. Grain test weight ranged from 59.8 to 60.8 lb/bu, with highest values in sorghum following wheat, soybean, and [SB]. Number of heads/plant ranged from 1.21 to 1.72, generally following the trend observed for yield. Head counts were highest for grain sorghum following [SB] and wheat, intermediate following soybean, and lowest after grain sorghum and [GS]. No lodging was observed.

Rainfall totaled 1.45 in. during the first 10 days after double-crop grain sorghum planting. Emergence occurred in 5 days, and stands averaged 38,750 plants/a. Yields of [GS] averaged 41.8 bu/a, about 34% of the full-season crop. No crop rotation effects occurred on yield or any of the other variables measured in [GS].

Highest 6-year average yields of 112.4 bu/a were recorded for grain sorghum after wheat, 105.5 bu/a for sorghum after soybean or [SB], and 90.8 bu/a in rotations where it followed sorghum or [GS]. Crop rotation did not affect [GS] yields, which maintained a 6-year average of 68.3 bu/a.

Soybean

Soybean received 0.55 in. of rainfall within 10 days after planting, and emerged in 1 week. Stands were excellent among all rotations (Table 3). Soybean developed plant heights that averaged 33 in., with minor differences among rotations. Soybean reached maturity at 129 to 130 days after planting. Soybean yields averaged 48.8 bu/a without meaningful rotation effects. No lodging occurred.

Double-crop soybean received 1.45 in. of rainfall within 10 days after planting, emerging in 6 days with excellent stands. Plant heights averaged 29 in., again with minor treatment differences. Double-crop soybean reached maturity without treatment effect at 123 days after planting. No lodging occurred. Yields of [SB] ranged from 32.3 to 37.5 bu/a without significant difference among rotations.

Long-term yields of soybean averaged 42.5 bu/a with little or no apparent rotation effect. Double-crop soybean in the W-[SB]-C-SB and W-[SB]-GS-SB rotations averaged 21.0 bu/a during the 6-year period, whereas [SB] in W-[SB]-GS-SF averaged 24.5 bu/a.

Sunflower

A total of 0.64 in. of rain fell during the first 10 days after sunflower planting, with emergence occurring 6 days after planting. Populations averaged 21,185 plants/a. Triumph s672 NuSun short-stature sunflower reached half-bloom stage at 55 days on average, and had an average height of 35 in. (Table 3). As in recent years, sunflower was significantly affected by head-clipper weevils. Approximately 15% of sunflower heads were lost because of head-clipper weevil activity. Lodging was minor. None of these variables were affected by crop rotation. When adjusted for variation in head-clipper damage, sunflower produced the highest yield of 1,857 lb/a in the W-GS-SF rotation. Double-cropping with soybean or grain sorghum after wheat reduced sunflower yield by an average of 250 lb/a. Also, 6-year average yields tended to be slightly lower in the rotations with [SB] and [GS].

Table 1. Effects of crop rotation on no-till wheat, Harvey County Experiment Field, Hesston, KS, 2009

		Yield[2]							
Crop	Crop rotation[1]	2009	6-year avg.	Test weight	Stand	Heading[3] date	Plant height	Plant N[4]	Grain protein
		----- bu/a -----		lb/bu	%		in.	%	%
Wheat	W-C-SB	56.3	56.8	59.3	99	44	36	1.54	10.9
	W-[SB]-C-SB	59.9	57.7	59.6	99	44	36	1.49	10.7
	W-SB-C	49.3	49.9	59.0	94	44	35	1.53	10.3
	W-GS-SB	55.1	57.0	59.5	97	44	36	1.45	10.3
	W-[SB]-GS-SB	57.9	56.9	59.2	99	44	35	1.34	10.2
	W-[GS]-GS-SB	56.2	55.1	59.2	96	46	35	1.47	10.2
	W-GS-SF	58.8	48.7	59.1	98	43	35	1.10	9.1
	W-[SB]-GS-SF	57.5	49.2	58.7	98	42	36	1.03	9.4
	W-[GS]-GS-SF	55.7	47.7	59.0	97	43	35	1.08	9.2
	LSD (0.05)	5.8		0.4	NS	NS	NS	0.20	0.75
	LSD (0.10)	4.8		0.3	NS	NS	NS	0.17	0.62
	Preceding crop main effect means								
	Corn	49.3	49.9	59.0	94	44	35	1.53	10.3
	Soybean	57.1	56.7	59.4	98	44	36	1.46	10.5
	Sunflower	57.3	48.5	58.9	98	43	35	1.07	9.2
	LSD (0.05)[5]	3.2		0.2	NS	NS	NS	0.12	0.43
	LSD (0.10)[5]	2.7		0.2	1.8	NS	NS	0.10	0.36

[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 levels at late boot to early heading.

[5] Estimate based on the average number of crop sequences involving the same preceding crop = 3.0.

Table 2. Effects of crop rotation on no-till corn and grain sorghum, Harvey County Experiment Field, Hesston, KS, 2009

		Yield[2]							
Crop	Crop rotation[1]	2009	6-year avg.	Test weight	Stand	Maturity[3] date	Ears or heads/ plant	Lodging	Leaf[4] N
		----- bu/a -----		lb/bu	1,000/a			%	%
Corn	W-C-SB	141.1	109.5	58.4	20.1	55	0.93	1	2.59
	W-[SB]-C-SB	128.5	106.1	58.4	21.2	56	0.90	1	2.69
	W-SB-C	135.1	105.6	58.9	19.4	56	0.92	2	2.50
	GS-C-SB	114.6	100.4	58.3	19.9	57	0.91	1	2.56
	LSD (0.05)	13.9		NS	NS	0.7	NS	NS	NS
	LSD (0.10)	11.2		NS	NS	0.5	NS	NS	NS
Sorghum	W-GS-SB	141.3	112.0	60.8	37.2	64	1.46	0	2.99
	W-[SB]-GS-SB	133.5	105.6	60.7	34.2	64	1.59	0	3.04
	W-[GS]-GS-SB	105.6	91.2	60.0	34.7	67	1.23	0	2.54
	W-GS-SF	139.3	112.8	60.5	36.4	65	1.60	0	2.86
	W-[SB]-GS-SF	134.7	104.9	60.1	33.7	65	1.72	0	2.81
	W-[GS]-GS-SF	108.5	92.4	59.8	35.6	68	1.21	0	2.52
	GS-C-SB	119.1	105.7	60.5	36.8	65	1.37	0	2.79
	GS-GS-GS	93.5	89.8	59.8	35.6	68	1.21	0	2.52
[Sorghum]	W-[GS]-GS-SB	40.6	67.4	53.4	38.7	57	1.00	0	2.26
	W-[GS]-GS-SF	43.0	69.1	53.8	38.8	57	1.00	0	2.15
	LSD (0.05)	13.6		1.0	2.5	1.4	0.07	NS	0.16
	LSD (0.10)	11.2		0.8	2.1	1.1	0.06	NS	0.13
	Preceding crop main effect means								
Sorghum	Wheat	140.5	112.4	60.6	36.7	64	1.54	0	2.92
	[Soybean]	133.4	105.3	60.4	33.9	65	1.65	0	2.92
	Soybean	119.1	105.7	60.5	36.8	65	1.37	0	2.79
	[Sorghum]	107.7	91.8	59.9	35.2	68	1.22	0	2.53
	Sorghum	93.5	89.8	59.8	35.6	68	1.21	0	2.52
	LSD (0.05)[5]	10.3		0.6	NS	0.9	0.08	NS	0.14
	LSD (0.10)[5]	8.5		0.5	1.7	0.8	0.07	NS	0.12

[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, and grain sorghum – number of days from planting to half-bloom.

[4] N level 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 to full-season grain sorghum = 1.6.

Table 3. Effects of crop rotation on no-till soybean and sunflower, Harvey County Experiment Field, Hesston, KS, 2009

		Yield[2]					
Crop	Crop rotation[1]	2009	6-year avg.	Stand[3]	Plant height	Maturity[4] date	Lodging
		--------- bu/a ---------			in.		%
Soybean	W-C-SB	44.4	42.6	100	32	130	0
	W-[SB]-C-SB	50.7	43.7	100	32	130	0
	W-SB-C	47.9	42.6	100	34	129	0
	W-GS-SB	47.7	42.4	100	33	130	0
	W-[SB]-GS-SB	45.1	40.6	99	33	129	0
	W-[GS]-GS-SB	52.3	42.8	100	33	130	0
	GS-C-SB	53.5	42.6	100	32	129	0
[Soybean]	W-[SB]-C-SB	32.3	21.6	100	29	123	0
	W-[SB]-GS-SB	32.4	20.4	100	27	123	0
	W-[SB]-GS-SF	37.5	24.5	100	30	123	0
	LSD (0.05)	7.4		NS	1.6	1.3	NS
	LSD (0.10)	6.1		NS	1.4	1.1	NS
	Preceding crop main effect means						
	Wheat	47.9	42.6	100	34	129	0
	Corn	49.5	42.9	100	32	130	0
	Sorghum	48.4	41.9	100	33	129	0
	LSD (0.05)[5]	NS		NS	0.9	NS	NS
	LSD (0.10)[5]	NS		NS	0.8	NS	NS
Sunflower	W-GS-SF	1857	1616	21.0	36	54	2
	W-[SB]-GS-SF	1659	1536	22.3	35	55	2
	W-[GS]-GS-SF	1555	1504	20.3	35	55	1
	LSD (0.05)	NS		NS	NS	NS	NS
	LSD (0.10)	169		NS	NS	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 in lb/a). Sunflower also adjusted for variation in number of heads lost from head-clipper weevil damage.

[3] Stand expressed as a percentage for soybean and as plant population in thousands per acre for sunflower.

[4] Maturity expressed as number of days from planting to 95% mature pod color for soybean and as number of days from planting to half-bloom for sunflower.

[5] Estimate based on the average number of crop sequences involving the same preceding crop to full-season soybean = 2.3.

Soil Response to Wheel Traffic and Intensive Cropping Systems in No-Till

H. Blanco-Canqui, M.M. Claassen, and L.R. Stone

Summary

Excessive wheel traffic can adversely affect soil physical and hydraulic properties, particularly in no-till intensive cropping systems. More experimental data are needed to better understand the magnitude of wheel traffic impacts on soil properties. We studied the effects of wheel traffic and intensive cropping systems on soil physical and hydraulic properties on a Ladysmith silty clay loam near Hesston, KS, after 8 years under no-till management. Four crop rotations were studied: continuous grain sorghum, winter wheat-grain sorghum-soybean, wheat-[double-cropped sorghum]-sorghum-soybean, and wheat-[double-cropped soybean]-sorghum-soybean. In double crops, sorghum or soybean was planted immediately after wheat harvest. Wheel traffic affected soil physical and hydraulic properties, but cropping systems had less of an effect. Wheel traffic adversely impacted all soil properties except wet aggregate stability. It increased bulk density, cone index, shear strength, and aggregate tensile strength in the 0- to 3-in. soil depth. Increased soil compaction reduced soil macroporosity, water infiltration rates, saturated hydraulic conductivity, soil water retention capacity, and plant-available water content. Overall, results from this study support the strong need for controlling wheel traffic in no-till cropping systems to reduce deterioration of soil physical and hydraulic properties.

Introduction

Intensive cropping systems such as diverse crop rotations or double-cropping systems in no-till can have beneficial effects on crop production, soil erosion control, and soil properties over short rotations or crop-fallow systems. Intensive cropping systems maintain a permanent cover on the soil surface, which protects soil from erosion by water and wind, reduces evaporation, and increases soil organic matter content. Intensified cropping systems may impact soil properties differently from short rotations due to differential biomass input and management.

No-till intensive cropping systems also can be particularly prone to wheel traffic compaction due to reduced soil disturbance. Intensified cropping systems may increase the risks of soil compaction over short rotations or crop-fallow systems because of increased frequency of machinery traffic for additional cultural operations. Soil response to the combined effects of wheel traffic and intensive cropping systems in no-till farming is not well understood.

No-till systems generally improve soil physical and hydraulic properties over time; however, excessive wheel traffic may reduce the benefits from no-till. The level of cropping system also may affect the performance of no-till. Knowledge of wheel traffic impacts on soil properties is important to better manage soil against excessive compaction. We studied the impacts of intensive cropping systems and wheel traffic on physical and hydraulic properties under no-till.

Procedures

This study was conducted as part of a larger no-till crop rotation experiment established in 2001 near Hesston, KS. Four crop rotations under controlled wheel traffic were studied: continuous grain sorghum, winter wheat-grain sorghum-soybean, wheat-double-cropped sorghum-sorghum-soybean, and wheat-double-cropped soybean-sorghum-soybean. In double-cropped systems, wheat was harvested by early summer and then sorghum or soybean was planted in the same plots for harvest in the fall. The experiment was as a randomized complete block design with four replications and each phase of the rotations was present each year. Wheel traffic was controlled and wheel tracks within each plot occurred in the same rows year after year. Wheat in all rotations was fertilized with 120 lb/a of N and 33 lb/a of P. Full-season grain sorghum received 90 lb/a of N and 31 lb/a of P, whereas double-cropped sorghum received 60 lb/a of N and 31 lb/a of P.

Soil compaction, structural, and hydraulic properties were studied after sorghum harvest in fall 2009. Water infiltration, bulk density, cone index, shear strength, wet aggregate stability, aggregate tensile strength, saturated hydraulic conductivity, and soil water retention were measured. Effective porosity as the difference in volumetric water content between 0 and -33 kPa, plant-available water as the difference in volumetric water content between -33 and -1,500 kPa, and pore-size distribution were computed from the water retention data. Two measurements were made within nontrafficked and trafficked rows for a total of four measurements per plot. Bulk density and cone index were measured at different depth increments to 18-in. soil depth. Cone index values were adjusted using measured water content and a constant water content value. Data were analyzed by soil depth with the PROC GLM procedure of SAS (SAS Institute Inc., Cary, NC) utilizing a split-plot design with cropping system as the main factor and traffic as the subfactor. MEANS statement in PROC GLM was used to separate treatment means at the 0.05 probability level.

Results

Wheel Traffic Effects

Wheel traffic affected soil compaction, structural, and hydraulic parameters except wet aggregate stability. Impacts of wheel traffic were more than those of cropping systems. Effects of wheel traffic on measures of soil compaction such as bulk density, cone index, shear strength, and aggregate tensile strength were most pronounced in the 0- to 3-in. depth and diminished with increasing soil depth. Wheel traffic also impacted water infiltration, saturated hydraulic conductivity, soil water retention, effective porosity, plant-available water, and pore-size distribution.

Soil Compaction Parameters

Wheel traffic increased bulk density by about 20% in the 0- to 3-in. depth and by 5 to 8% in the 3- to 6-in. depth. Impacts of wheel traffic on bulk density decreased with an increase in soil depth. Averaged across crop rotations, cone index was 1.8 MPa (megapascals) in nontrafficked rows and 3.1 MPa in trafficked rows in the 0- to 3-in. depth (Figure 1). The increase in cone index from 1.8 to 3.1 MPa due to wheel traffic reflects the drastic consequences of wheel compaction. Cone index values exceeding 3 MPa can restrict root growth for most crops. Wheel traffic also increased cone index at deeper depths in most rotations. Wheel traffic impact on shear strength in trafficked rows was

2.7 times more than in nontrafficked rows near the soil surface. Data on shear strength indicate that wheel traffic can increase the energy required to shear soil over nontrafficked rows. Wheel traffic increased tensile strength of soil aggregates by 1.6 times in the 0- to 3-in. depth over nontrafficked rows in continuous sorghum and three times in other rotations. The greater tensile strength values indicate that aggregates from trafficked rows were more consolidated, cemented, and cohesive than those from nontrafficked rows.

Soil Hydraulic Parameters

Wheel traffic affected water infiltration in all rotations except continuous sorghum; it reduced cumulative infiltration by 120 times for wheat-double-cropped sorghum-sorghum-soybean, by 50 times for wheat-double-cropped soybean-sorghum-soybean, and by 40 times for wheat-sorghum-soybean. The saturated hydraulic conductivity in nontrafficked rows was more than in trafficked rows by 28 times for wheat-double-cropped sorghum-sorghum-soybean and by 130 times for wheat-double-cropped soybean-sorghum-soybean, but it did not differ for continuous sorghum and wheat-sorghum-soybean. Wheel traffic reduced soil water retention at 0 and -0.5 kPa by 16% compared to nontrafficked rows in most rotations; however, increased water retention by 18% at -1,500 kPa over nontrafficked rows for all rotations except wheat-double-cropped sorghum-sorghum-soybean. Wheel traffic reduced volume of >100 μm soil pores in all rotations (Figure 2). Effective porosity was reduced by two to three times for all rotations in trafficked rows, whereas plant-available water was reduced by 1.5 times in wheat-sorghum-soybean and by 1.8 times in wheat-double-cropped soybean-sorghum-soybean. The reduction in water infiltration with wheel traffic is attributed to the reduction in soil macroporosity. Wheel traffic compressed soil and reduced the volume of water-conducting large pores. Between 10 and 20% more pore space was available in nontrafficked than in trafficked rows. The greater water infiltration and plant-available water in nontrafficked rows suggest more rainfall can infiltrate and more water can become available in soils where traffic is controlled. Saturated hydraulic conductivity was correlated with effective porosity (Figure 3), indicating that saturated water flow in trafficked rows decreases due to a decrease in effective porosity.

Cropping System Impacts

Cropping system affected cone index, shear strength, and water infiltration, but its impact on other soil properties was not significant. Wheat-sorghum-soybean rotation had lower cone index than the more intensive wheat-double-cropped sorghum-sorghum-soybean rotation in nontrafficked rows in the 0- to 3-in. depth. Shear strength in trafficked rows was 17% greater for continuous sorghum than other rotations for the same soil depth. Initial water infiltration and cumulative infiltration for wheat-sorghum-soybean rotation was about 2.4 times greater than for other rotations in nontrafficked rows. The greater shear strength and lower water infiltration in continuous sorghum than in other rotations in trafficked rows suggest continuous sorghum systems may have the least beneficial effects on soil physical quality because it may increase risks of compaction and reduce water infiltration over more diverse crop rotations. The wider row spacing in continuous sorghum probably left more soil unprotected between rows than in rotations with wheat, increasing risks of soil compaction.

Intensive cropping systems had small impacts, but wheel traffic had large effects on soil properties on a silty clay loam after 8 years of no-till management. Wheel traffic adversely affected all soil compaction, structural, and hydraulic parameters except wet aggregate stability. Wheel compaction reduced soil macroporosity, which concurrently reduced water infiltration and saturated hydraulic conductivity. The lower water infiltration with wheel traffic suggests compaction can reduce infiltration of rain or irrigation water. Increased soil compaction also can reduce the ability of the soil to retain water. The drastic effects of wheel traffic on soil properties suggest wheel traffic needs to be controlled to improve soil properties.

Additional details from this work on soil properties are found in:

Blanco-Canqui, H., M.M. Claassen, and L.R. Stone. 2010. Controlled traffic impacts on physical and hydraulic properties in an intensively cropped no-till soil. Soil Science Society America Journal 74(6):2142-2150.

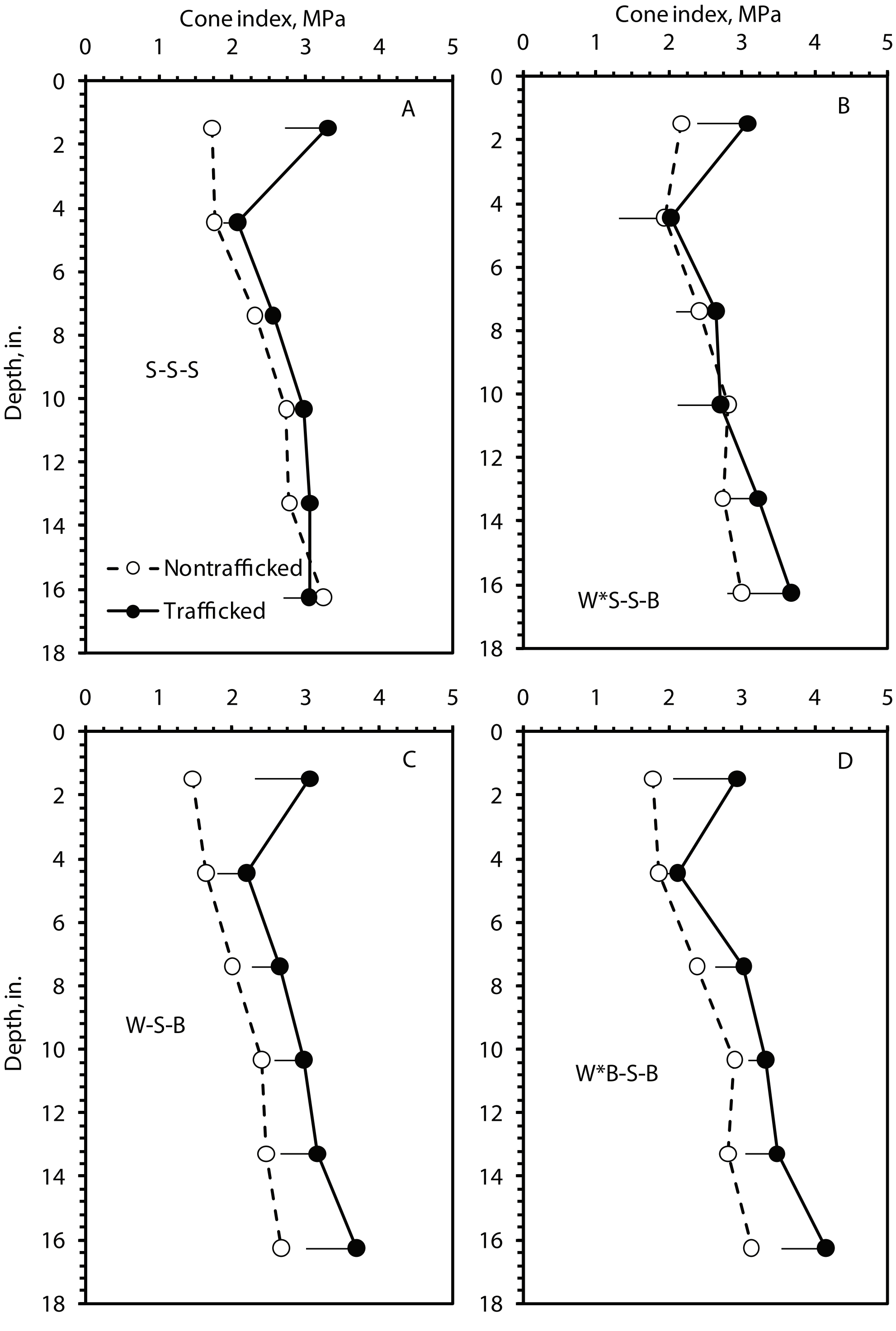

Figure 1. Soil depth distribution of cone index under nontrafficked and trafficked rows for (A) continuous grain sorghum (S-S-S), (B) wheat-double-cropped sorghum-sorghum-soybean (W*S-S-B), (C) wheat-grain sorghum-soybean (W-S-B), and (D) wheat-double-cropped soybean-sorghum-soybean (W*B-S-B) managed under no-till. Error bars for each depth interval are the LSD values to compare differences between traffic positions.

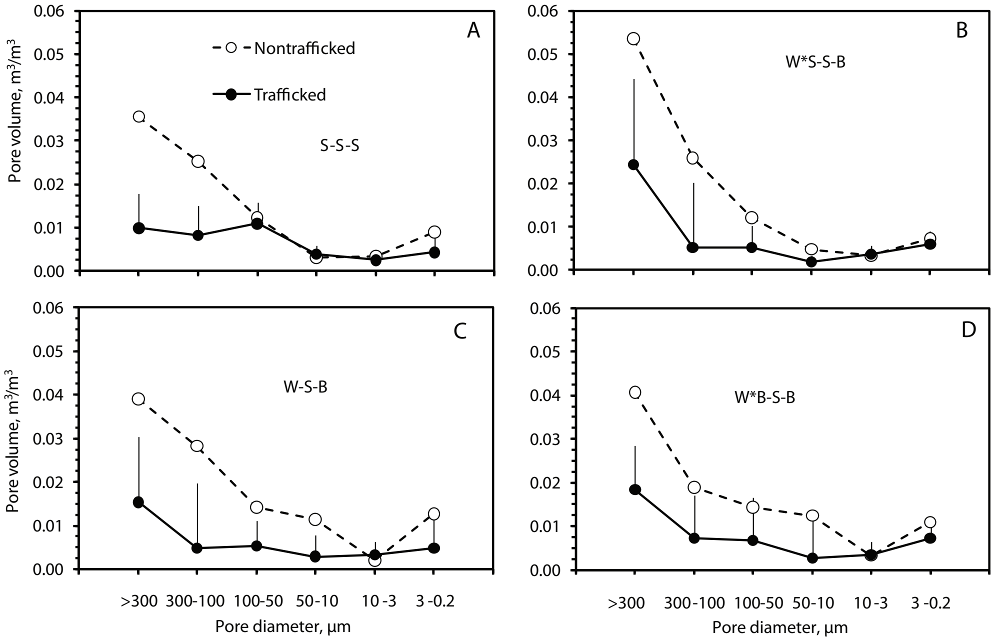

Figure 2. Differences in soil pore-size distribution between nontrafficked and trafficked rows for (A) continuous grain sorghum (S-S-S), (B) wheat-double-cropped sorghum-sorghum-soybean (W*S-S-B), (C) wheat-grain sorghum-soybean (W-S-B), and (D) wheat-double-cropped soybean-sorghum-soybean (W*B-S-B) managed under no-till. Error bars are the LSD values to compare differences between traffic positions.

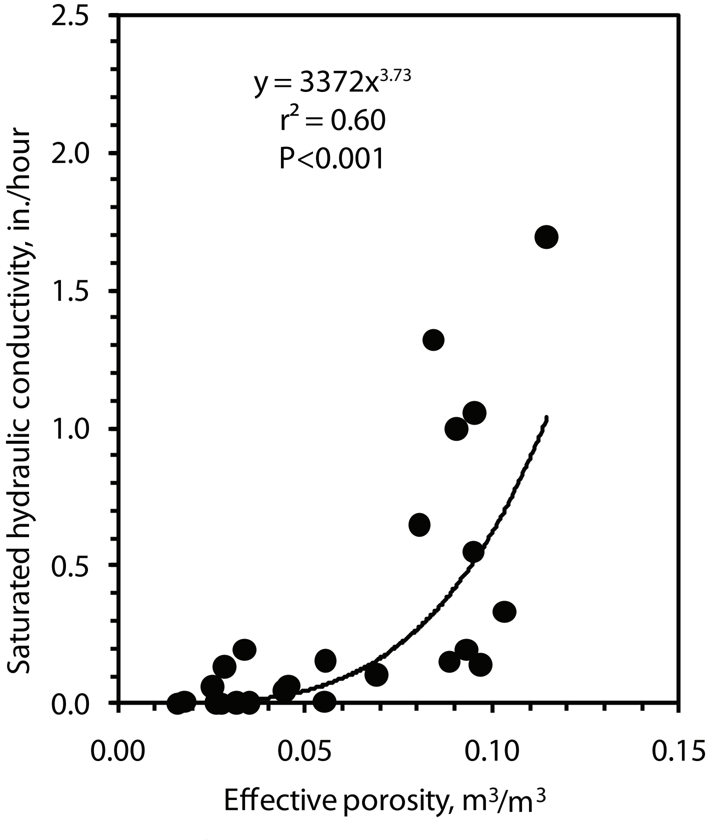

Figure 3. Near-surface saturated hydraulic conductivity increases with an increase in soil-effective porosity under controlled traffic.

Effects of Late-Maturing Soybean and Sunn Hemp Summer Cover Crops and Nitrogen Rate in a No-Till Wheat-Grain Sorghum Rotation

M.M. Claassen

Summary

Wheat and grain sorghum were grown in three no-till crop rotations, two of which included either a late-maturing Roundup Ready soybean or a sunn hemp cover crop established following wheat harvest. Nitrogen (N) fertilizer was applied to both grain crops at rates of 0, 30, 60, and 90 lb/a. Experiments were conducted on adjacent sites where different phases of the same rotations were established.

On the first site, grain sorghum followed cover crops that had been grown in 2008 for the fourth time in the rotations. In that season, soybean and sunn hemp produced an average of 3.68 and 4.13 ton/a, with corresponding N yields of 195 and 146 lb/a, respectively. Grain sorghum yields in 2009 ranged from 75.2 to 119.7 bu/a. When averaged over N rate, grain sorghum produced 16.0 bu/a more in the rotations with soybean and sunn hemp than in the rotation with no cover crop. N rate main effect also was significant, with an increase in grain sorghum yield at 30 lb/a, but not at the higher N levels. In grain sorghum after soybean vs. no cover crop, yields tended to be higher at most N rates, but significantly so only at the 0 and 30 lb/a rate. Grain sorghum following sunn hemp vs. no cover crop had a similar yield response to N rate.

On the second site, wheat followed grain sorghum after these cover crops had been grown in the second cycle of the rotations in 2007. In that season, soybean and sunn hemp produced 65 and 165 lb/a of potentially available N, respectively. The grain sorghum crop that followed produced an average of 109.4 bu/a across all rotations. Wheat yields in 2009 ranged from 7.6 to 38.4 bu/a. Soybean had no residual benefit for wheat yield at any N rate, but sunn hemp tended to have a small positive effect on wheat yield at the lowest N rates. When averaged over N rate, sunn hemp improved wheat yield by 4.2 bu/a vs. no cover crop. Over all rotations, N increased wheat yield by an average of 7 to 11 bu/a for each 30-lb/a increment.

In 6 site-years from 2002 through 2008, soybean and sunn hemp produced dry matter yields of 2.42 and 3.43 ton/a with N yields of 111 and 134 lb/a, respectively. Both cover crops had a positive impact on grain sorghum yield, particularly at N rates of 60 lb/a or less. The soybean effect was masked with 90 lb/a of N. Over the long term, however, sunn hemp tended to show a sorghum yield benefit even at the highest N rate. Averaged over N rates, soybean and sunn hemp resulted in 6-year average grain sorghum yield increases of 8.8 and 14.9 bu/a, respectively. Positive residual effects of soybean and sunn hemp on the yield of wheat after sorghum were small and mostly observed at N rates of 60 lb/a or less. Five-year mean wheat yields combined from the two sites and averaged over N rate indicated numeric increases of 2.2 and 2.9 bu/a in rotations with soybean and sunn hemp vs. no cover crop.

Introduction

Research at the Kansas State University Harvey County Experiment Field over an 8-year period explored the use of hairy vetch as a winter cover crop following wheat in a winter wheat-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 of approximately 100 lb/a. However, using hairy vetch as a cover crop also has significant disadvantages including cost and availability of seed, interference with control of volunteer wheat and winter annual weeds, and the possibility of hairy vetch becoming a weed in wheat after sorghum. New interest in cover crops has been generated by research in other areas that shows the positive effect these crops can have on overall productivity of no-till systems.

In the current experiment, late-maturing soybean and sunn hemp, a tropical legume, were evaluated as summer cover crops for their effect on no-till sorghum grown in the spring after wheat harvest as well as on double-crop, no-till wheat after grain sorghum. Yield determinations were concluded after the 2009 season, and soil samples were collected for analyses to assess the long-term impact of treatment factors.

Procedures

Experiments were established on adjacent Geary silt loam sites that had been used for hairy vetch cover crop research in a wheat-sorghum rotation from 1995 to 2001. In accordance with the previous experimental design, soybean and sunn hemp were assigned to plots where vetch had been grown, and remaining plots retained the no-cover crop treatment. The existing factorial arrangement of N rates on each cropping system also was retained. In 2009, grain sorghum was grown on Site 1 in the fourth cycle of the rotations. Winter wheat was produced on Site 2 in the second cycle of the rotations. Selected plots only from Site 1 were sampled for the determination of soil chemical and physical properties following the conclusion of the 2009 growing season. See *Cover Crops Combined with No-Till Improve Soil Physical Properties* on page 28.

Grain Sorghum

Wheat on Site 1 was harvested July 1, 2008. Weeds in wheat stubble were controlled with glyphosate application just before cover crop planting. Asgrow AG7601 Roundup Ready soybean and sunn hemp seed were treated with respective rhizobium inoculants and no-till planted in 7.5-in. rows with a JD 1590 drill on July 3, 2008, at 60 lb/a and 10 lb/a, respectively. Fallow plots were sprayed with glyphosate in mid-August. Before loss of leaves, forage yield of each cover crop was determined by harvesting a 3.28 ft^2 area in each plot. Samples were subsequently analyzed for N content. Sunn hemp and soybean cover crops were rolled down with a crop roller on September 26 and October 21, respectively. The first fall freeze occurred on October 26. Weeds were controlled in the fall with a late November application of glyphosate over the entire site. Glyphosate was applied in mid-May with low rates of Clarity and 2,4-D$_{\text{LVE}}$ and reapplied alone just before planting. Pioneer 85G01 grain sorghum treated with Concep III safener and Cruiser insecticide was planted in 30-in. rows at approximately 42,000 seeds/a on June 24, 2009. Atrazine and Dual II Magnum were applied preemergence for residual weed control. All plots received 37 lb/a P_2O_5 banded as 0-46-0 at planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected 10 in. from the row on July 18. Grain sorghum was combine harvested on November 8, 2009.

Wheat

Grain sorghum on Site 2 was combine harvested on October 1, 2008. After a wet weather delay, 'Jagger' variety winter wheat was no-till planted in 7.5-in. rows with a JD1590 drill on November 3 at 90 lb/a with 32 lb/a P_2O_5 fertilizer banded as 0-46-0 in the furrow. N rates were reapplied as broadcast 46-0-0 just before planting. Wheat was harvested on June 26, 2009.

Results

Grain Sorghum

During the first 10 days after cover crop planting in 2008, several showers brought total rainfall of 1.82 in. Total rainfall for the months of August, September, and October was 4.55 in. above normal. Cover crop stands were very good. Soybean and sunn hemp reached mature plant heights of 36 and 96 in., respectively. Late-maturing soybean produced 3.68 ton/a of aboveground dry matter with N content of 2.64% or 195 lb/a of N (Table 1). Sunn hemp reached early flowering stage in late September and produced 4.13 ton/a of aboveground dry matter with an N content of 1.78% or 146 lb/a of N. Late-maturing soybean and sunn hemp at maturity provided 100 and 91% volunteer wheat control, respectively.

The 2009 grain sorghum crop emerged 5 days after planting. Final stands averaged 35,850 plants/a following cover crops, about 1,450 plants/a more than in the rotations without a cover crop. During the first 10 days after planting, rainfall totaled 0.23 in. The season was relatively mild and generally favorable for sorghum. Both cover crop and N rate affected grain sorghum. Soybean and sunn hemp significantly increased sorghum nutrient concentration by 0.28% and 0.12% N, respectively, but only in the absence of fertilizer N. At N rates of 30 lb/a or more, sorghum leaf N concentration was comparable in all rotations. At zero lb/a N, cover crops tended to increase the number of heads/plant, but not at the other N rates. Averaged over N rate, grain sorghum heads/plant increased by 7% in rotations with vs. without cover crops. Cover crops had a minor influence on the length of time for grain sorghum to reach the half-bloom stage. However, at zero fertilizer N, half bloom was delayed by several days in the rotation with no cover crop.

The main effect of cover crop on grain sorghum yield was significant, with comparable increases of 16.6 and 15.3 bu/a for soybean and sunn hemp, respectively. Grain yields tended to increase the most with cover crops at zero and 30 lb/a N. Specifically, an average increase of 38.2 and 14.6 bu/a occurred, respectively, at these N levels. At higher N rates, the yield benefit from cover crops failed to reach statistical significance. When averaged over all three crop rotations, sorghum yields increased by 11.6 bu/a with 30 lb/a N, but did not improve significantly at higher N rates.

With data combined from Site 1 and Site 2, 6-year average soybean and sunn hemp dry matter yields were 2.42 and 3.43 ton/a. The corresponding N content was 111 and 134 lb/a, respectively. Late-maturing soybean increased grain sorghum yields at N rates of 60 lb/a or less, but generally had no yield benefit vs. no cover crop when N rate increased to 90 lb/a. Sunn hemp tended to increase yields of sorghum at all N rates, although to a lesser extent at the highest N level. When averaged over N rate, the long-term grain sorghum yield benefits from late-maturing soybean and sunn hemp amounted to 8.8 and 14.9 bu/a, respectively.

Wheat

The second cycle of the crop rotations on Site 2 began in 2007, when soybean and sunn hemp produced an average of 1.06 and 3.05 ton/a with corresponding N yields of 65 and 165 lb/a, respectively (Table 2). In 2008, averaged across N rate, grain sorghum yielded 107.5 bu/a after soybean and 120.2 bu/a following sunn hemp.

Wheat yield potential was limited to some extent by late planting. Soybean and sunn hemp cover crops significantly increased wheat plant height by 1 to 2 in., respectively, when averaged over N rates. Each N increment more notably influenced plant height, with increases of 1 to 5 in. Soybean had no influence on wheat plant N content, but sunn hemp increased plant N at the highest N rates by 0.17 to 0.25% N. Soybean in the rotation did not appreciably affect wheat yield. On the other hand, sunn hemp increased wheat yield to a minor extent, but mainly at the lowest N rates. When averaged over N rate, the sunn hemp benefit was 4.2 bu/a. Each 30 lb/a N increment increased wheat yield by 7 to 11 bu/a on average. Grain test weights were not affected by cover crop or N rate.

Five-year average wheat yields including data combined from Site 1 and Site 2 followed a pattern similar to the results observed in 2009. Over the longer period of time, soybean and sunn hemp had a small positive residual effect on wheat production, but primarily at N rates of 60 lb/a or less. When averaged over N rates, wheat yield increases of 2.2 and 2.9 bu/a were associated with soybean and sunn hemp cover crops.

Table 1. Effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till grain sorghum after wheat, Hesston, KS, 2009

		Cover crop yield[3]		Grain Sorghum						
				Yield[4]						
Cover crop[1]	N Rate[2]	Forage	N	2009	6-year avg.	Test weight	Stand	Half-bloom[5]	Heads/plant	Leaf N[6]
	lb/a	ton/a	lb/a	-------- bu/a --------		lb/bu	1,000 s/a	days	no.	%
None	0	---	---	75.2	62.7	55.1	34.6	63	1.13	2.17
	30	---	---	102.5	80.1	56.5	34.5	61	1.30	2.45
	60	---	---	109.2	93.3	57.2	33.8	61	1.37	2.46
	90	---	---	114.7	98.8	56.6	34.8	61	1.44	2.59
Soybean	0	3.75	201	116.5	80.5	57.1	35.0	60	1.41	2.45
	30	3.59	204	119.3	91.2	57.2	36.2	60	1.38	2.50
	60	3.93	203	118.6	100.4	57.2	36.4	60	1.35	2.53
	90	3.47	172	113.6	97.7	56.8	35.3	61	1.45	2.50
Sunn hemp	0	4.45	147	110.2	89.1	57.1	36.7	60	1.26	2.29
	30	3.81	142	114.8	96.3	57.0	36.1	61	1.32	2.59
	60	3.90	149	118.3	103.4	56.6	35.7	61	1.37	2.37
	90	4.35	145	119.7	105.7	57.2	35.4	60	1.46	2.69
LSD (0.05)		0.91	45	12.8		1.0	1.4	1.9	0.14	0.22
Means:										
Cover crop										
None		---	---	100.4	83.7	56.4	34.4	61	1.31	2.42
Soybean		3.68	195	117.0	92.5	57.1	35.7	60	1.40	2.49
Sunn hemp		4.13	146	115.7	98.6	57.0	36.0	60	1.35	2.48
LSD (0.05)		0.46	23	6.4		0.5	0.7	0.9	0.07	NS
N rate										
0		4.10	174	100.6	77.4	56.5	35.4	61	1.27	2.30
30		3.70	173	112.2	89.2	56.9	35.6	61	1.33	2.51
60		3.92	176	115.3	99.0	57.0	35.3	61	1.37	2.45
90		3.91	159	116.0	100.7	56.9	35.2	60	1.45	2.59
LSD (0.05)		NS	NS	7.4		NS	NS	NS	0.08	0.13

[1] Cover crops planted July 7, 2008, and terminated in the fall.

[2] N applied as 28-0-0 injected July 18, 2008.

[3] Oven-dried weight and N content for sunn hemp and soybean at termination.

[4] Means of four replications adjusted to 12.5% moisture. Combined 6-year means from Site 1 (2003, 2005, 2007, 2009) and Site 2 (2006, 2008).

[5] Days from planting to half-bloom.

[6] Flag leaf at late boot to early heading.

Table 2. Residual effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till wheat after grain sorghum, Hesston, KS, 2009

					Wheat				
		Cover crop yield[3]		Sorghum yield 2008	Yield[4]				
Cover crop[1]	N rate[2]	Forage	N		2009	5-year avg.	Test weight	Plant height	Plant N[5]
	lb/a	ton/a	lb/a	bu/a	-------- bu/a	--------	lb/bu	in.	%
None	0	---	---	69.4	7.7	7.7	59.6	19	1.32
	30	---	---	91.8	15.0	19.7	60.1	23	1.09
	60	---	---	115.6	27.5	29.5	59.9	29	1.11
	90	---	---	125.3	36.7	35.7	60.1	30	1.36
Soybean	0	0.49	32	72.2	7.6	10.5	59.8	19	1.36
	30	1.05	63	106.5	18.7	22.7	60.1	25	1.12
	60	1.25	76	125.2	30.5	32.2	60.2	30	1.24
	90	1.46	88	125.9	35.8	35.9	60.0	30	1.37
Sunn hemp	0	3.26	160	102.8	11.9	11.2	59.7	21	1.20
	30	3.29	150	117.8	21.7	24.1	59.8	26	1.12
	60	3.96	202	130.6	31.5	32.2	60.4	30	1.28
	90	3.51	149	129.7	38.4	36.6	60.0	31	1.61
LSD (0.05)		0.96	57	12.0	4.6		NS	3	0.17
Means:									
Cover crop									
None		---	---	100.5	21.7	23.1	59.9	25	1.22
Soybean		1.06	65	107.5	23.1	25.3	60.0	26	1.27
Sunn hemp		3.50	165	120.2	25.9	26.0	60.0	27	1.30
LSD (0.05)		0.48	28	6.0	2.3		NS	1	NS
N rate									
0		1.87	96	81.5	9.0		59.7	20	1.29
30		2.17	106	105.4	18.5	9.8	60.0	25	1.11
60		2.60	139	123.8	29.8	22.2	60.2	29	1.21
90		2.48	118	127.0	36.9	31.3	60.0	30	1.44
LSD (0.05)		NS	NS	7.0	2.7	36.1	NS	1	0.10

[1] Cover crops planted July 16, 2007 and terminated at the end of October.

[2] N applied as 28-0-0 injected June 12, 2008 for sorghum and 46-0-0 broadcast on November 1, 2008 for wheat.

[3] Oven-dried weight and N content for sunn hemp and soybean at termination.

[4] Means of four replications adjusted to 12.5% moisture. Combined 5-year means from Site 1 (2004, 2006, 2008) and Site 2 (2007, 2009).

[5] Whole-plant N concentration at early heading.

Cover Crops Combined with No-Till Improve Soil Physical Properties

H. Blanco-Canqui, M.M. Mikha, D.R. Presley, and M.M. Claassen

Summary

Inclusion of cover crops in no-till cropping systems may improve soil physical properties over no-till alone. Changes in soil physical properties may be directly associated with the cover crop-induced increase in soil organic carbon (C) concentration. We assessed the impacts of sunn hemp and late-maturing soybean cover crops on the relationships between soil physical properties and soil organic C in a 15-year experiment involving a winter wheat-grain sorghum rotation managed with four N rates at Hesston, KS. Hairy vetch cover crop was used during the first three crop cycles, whereas sunn hemp and late-maturing soybean were used in subsequent crop cycles. Across N rates, cover crops increased soil aggregate stability in the 0- to 3-in. depth relative to no-cover crop plots. Sunn hemp reduced soil bulk density and increased water infiltration. Cover crops reduced soil compactibility and increased soil water content at which a no-till soil can be trafficked without causing compaction. Cover crops increased soil organic C concentration by 20 to 30% over no-cover crop plots. This increase in soil organic C concentration reduced soil compactibility and increased aggregate stability and water infiltration. Adding cover crops to no-till systems increases soil organic C concentration and improves soil properties.

Introduction

Use of cover crops with no-till cropping systems is generating interest. Cover crops may enhance performance of no-till, particularly in soils where no-till alone may have limited potential for improving soil properties and sequestering C. Cover crops provide additional biomass input and thus can be used as a strategy to reduce the adverse impacts of crop residue removal when that residue is utilized for off-farm purposes. Previous studies, however, have shown somewhat inconsistent impacts of cover cropping on soil physical properties. Some studies have found significant changes in soil physical properties but others have reported little or no effects of cover crops. Cover crop impacts may depend on type of cover crop, type of soil, tillage and cropping system, management history, and climate. Most of the previous studies on cover crops in relation to soil physical properties were short-term (less than five years). Changes in soil properties are often measurable in the long term. Data from long-term cover crop experiments can provide further insights into the potential of cover crops for improving soil functions.

Increased aboveground biomass input from cover crops can protect soil surface conditions, improve soil physical properties, and increase soil organic C concentration. The hypothesis is that improvement in soil physical properties may depend on whether cover crops increase soil organic C concentration. We quantified the effects of cover crops on soil physical properties and studied correlations between cover crop-induced changes in soil organic C concentration and soil physical properties in south central Kansas.

Procedures

This study was conducted on a long-term cover crop experiment at Hesston, KS, established in 1995 on a Geary silt loam with a <3% slope. The experiment was designed as a randomized complete block consisting of 12 treatments with four replicates for a factorial combination of three cover crop treatments and four N fertilization levels (0, 30, 60, and 90 lb N/a). Hairy vetch was used as a winter cover crop between 1995 and 2000, during which time management involved reduced tillage. Sunn hemp and late-maturing soybean as summer cover crops replaced hairy vetch and were compared with no-cover crop in a winter wheat-grain sorghum rotation starting in 2002. All phases of the experiment subsequently were conducted exclusively under no-till conditions. Sunn hemp and late-maturing soybean were assigned to plots where hairy vetch had been grown, and the remaining plots retained the no-cover crop treatment. The factorial arrangement of the four N rates also was retained. Sunn hemp and late-maturing soybean were planted after wheat, terminated in September or October, and grain sorghum was planted in June of the following year.

Field measurements and soil sampling were conducted in the spring of 2010. Water infiltration, wet aggregate stability, Proctor bulk density (a parameter of soil compactibility), and soil organic C concentration were measured. The Proctor critical water content (soil water content at which a soil is most compacted) also was measured. Because hairy vetch was the first cover crop during the first three crop cycles followed by either sunn hemp or late-maturing soybean in subsequent crop cycles of the experiment, changes in soil properties observed at the end of 15 years may not be due solely to the effects of sunn hemp and late-maturing soybean. Rather, those changes may be the result of a cumulative effect of hairy vetch plus sunn hemp and late-maturing soybean. Data were analyzed using PROC MIXED procedure of SAS (SAS Institute Inc., Cary NC). Fixed factors were cover crop treatment, N application level, and soil depth; random factors were replicate and interactions with cover crop treatment and N application level. For the analysis of data on water infiltration, the fixed factor was cover crop treatment, and the random factor was replicate. Means among treatments were compared using LSMEANS in PROC MIXED. Correlations between soil physical properties and soil organic C concentration were studied using PROC STEPWISE and PROC CORR in SAS.

Results

Cover crops affected soil physical properties and soil organic C concentration. Cover crops impacted soil properties more than the N rates. Sunn hemp reduced bulk density relative to plots without cover crops. Late-maturing soybean, however, had no effect on bulk density. Both cover crops altered soil compactibility in the 0- to 3-in. depth. At 0 lb N/a, Proctor maximum bulk density (equivalent to maximum soil compactibility) in cover crops was about 5% lower than in plots without cover crops (Figure 1A). At 60 lb N/a, soil compactibility was not affected by cover crops (Figure 1B). Critical water content at which maximum soil compaction occurs was 10% lower in no-cover crop plots than in plots with cover crops. Changes in soil organic C concentration explained some of the changes in soil compaction parameters. Averaged across N rates, soil organic C concentration was 1.3 times greater in sunn hemp and 1.2 times greater in late-maturing soybean than in plots without cover crops for the 0- to 3-in. depth (Figure 2). Figure 3A shows that Proctor maximum bulk density was strongly and negatively correlated (*r* = -0.77) with cover crop-induced increase in soil organic C concentration. Similarly, Proctor critical water content was positively correlated with cover crop-induced increase in soil organic C concentration (*r* = 0.82; Figure 3B). These results indicate that maximum soil compactibility decreased whereas the water content at which the soil is most compacted increased linearly with the cover crop-induced increase in soil organic C concentration. Data on Proctor critical water content suggest soils under cover crops can be trafficked at greater soil water content without the risks of causing maximum compaction compared with soils without cover crops.

Cover cropping also improved soil aggregate stability for the 0- to 3-in. depth. The proportion of macroaggregates was greater under cover crops than in plots without cover crops. Aggregate stability also was strongly correlated (*r* = 0.71) with changes in soil organic C concentration. Aggregate stability increased with an increase in soil organic C concentration in the 0- to 3-in. depth. Sunn hemp increased water infiltration rates and cumulative infiltration by three times when compared with no-cover crop plots (Fig. 4). Differences in water infiltration rates between late-maturing soybean and no-cover crop plots were not statistically significant. Water infiltration rates also were positively correlated (*r* = 0.52) with soil organic C concentration. It increased as the soil organic C concentration increased. Differences in residue amount produced by the cover crops may explain the differential impact of cover crops on water infiltration. Sunn hemp produced more residues than late-maturing soybean. Averaged across the three previous rotation cycles and N rates, sunn hemp produced 6,268 ton/a of residues whereas late-maturing soybean produced 4,750 ton/a. Thus, the greater benefits of sunn hemp than late-maturing soybean for increasing water infiltration may be due to the greater residue input. Notably, however, both cover crops had significant impacts on soil compactibility, aggregate stability, and organic C concentration.

Addition of cover crops enhanced no-till performance by improving near-surface soil physical and hydraulic properties and increasing soil organic C concentration in south central KS. Results suggested cover crops may ameliorate some risks of excessive near-surface soil compaction and improve soil structure in no-till systems. Results also suggested cover crops, particularly sunn hemp, may reduce runoff and soil loss by increasing water infiltration. Significant correlations indicated that cover crops may change soil physical properties by increasing soil organic C concentration. Cover crops appear to have more beneficial effects on soil physical properties at 0 lb N/a than at higher N rates or when averaged across the four N rates, suggesting than N fertilization may diminish, partly, the benefits from cover crops. Results suggest no-till farming should be integrated with cover crops to enhance the potential of no-till technology for improving soil properties. More research on cover crop management is recommended, particularly for regions with low precipitation (<30 in.) where growing cover crops may reduce plant-available water for the main crops. Management strategies such as early termination of cover crops and its effects on plant-available water use should be further investigated.

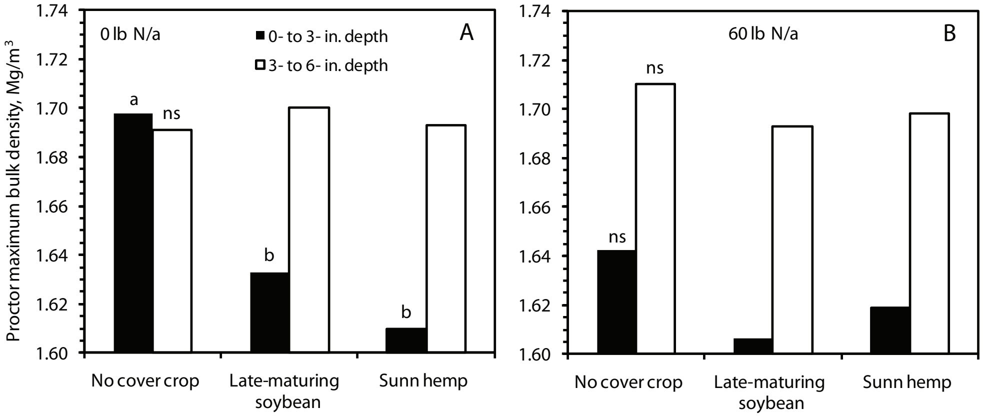

Figure 1. Mean Proctor maximum bulk density at 0 lb N/a (A) and 60 lb N/a (B) under three cover crop treatments at two soil depths. Bars with different letters within the same soil depth indicate significant differences. The ns label indicates no significant differences among the three cover crop treatments within the same depth.

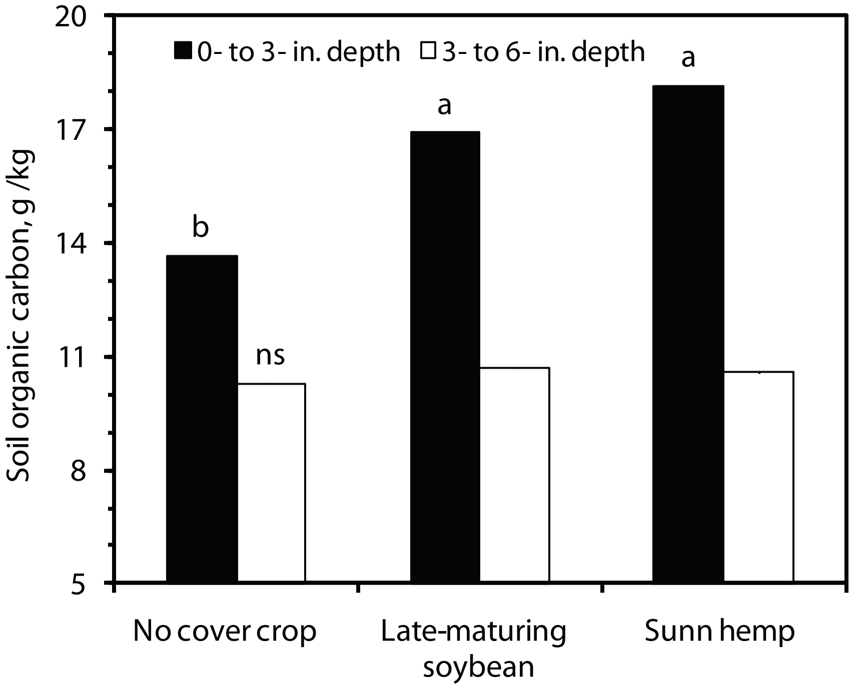

Figure 2. Mean soil organic carbon concentration averaged across N rates under three cover crop treatments at two soil depths. Means with different letters within the same soil depth indicate significant differences. The ns label indicates no significant differences among treatments within the same depth.

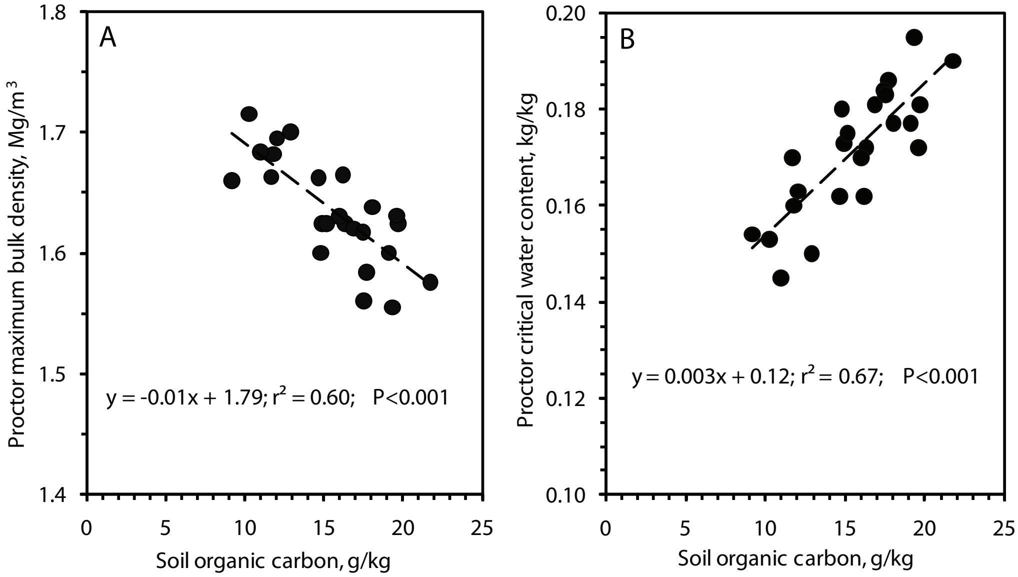

Figure 3. Relationship of soil organic carbon concentration with maximum bulk density (A) and critical water content (B) across four N application rates (0, 30, 60, and 90 lb N/a).

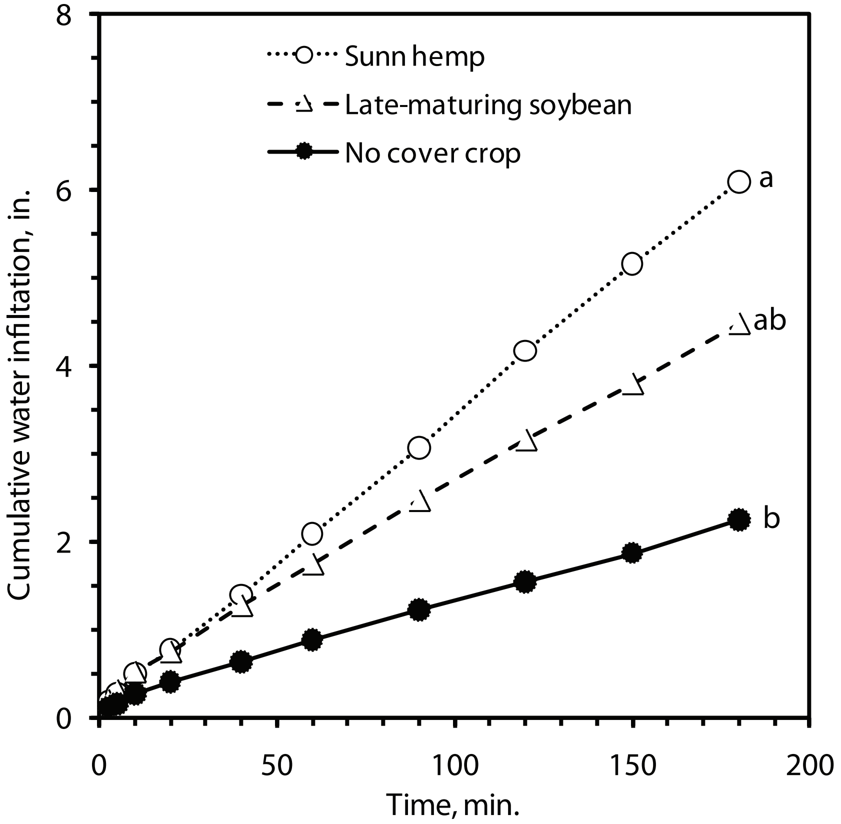

Figure 4. Cover crop effects on cumulative water infiltration. Means with different letters indicate significant differences.

Kansas River Valley Experiment Field

Introduction

The Kansas River Valley Experiment Field was established to study management and effective use of irrigation resources for crop production in the Kansas River Valley. The Paramore Unit consists of 80 acres located 3.5 miles east of Silver Lake on U.S. Highway 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 U.S. Highway 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. Except for small areas of Kimo and Wabash soils in low areas, the soils are well drained. 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.

2010 Weather Information

The frost-free season was 197 days at the Paramore and Rossville units (average, 173 days). The last spring freeze was April 4 (average, April 21), and the first fall freeze was October 28 (average, October 11) at the Paramore and Rossville units, respectively. There were 53 and 54 days above 90°F and 7 and 8 days above 100°F at the Paramore and Rossville units, respectively. Precipitation was above normal at both fields for the growing season (Table 1). The rain gauge at the Paramore Unit does not record the proper total for heavy rainfall events, so the total appears to be lower than the average. Precipitation was below average from December through April and above normal in May and June, but irrigation was necessary in late July and August. Corn and soybean yields were good at both fields.

Table 1. Precipitation at the Kansas River Valley Experiment Field

	Rossville Unit		Paramore Unit	
Month	2009-2010	30-year avg.	2009-2010	30-year avg.
	------------------ in.	-----------------	------------------ in.	-----------------
October	3.00	0.95	1.71	0.95
November	2.55	0.89	1.83	1.04
December	0.80	2.42	1.13	2.46
January	0.27	3.18	0.19	3.08
February	0.97	4.88	1.13	4.45
March	1.93	5.46	1.11	5.54
April	3.05	3.67	2.83	3.59
May	5.41	3.44	4.55	3.89
June	8.27	4.64	6.32	3.81
July	4.73	2.97	3.98	3.06
August	2.25	1.90	1.02	1.93
September	5.23	1.24	3.74	1.43
Total	38.46	35.64	29.54	35.23

Effect of Seed Treatment Fungicides on Stand and Yield of Soybean

D.J. Jardine and L.D. Maddux

Summary

Effects of fungicide and insecticide seed treatments were evaluated at the Kansas River Valley Rossville Unit in 2010. Fungicide seed treatments at planting time have consistently shown an average yield increase of 2.5 bu/a in soybean planted in May in Kansas. Companies are continually fine-tuning their products and adjusting the rates and combinations of fungicide and insecticides used in the formulations. In this experiment, although no product statistically increased initial stands, the range of stand increase due to seed treatment was 1.5 to 14%. Differences in yield were not statistically significant.

Introduction

Chemical companies have increased their marketing of fungicide and insecticide seed treatments for soybean in recent years. Many soybean growers are unsure whether this is a necessary production expense; input prices range from approximately $3.00 to $12.00 depending on the exact products and rates used. Growers are seeking unbiased evaluations of the products so they can make decisions.

Procedures

Plots were established at the Rossville Experiment Field near Rossville, KS. Chemical seed treatments were applied to Steyer 3840 RR soybean seed using commercial seed treating equipment. Plots were planted on May 27, 2010, using a four-row cone-type plot planter. Plots consisted of four 25-ft-long rows with between-row spacing of 30 in. and in-row spacing of 1.5 in. Four replications per treatment were arranged in a randomized complete block design. Stand counts were taken on June 16 by counting all emerged plants in the middle 5 ft of the middle two rows. Plots were harvested on October 4 using a two-row small plot combine. Yields were adjusted to 13% moisture and 60 lb/bu. Rainfall between planting and the 20-day stand count was 6.27 in.

Results

Overall yields were affected by an extended period of hot, dry weather in late July and early August. Although no product statistically increased initial stands, we saw a trend toward stand improvement with increases of 1.5 to 14% (Table 1). Differences in yield were not statistically significant.

Table 1. Effect of fungicide and insecticide seed treatments on stand and yield of soybean at Rossville, KS, in 2010

Treatment and rate/100 lb seed	Stand (plants/10 ft)	Yield (bu/a)
Untreated check	79.5	46.0
Maxim 4FS 0.08 fl oz + Apron XL 3SL 0.64 fl oz + Cruiser 5FS 1.28 fl oz	89.3	46.2
Trilex 2SC 0.32 fl oz + Allegiance-FL 2.65SC 0.75 fl oz + Yield Shield 100SS 0.1 fl oz + Gaucho 600FS 1.6 fl oz	90.5	44.7
Rancona Xxtra .24FS 3.5 fl oz + V-10209 2.65FS 0.55 fl oz + Nipsit Inside Insecticide 5FS 1.28 fl oz	89.0	42.7
Rancona Xxtra .24FS 3.5 fl oz + V-10209 2.65FS 0.55 fl oz + Nipsit Inside Insecticide 5FS 1.28 fl oz + Belay 2.13SC 4.0 fl oz	80.7	43.3
LSD (0.05)	NS*	NS*

* Not significant.

Soybean Herbicide Performance Tests

L.D. Maddux

Summary

Three studies were conducted at the Rossville Unit to compare herbicide treatments for soybean. Nine herbicide treatments were evaluated for burndown of marestail and henbit in no-till soybean. Two other studies that included 11 treatments each were conventionally tilled. The treatments in all three studies were evaluated for control of large crabgrass, Palmer amaranth, common sunflower, and ivyleaf morningglory and their effects on grain yield. Most treatments resulted in good to excellent weed control with only a few treatments with less than optimum control of large crabgrass and ivyleaf morningglory. No significant difference in grain yield among herbicide treatments was observed.

Introduction

Controlling weeds in row crops with chemical weed control and cultivation can reduce weed competition and, in turn, weed yields. These studies evaluated several herbicides and application timings for their effects on weed control and grain yield in soybean.

Procedures

Three studies, one no-till study (NT) and two conventional tilled studies (CT1, CT2), were conducted on a Eudora silt loam soil previously cropped to corn. Soil at the test site had 1.1% organic matter and pH 6.9. The experimental design in each study was a randomized complete block with three replications per treatment. An untreated check was included in each study. The populations of all weeds were moderate to heavy. All herbicide treatments were broadcast at 15 gal/a with 8003XR flat fan nozzles at 17 psi. Fertilizer, 100 lb/a of 11-52-0, was broadcast prior to planting and prior to field cultivation on CT1 and CT2. The studies were planted May 25 to Asgrow 4005 soybean at 139,000 seeds/a in 30-in. rows. Plots were not cultivated. The studies were harvested October 7 with a modified John Deere 3300 plot combine.

All herbicide treatments on the NT study were applied April 19 as a preplant burndown application and are listed in Tables 1 and 2. Evaluations for the control of marestail and henbit (present at application) and large crabgrass (CG) were made May 25 prior to planting. All plots, including the untreated check, received an application of Roundup PowerMax, 22 oz/a + AMS 17 lb/100 gal on June 24 following weed control evaluations for CG, Palmer amaranth (PA), common sunflower (SF), and ivyleaf morningglory (IM).

Corn stubble in CT1 and CT2 was disked and chiseled in the fall and field cultivated in the spring. Soybean variety Asgrow 4005 was planted May 25 at 139,000 seeds/a in 30-in. rows. Herbicide treatments were applied in both studies as follows: PRE on May 25; early postemergence (EP) on June 18 to 2- to 4-in. CG, 4- to 8-in. PA and SF, and 1- to 2-in. IM; mid-postemergence (MP) on June 24 to 1- to 3-in. CG, 4- to 12-in. PA, 6- to 12-in. SF, and 1- to 3-in. IM; and late postemergence (LP) on July 14 to 2- to 4-in. CG, PA, and IM with no SF present. Herbicides and rates applied are listed in Table 3

(CT1) and Table 4 (CT2). Small rainfall amounts of 0.08 in., 0.19 in., and 0.05 in. were received after PRE applications on May 26, May 30, and June 2, respectively, with 1.35 in. received on June 8. The studies were irrigated as needed. The weed control ratings reported were made July 22.

Results

No significant crop injury was observed with any of the preplant treatments in the NT study (Table 1). Basis must be applied at least 15 days prior to planting soybean and 2,4-D LV Ester at least 7 days prior. Burndown of the marestail and henbit was excellent with all treatments. Control of CG at planting time was good to excellent, with the Sharpen treatment giving the lowest control. Table 2 shows that control of broadleaf weed species PA, SF, and IM was good to excellent on June 24, but CG control had dropped off with all treatments. The June 24 application of Roundup PowerMax did an excellent job of controlling weeds, even in the untreated checks, and no significant difference in grain yield was observed.

No significant crop injury was observed from the PRE treatments in the CT1 and CT2 studies, or from the postemergent treatments in the CT2 study (data not shown). However, some injury was observed with the postemergent treatments in CT1 (Table 3). Control of PA and SF was very good to excellent in both studies with all treatments (Tables 3 and 4). CG control ranged from 80 to 100% in CT1 and 82 to 97% in CT2. Control of IM was the poorest of all four weeds with four treatments in the studies giving less than 80% control. However, grain yield did not differ among treatments, with all treatments yielding more than the untreated checks.

Table 1. Soybean injury and weed control ratings from preplant burndown treatments in no-till soybean, Rossville Field, May 25, 2010

			% weed control, May 25[2]		
Treatment[1]	Rate/a	Phyto	CG	Marestail	Henbit
		%			
Canopy EX Roundup PowerMax 2,4-D LV Ester	2.0 oz 22.0 oz 1.0 pt	0	98	100	100
Basis Roundup PowerMax 2,4-D LV Ester	0.5 oz 22.0 oz 1.0 pt	0	95	100	100
Valor Roundup PowerMax 2,4-D LV Ester	2.0 oz 22.0 oz 1.0 pt	0	100	100	100
Sharpen Roundup PowerMax	1.0 oz 22.0 oz	0	85	100	100
Canopy EX Sharpen Roundup PowerMax	2.0 oz 1.0 oz 22.0 oz	0	93	100	100
Basis Sharpen Roundup PowerMax	0.5 oz 1.0 oz 22.0 oz	0	100	100	100
Envive Valor Roundup PowerMax 2,4-D LV Ester	3.5 oz 2.0 oz 22.0 oz 1.0 pt	0	100	100	100
Envive Valor Sharpen Roundup PowerMax	3.5 oz 2.0 oz 1.0 oz 1.0 pt	0	100	100	100
Roundup PowerMax 2,4-D LV Ester	22.0 oz 1.0 pt	0	90	100	100
Untreated check	---	0	0	0	0
LSD (0.05)		NS	6	0	0

[1] All treatments included AMS at 17 lb/100 gal.

[2] CG – large crabgrass.

Table 2. Weed control ratings from preplant burndown treatments in no-till soybean, June 23, and grain yield at harvest, Rossville Field, 2010

		% weed control, June 23[2]				
Treatment[1]	Rate/a	CG	PA	SF	IM	Yield
						bu/a
Canopy EX	2.0 oz	75	95	100	97	55.2
Roundup PowerMax	22.0 oz					
2,4-D LV Ester	1.0 pt					
Basis	0.5 oz	77	98	100	92	56.7
Roundup PowerMax	22.0 oz					
2,4-D LV Ester	1.0 pt					
Valor	2.0 oz	72	98	100	87	55.5
Roundup PowerMax	22.0 oz					
2,4-D LV Ester	1.0 pt					
Sharpen	oz	47	95	100	90	59.3
Roundup PowerMax	22.0 oz					
Canopy EX	2.0 oz	72	97	100	97	54.3
Sharpen	1.0 oz					
Roundup PowerMax	22.0 oz					
Basis	0.5 oz	77	93	100	90	58.0
Sharpen	1.0 oz					
Roundup PowerMax	22.0 oz					
Envive	3.5 oz	82	98	100	90	57.2
Valor	2.0 oz					
Roundup PowerMax	22.0 oz					
2,4-D LV Ester	1.0 pt					
Envive	3.5 oz	83	98	100	93	53.2
Valor	2.0 oz					
Sharpen	1.0 oz					
Roundup PowerMax	1.0 pt					
Roundup PowerMax	22.0 oz	53	95	100	92	63.3
2,4-D LV Ester	1.0 pt					
Untreated check	---	0	0	0	0	55.0
LSD (0.05)		18	9	0	9	14.3

[1] All preplant treatments included AMS at 17 lb/100 gal and all plots were treated with Roundup PowerMax, 22 oz/a on June 24 + AMS at 17 lb/100 gal.

[2] CG – large crabgrass; PA – Palmer amaranth; SF – common sunflower; IM – ivyleaf morningglory.

Table 3. Effect of herbicide applications on weed control and grain yield in conventional tillage soybean, Rossville Field, 2010

Treatment[1]	Rate/a	Application time[2]	Phyto	% weed control, July 22[3]				Yield
				CG	PA	SF	IM	
			%, 6/28					bu/a
Untreated check			0	0	0	0	0	21.0
Flexstar GT	38 oz	MP	7	90	100	100	88	55.2
Resource Roundup PowerMax	3.0 oz 22 oz	MP	5	87	100	100	80	60.3
Cadet Roundup PowerMax	0.5 oz 22 oz	MP	7	83	95	100	73	55.0
Flexstar GT	48 oz	MP	8	83	100	100	85	61.3
Roundup PowerMax	22 oz	MP	0	85	100	100	82	58.9
Roundup PowerMax	28 oz	MP	0	80	97	100	75	55.8
Cobra Roundup PowerMax	10 oz 28 oz	MP	17	87	98	100	83	60.6
Flexstar GT Flexstar GT	30 oz 30 oz	EP LP	2	100	93	100	93	43.2
Roundup PowerMax	18 oz 18 oz	EP LP	0	97	97	100	88	55.3
Boundary Flexstar GT	1.5 pt 48 oz	PRE MP	7	93	100	100	88	57.7
LSD (0.05)			4	0	7	0	9	18.7

[1] All Flexstar GT and Roundup PowerMax treatments included AMS at 17 lb/100 gal.

[2] PRE – preemergence, 5/25; EP – early postemergence, 6/18; MP – mid-postemergence, 6/24; LP – late postemergence, 7/14.

[3] CG – large crabgrass; PA – Palmer amaranth; SF – common sunflower; IM – ivyleaf morningglory.

Table 4. Effect of two-pass herbicide applications on weed control and grain yield in conventional tillage soybean, Rossville Field, 2010

Treatment[1]	Rate/a	Application time[2]	% weed control, July 22[3] CG	PA	SF	IM	Yield
							bu/a
Untreated check			0	0	0	0	4.4
Sonic Durango DMA	3.0 oz 24 oz	PRE MP	82	97	100	84	63.2
Durango DMA + FirstRate Durango DMA	24 oz 0.3 oz 24 oz	EP LP	97	100	100	82	64.8
Authority Broadleaf Roundup PowerMax	4.0 oz 22 oz	PRE MP	83	97	100	87	65.4
Authority Assist Roundup PowerMax	5.0 oz 22 oz	PRE MP	87	98	100	90	63.5
Authority First Roundup PowerMax	3.2 oz 22 oz	PRE MP	87	98	100	95	60.1
Authority MTZ Roundup PowerMax	10 oz 22 oz	PRE MP	87	98	100	85	60.8
Valor XLT Roundup PowerMax	2.5 oz 22 oz	PRE MP	83	100	100	78	60.1
Valor XLT Roundup PowerMax	3.5 oz 22 oz	PRE MP	88	100	100	90	53.1
Prefix Roundup PowerMax	2.0 pt 22 oz	PRE MP	92	98	100	75	62.2
Optill Roundup PowerMax	2.0 oz 22 oz	PRE MP	88	97	100	87	59.6
Roundup PowerMax	22 oz 22 oz	EP LP	93	100	100	92	63.9
LSD (0.05)			8	5	0	10	9.2

[1] All Durango DMA and Roundup PowerMax treatments included AMS at 17 lb/100 gal.

[2] PRE – preemergence, 5/25; EP – early postemergence, 6/18; MP – mid-postemergence, 6/24; LP – late postemergence, 7/14.

[3] CG – large crabgrass; PA – Palmer amaranth; SF – common sunflower; IM – ivyleaf morningglory.

Fixed- and Flex-Ear Corn Hybrid Response to Different Plant Populations in Irrigated Environments

S.R. Duncan, L.D. Maddux, and W.B. Gordon

Summary

Plentiful precipitation and mild temperatures favored corn growth and development through the early 2010 growing season. About midway through grain fill, average daytime temperatures approached record levels, resulting in heat stress on the crop at Scandia and Silver Lake. Both sites were adequately irrigated through this period. Charcoal rot infested the fixed-ear hybrid plots at both locations. Overall, 2010 yields were 42 bu/a and 57 bu/a lower at Silver Lake and Scandia, respectively, than in 2009. Yields increased as plant population increased up to the recommended levels, then leveled off, even with increasing populations at both sites. Ear size trended lower with increasing populations at Scandia, whereas at Silver Lake ear size decreased with population only in the flex-hybrid. Flex-hybrid ears were heavier than those of the fixed hybrid at Scandia, presumably due to stalk rot; this result was in contrast to no difference in 2009. At Silver Lake only the flex-hybrid ears were smaller and only at populations above recommended levels. Neither hybrid produced harvestable secondary ears. This contrasted with 2009 results in which the fixed-ear hybrid produced primary ears larger than those of the flex-ear hybrid, and also set secondary ears at lower populations. Different hybrids were used in 2010 vs. 2009, but in both years one hybrid was strongly fixed whereas the other had strong flexing capacity. Our results indicate that fixed- and flex-ear hybrids will increase ear size substantially at lower populations. At extremely low populations, a fixed hybrid might produce harvestable secondary ears (one of four sites in this study), but the impact on grain yield is small (+3%). When grown under irrigated conditions, producers should plant recommended populations of a high-yielding hybrid with good levels of stalk rot tolerance regardless of ear type

Introduction

Recommended plant populations for corn production have increased steadily in the past three decades. Insect resistance traits were introduced in hybrids in the mid- to late 1990s. Since then, different insect and herbicide resistance traits have been incorporated into a greater percentage of newly released hybrids. At the same time, the price per unit of corn seed also has increased, leading to growers' interest in targeting optimum populations for their particular acreage. Irrigated corn growers increase populations of hybrids that will produce maximum yields without diverting energy to secondary ear production. Hybrids differ in their relative fixed abilities to flex when yield-limiting factors are minimal. The objective of this study was to compare a fixed-ear hybrid that would maintain a relatively stable ear number to a flex-ear hybrid in a range of populations in dryland and irrigated environments.

Procedures

Irrigated experiments were established at the Kansas River Valley Experiment Field (KRV) at Rossville, KS, in 2009; at Silver Lake, KS, in 2010; and at the Irrigation and North Central Experiment Fields (NC) at Scandia, KS, in 2009 and 2010. Site descriptions and cultural practices are listed in Table 1. Different hybrids were used in 2010 vs. 2009, but ear-flex characteristics were consistent. Seed drop was approximately 35,000 to 36,000 seeds/a. Five target populations (Table 2) were established by hand thinning to the desired populations when the plants were from V2 to V4 growth stage (two to four leaf collars showing), and then returning 10 to 14 days later and removing late-emerging plants. None of the 2010 plots had plants that produced a secondary ear, although some were present in the KRV 2009 fixed-ear hybrids. Secondary ears were hand harvested prior to machine harvesting of the plots. Grain yields were adjusted to 15.5% moisture. Measurements taken include harvest populations; grain yield from the whole plot, main and secondary ears; grain moisture and test weight; average kernel weight; and percentage of plants producing secondary ears and their contribution to total yield.

Results

Thinning resulted in the desired differences between population groups (PG) in 2010. As a result of a second thinning within 14 days of the first, no differences in plant numbers existed across all five population groups in 2010. No yield differences were noted among PGs of the fixed hybrid at NC (Table 3), probably due to the onset of charcoal/stalk rot in this particular hybrid. Fixed-hybrid plots lodged from 18% in PG 1 to 41% in PG 5 at NC, but lodging in the flex-hybrid plots averaged 3% or less. Below recommended populations in flex-hybrid plots at NC resulted in significantly reduced yields vs. the standard and PG 5 plots. At KRV, fixed-plot lodging scores ranged from 9% in PG 2 to 42% in PG 5, but yields (Table 3) from fixed PG 4 (208 bu/a) and 5 (204 bu/a) were greater than those from PG 1 (164 bu/a) and 2 (173 bu/a). Lodging in flex-hybrid plots was no greater than 6% at KRV, where no differences in yield were measured across PG of flex plots, but flex PG 3 yield (192 bu/a) was greater than grain yield of PG 1 fixed plots (164 bu/a). The second thinning was implemented because the 2009 KRV and NC final fixed-ear hybrid populations were 5 to 7% greater than those of flex-ear plots, which resulted in 15% greater grain yields at KRV. Neither hybrid nor PG had an influence on grain moisture and test weight in the KRV plots; however, kernel weight was greatest in the flex hybrid and in the two lowest PG. This reflects the effects of stalk rot/lodging of the fixed hybrid and in plots with the recommended PG or higher. The stalk rot/lodging tolerance of the flex hybrid at NC resulted in greater grain moisture, test weight, and kernel weight vs. grain from the fixed hybrid. No difference in ear size of hybrids was recorded at KRV, but the ears from the flex hybrid were 11% heavier than those of the fixed hybrid at NC. As expected, when plant population increased, ear size decreased at both locations. Secondary ear yields were negligible (<1%) and were not included in the analysis of this study in 2010.

Table 1. Cultural practices for a flex- vs. fixed-ear hybrid comparison study

	2010		2009	
	Scandia	Silver Lake	Scandia	Rossville
Soil type	Crete silt loam	Eudora silt loam	Crete silt loam	Eudora silt loam
Hybrid				
Fixed	Garst 83X61	Garst 83X61	Garst 85E97	Garst 85E97
Flex	Garst 84U96	Garst 84U96	Garst 85R08	Garst 85R08
Fertilizer program	200 lb N/a - AA[1] 20-20-0 - StB[2]	150 lb N/a - AA 11-52-60 - PPI[3]	200 lb N/a - AA 20-20-0 - StB	150 lb N/a - AA 11-52-60 - PPI
Weed control program	Bd[4] - glyphosate 1qt/a Pre[5] - Lexar 3qt/a	Pre - Lexar 3 qt/a Post[6] - Callisto 3 oz/a Post - Roundup WeatherMax 22 oz/a	Bd - glyphosate 1 qt/a Pre - Lexar 3 qt/a	Pre - Harness Xtra - 2.4 qt/a Post - Roundup WeatherMax 22 oz/a
Irrigation	July 9 – 1.25 in. July 15 – 1.25 in. July 26 – 1.25 in. August 3 – 1.25 in. August 10 – 1.25 in.	July 22 – 0.91 in. July 29 – 0.94 in. August 2 – 1.12 in. August 10 – 1.11 in.	unavailable	none

[1] Anhydrous ammonia applied preplant.

[2] Starter Band placed 2 in. × 2 in. from the row.

[3] Preplant-incorporated.

[4] Burndown application, preplant.

[5] Preemerge application.

[6] Postemergence application.

Table 2. Target populations for a flex- vs. fixed-ear hybrid comparison study

Population group (PG)	Difference from local standard	Target population		Actual population			
		NC	KRV	NC 2010	KRV 2010	NC 2009	KRV 2009
		plants/a					
1	-5,000	23,000	22,000	23,174	22,729	22,651	22,586
2	-2,500	25,500	24,500	25,134	24,742	25,657	24,045
3	0	28,000	27,000	27,530	26,485	26,964	26,223
4	+2,500	30,500	29,500	29,577	28,401	29,229	29,468
5	+5,000	33,000	32,000	31,581	30,361	30,405	31,102

Table 3. Grain yields from an irrigated flex- vs. fixed-ear hybrid comparison study

		2010					2009	
		NC		KRV			NC	KRV
Ear type	Population group	Yield	Lodging	Yield	Lodging	Ear type	Yield, bu/a	
		bu/a	%	bu/a	%	Fixed	227	241
Fixed	1	167	18	164	18	Flex	238	209
	2	166	28	173	9	Mean	233	225
	3	162	31	187	33	LSD (0.05)	19	12
	4	168	38	208	28			
	5	168	41	204	42			
						Population group		
Flex	1	175	2	176	3	1	212	209
	2	180	3	171	2	2	228	214
	3	195	2	192	6	3	233	227
	4	186	1	177	6	4	251	233
	5	197	2	178	6	5	239	241
Mean		176	17	183	16	Mean	233	225
LSD (0.05)		17	7.9	26.5	19	LSD (0.05)	11.9	19

Table 4. Flex vs. fixed hybrid ear and kernel weights from an irrigated corn study

	2010							2009				
	NC		KRV						NC		KRV	
Ear type	Main ear	Kernel weight	Ear type	Population group	Main ear	Ear type	Kernel weight	Ear type	Main ear	Kernel weight	Main ear	Kernel weight
	oz/ear	g/1,000			oz/ear		g/1,000		oz/ear	g/1,000	oz/ear	g/1,000
Fixed	5.4	318	Fixed	1	6.5	Fixed	248	Fixed	7.8	402	8.3	342
Flex	6.0	246		2	6.2	Flex	282	Flex	7.7	383	7.4	387
Mean	5.7	282		3	6.2	Mean	265	Mean	7.7	393	7.8	364
LSD (0.05)	0.4	7.7		4	6.4	LSD (0.05)	23	LSD (0.05)	NS	NS	0.4	7.5
				5	6.0							
Population group			Flex	1	6.8	Population group		Population group				
1	6.5	286		2	6.1	1	273	1	8.3	401	8.6	369
2	6.0	283		3	6.5	2	272	2	7.9	393	8.1	369
3	5.7	284		4	5.5	3	258	3	7.7	393	7.9	364
4	5.3	279		5	5.1	4	267	4	7.7	390	7.5	361
5	5.1	278				5	257	5	7.0	386	7.1	357
Mean	5.7	282			6.1		256	Mean	7.7	393	7.8	364
LSD (0.05)	0.3	NS			0.75		14.8	LSD (0.05)	0.3	9.0	0.6	12.0

Fixed- and Flex-Ear Corn Hybrid Response to Different Plant Populations in Dryland Environments

S.R. Duncan, L.D. Maddux, W.B. Gordon, and K.A. Janssen

Summary

This was the final year of a two-year study. Different hybrids were used in 2010 vs. 2009, but in both years one hybrid was strongly fixed while the other had a strong flexing capacity. Plentiful precipitation and mild temperatures favored corn growth and development throughout the 2009 growing season and the first half of the 2010 growing season. Midway through 2010 grain fill, daytime temperatures reached near or above record levels at all sites: Belleville, KS; Kansas River Valley (KRV); and Ottawa, KS. Grain yields in 2010 were 29% and 46% lower than those in 2009 at KRV and Belleville, respectively. Hybrid type affected grain yield at KRV in both years where fixed-ear hybrid yields were greater than those of the flex-ear type. Grain yields increased as plant population increased to the recommended levels and then leveled off at low-yielding sites in 2010. At high-yielding sites, yields continued to increase at above recommended plant populations. Overall, ear size decreased as plant population increased. Fixed-hybrid primary ears were heavier than those of the flex hybrid at KRV in both years, but not at any other location. Secondary, or double, ears were small and decreased in size and number as plant population increased. The fixed-ear hybrids were more likely to produce secondary ears, which at extremely low populations, contributed 12 to 18% of final grain yield. At two of three high-yielding locations, the fixed-ear hybrids tended to outyield the flex-ear hybrids, but yield differences were not observed between types at lower-yielding sites. If dryland corn is to be planted where yield potential is 150 bu/a or greater, recommended plant populations need to be revisited and perhaps increased.

Introduction

Recommended plant populations for corn production have steadily increased in the past three decades. Insect resistance traits were introduced into hybrids in the mid- to late 1990s. Since then, different insect and herbicide resistance traits have been incorporated into a greater percentage of newly released hybrids. At the same time, the price per unit of corn seed has also increased, leading to growers' interest in targeting optimum populations for their particular acreage. Dryland corn growers tend to increase seed drop, and therefore plant populations of hybrids that will produce maximum yields. On fields with low yet profitable yield potential, target populations will be reduced compared to higher yield potential fields. One criterion that may influence hybrid selection for dryland corn growers is a hybrid's degree of ability to "flex" and utilize excess production factors such as moisture or fertility. Hybrids differ in their relative ability to flex when yield-limiting factors are minimal. The objective of this study was to compare flex- and fixed-ear hybrids over a range of populations in dryland environments.

Procedures

Rainfed experiments were established at the Kansas River Valley Experiment Field (KRV) near Rossville (2009) and Silver Lake (2010), at the Irrigation and North Central Experiment Fields (NC) near Belleville (2009 and 2010), and at the East Central Kansas Experiment Field (EC) near Ottawa (2009 and 2010). Site descriptions and cultural practices are listed in Table 1. Although different hybrids were used in 2010 vs. 2009, the ear-flex characteristics were consistent. Seed drop was approximately 29,500 seeds/a. Five target populations (Table 2) were established by hand thinning to the desired populations when the plants were from V2 to V4 growth stage (two to four leaf collars visible), then returning 10 to 14 days later and removing late-emerging plants. If secondary ears were produced, they were hand harvested prior to machine harvesting of the plots. Grain yields were adjusted to 15.5% moisture. Measurements taken include harvest populations; grain yield from the whole plot, main and secondary ears; grain moisture and test weight; average kernel weight; percentage of plants producing secondary ears and their contribution to total yield.

Results

Thinning resulted in the desired differences between population groups (PG) in 2010. As a result of a second thinning within 14 days of the first, no differences in plant numbers existed across all five population groups in 2010 or at KRV in 2009. Late-emerging plants at NC in 2009 resulted in only four of five distinguishable populations. The 2009 sites at KRV and NC grew under relatively stress-free conditions the entire season. A severe thunderstorm on July 8, 2009, resulted in severe greensnap and the loss of the EC plot. Corn yields (Table 3) of PG 5 fixed-ear plots at KRV in 2009 were greater than PG 1 fixed-ear plots and all flex-ear plots except for PG 5. No yield differences between hybrid types were noted at NC or EC in either year; however, the fixed-ear hybrid produced 21% more grain than the flex-ear hybrid at KRV in 2010.

Final plant stands in PG 1 plots averaged about 75% of PG 3 (recommended population) plots yet produced similar grain yields at NC in 2009 and EC in 2010 (stressed during grain fill). Increasing plant population from PG 3 to PG 5 never resulted in yield differences except at KRV in 2010 (relatively stress-free), where PG 5 yields were 21% greater than those of PG 3 plots. Neither hybrid nor PG influenced grain moisture or test weight except in the 2009 KRV plots, where the fixed-ear hybrid grain moisture was higher and test weight was lower compared to flex-ear grain. Slight differences in the primary ear size (Table 4) were noted, reflecting environmental influences. Ear size was diminished as plant population increased, except at the 2010 KRV site. Flex-ear hybrids tended to produce heavier kernels (Table 4) than fixed-ear hybrids. Increasing plant population had very little influence on kernel size. Secondary or double ears were not produced at NC in either year. If the flex-ear hybrid produced doubles, the contribution to total plot yield was ≤ 2% (Table 5). In PG 1 plots, fixed-ear hybrids produced 12 to 18% of total plot yield. When plant population of fixed-ear hybrids was near the recommended level, the double ear contribution dropped to 4 to 7% of total plot yield, and was insignificant at PG 4 and PG 5.

Table 1. Cultural practices for a rainfed flex- vs. fixed-ear hybrid comparison study

	2009			2010		
	Belleville	Silver Lake	Ottawa	Belleville	Rossville	Ottawa
Soil type	Crete silt loam	Eudora silt loam	Woodson silt loam	Crete silt loam	Eudora silt loam	Woodson silt loam
Hybrid						
Fixed	Garst 85E97	Garst 85E97	Garst 85E97	Garst 83X61	Garst 83X61	Garst 83X61
Flex	Garst 85R08	Garst 85R08	Garst 85R08	Garst 84U96	Garst 84U96	Garst 84U96
Fertilizer program	125 lb N/a – AA[1] 20-20-0 – StB[2]	125 lb N/a - AA 11-52-60 – PPI[3]	120-40-13 – ST[4]	125 lb N/a - AA 20-20-0 - StB	125 lb N/a - AA 11-52-60 - PPI	120-40-13 – ST 60 lb N/a TD[5]
Weed control program	Bd[6] - glyphosate 1qt/a Pre[7] - Lexar 3qt/a	Pre - Lexar 3 qt/a Post[8] - Callisto 3 oz/a Post - Roundup WeatherMax 22 oz/a	Pre - 1 lb Atrizane + 1 pt 2,4-D Post - GlyPhos Extra 40 oz/a	Bd - glyphosate 1 qt/a Pre - Lexar 3 qt/a	Pre - Harness Xtra 2.4 qt/a Post - Roundup WeatherMax 22 oz/a	Pre - 1 lb Atrizane + 1 pt 2,4-D Post - GlyPhos Extra 40 oz/a

[1] Anhydrous ammonia applied preplant.

[2] Starter band placed 2 in. × 2 in. from the row.

[3] Preplant-incorporated.

[4] Strip-tilled with fertilizer deep band applied.

[5] Top dressed at V10.

[6] Burndown application, preplant

[7] Preemerge application

[8] Postemergence application

Table 2. Target populations for a rainfed flex- and fixed-ear hybrid comparison study

Population group (PG)	Difference from local standard	Target population	Harvest population					
			NC 2009	KRV 2009	EC 2009[1]	NC 2010	KRV 2010	EC 2010
			plants/a					
1	−5,000	15,500	16,390	15,290	11,108	15,355	14,767	15,464
2	−2,500	18,000	18,840	17,849	11,979	17,364	17,511	17,152
3	0	20,500	21,236	19,667	14,070	20,909	20,081	19,874
4	+2,500	23,000	21,290	22,967	16,727	21,889	21,649	21,834
5	+5,000	25,500	23,907	24,697	18,295	25,030	24,481	23,795

[1] A severe thunderstorm caused severe greensnap, resulting in harvest population reductions. EC plots were not included in any final analyses.

Table 3. Grain yields from a rainfed flex- and fixed-ear hybrid comparison study

		2009			2010		
		KRV		NC	KRV	NC	EC
Ear type	Population group	Yield	Ear type	Yield		Yield	
		bu/a		----------	----------	bu/a	----------
Fixed	1	205	Fixed	181	169	123	102
	2	214	Flex	178	140	123	106
	3	214	Mean	180	154	123	104
	4	218	LSD (0.05)	NS	15.1	NS	NS
	5	235					
			Population group				
Flex	1	129	1	163	121	111	95
	2	167	2	180	145	117	100
	3	173	3	180	155	127	104
	4	199	4	189	160	133	110
	5	214	5	187	187	128	112
Mean		197	Mean	180	154	123	104
LSD (0.05)		22.7	LSD (0.05)	24.4	17.0	8.5	11.2

Table 4. Flex- vs. fixed-ear hybrid ear and average kernel weight in a rainfed corn study

	Main ear size					Thousand kernel weight							
	2009		2010				Population group	2009		2009	2010		
Ear type	NC	KRV	NC	KRV	EC	Ear type		KRV	Ear type	NC	NC	KRV	EC
	oz/ear							grams		grams			
Fixed	5.4	9.2	5.4	7.0	4.4	Fixed	1	344	Fixed	373	249	248	186
Flex	6.0	8.3	5.4	6.2	4.8		2	342	Flex	360	285	285	232
Mean	5.7	8.8	5.4	6.6	4.6		3	347	Mean	366	267	266	209
LSD (0.05)	0.4	0.5	NS	0.5	NS		4	338	LSD (0.05)	NS	14.0	10.0	15.1
							5	344					
Population group						Flex	1	390	Population group				
1	6.5	9.0	6.2	6.4	5.0		2	388	1	364	270	272	213
2	6.0	9.1	5.8	6.9	4.9		3	382	2	366	274	269	208
3	5.7	9.1	5.3	6.9	4.5		4	370	3	366	265	270	205
4	5.3	8.4	5.3	6.2	4.4		5	360	4	367	265	260	212
5	5.1	8.2	4.4	6.7	4.1				5	366	260	261	207
Mean	5.7	8.8	5.4	6.6	4.6			360	Mean	366	267	266	209
LSD (0.05)	0.3	0.8	0.4	NS	0.5			14.4	LSD (0.05)	NS	10.4	NS	NS

Table 5. Flex- vs. fixed-ear hybrid secondary ear contribution to yield and characteristics in a rainfed corn study

		2009 KRV				2010 KRV				2010 EC			
Ear type	Population group	Double[1]	Yield	Size	Percentage of total[2]	Double	Yield	Size	Percentage of total	Double	Yield	Size	Percentage of total
		%	bu/a	oz/ear		%	bu/a	oz/ear		%	bu/a	oz/ear	
Fixed	1	50	36	4.5	18	51	23	2.6	15	36	11	1.8	12
	2	29	18	3.6	9	29	15	2.5	9	19	6	1.5	6
	3	25	15	3.0	7	12	6	3.0	4	12	4	1.2	4
	4	10	6	2.4	3	7	3	1.8	2	4	1	1.1	1
	5	7	4	2.1	2	5	3	1.4	1	6	2	1	2
Flex	1	0	0	0	0	4	2	1.9	2	4	1	1	1
	2	0	0	0	0	2	1	1.0	2	4	2	1.3	2
	3	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0
Mean		24	16	3.1	7.5	11	5	1.5	3.4	9	3	0.9	2.7
LSD (0.05)		8.0	7.3	0.6	3.5	10.1	6.3	1.9	3.9	14.8	4.9	1.4	5.1

[1] Percentage of plants producing a secondary (double) ear.

[2] Percentage of total plot yield contributed by the secondary (double) ear.

Sorghum Canopy Architecture and Crop Water Productivity

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Summary

Sorghum grown for forage typically achieves greater biomass productivity than sorghum developed for grain production. This study investigates whether greater productivity of forage sorghum relates to canopy architecture. Four standard breeding lines and three exotic lines were grown in field plots; water use, light interception, and biomass were measured periodically. Sorghum lines differed in water productivity (biomass produced per unit of water use); crop water productivity was more strongly related to differences in biomass than to differences in water use. Crop conversion of sunlight into biomass generally increased with average distance between leaves and plant height; conversion of sunlight into biomass was positively related to crop water productivity. Factors affecting crop utilization of sunlight can increase crop water productivity and also may increase sorghum grain productivity.

Introduction

Increased sorghum (*Sorghum bicolor*) grain productivity may result from improved use of available water, nutrients, and solar radiation. Increasing crop water productivity, the ratio of biomass produced per unit of water transpired, can enhance crop productivity and yield potential. The term canopy architecture refers to the distribution, area, shape, and orientation of leaves, stems, and reproductive structures. Kato et al. (2004) reported that leaf area index and total increase in dry matter determine water productivity for a sparse crop. Clegg (1972) found that sorghum lines with upright leaves (more open canopy architecture) had a greater yield response to increased populations than lines with a more horizontal leaf orientation. The objective of this study was to evaluate the factors affecting water productivity among sorghum lines, which differ in crop canopy architecture.

Procedures

Four standard sorghum breeding lines and three exotic accessions were planted in 20-ft by 20-ft plots on June 25, 2009, and in 20-ft by 10-ft plots on May 28, 2010, at Colby, Kansas. Plots were arranged in a randomized complete block design (five replications) in 2009 and completely randomized design in 2010 (four replications). Optimum soil water and nutrient conditions were ensured for crops throughout both growing seasons by supplemental irrigation and fertilization. At maturity, stem height was determined as the distance between soil and flag leaf ligule; average distance between leaves (internode length) was calculated by dividing stem height by total leaf number.

In 2009, biomass was measured by destructive harvest at boot stage post-anthesis; biomass at an early day of vegetative growth was determined by an allometric method assuming dry biomass as a function of stem volume. In 2010, five consecutive plants were periodically harvested approximately biweekly from each plot from 35 to 105 days after planting. At grain maturity, panicles and stems were harvested separately from each plot.

Crop water use was determined by the soil water balance, which includes soil water depletion (measured by neutron thermalization), irrigation, and precipitation. Soil evaporation was suppressed by adding wheat straw at a depth of 2 in. in rows with access tubes in 2009. Crop water productivity was calculated as the slope of the regression of aboveground biomass on water use.

Results

Growth characteristics of the sorghum lines are shown in the Table 1. Three of the four standard breeding lines had normal flowering times (photoperiod sensitivity), whereas one line (TX 399) had delayed flowering. These lines had standard commercial heights, with average distance between leaves (internode lengths) from 1.2 to 1.7 in. One of the exotic lines (Liang Tang Ai) was somewhat taller with slightly greater distance between leaves. The other two exotic lines were tall, flowered late, and had greater average distance between leaves (3 to 5.9 in.), representing a more open canopy architecture.

Crop water productivity (lb biomass/a-in. of crop water use) differed among the breeding lines and the two tall exotic accessions (Table 1 and Figure 1); the ranking of crop water productivity was similar in 2009 and 2010 growing seasons. The smaller water productivity levels in 2009 are attributed to delayed planting (due to wet spring conditions) and final harvest just after heading, when sorghum productivity is strong. In comparison, the 2010 crop was able to grow through maturity for these measurements. The two tall exotic accessions had greatest biomass growth relative to their respective water use. This difference is attributed to increased conversion of light into biomass; we infer that more open canopy architecture permitted greater leaf productivity for these lines. Confirming this observation can establish the basis for developing and selecting sorghum hybrids with similar increased productivity.

References

Kato, T., R. Kimura, M. Kamichika. 2004. Estimation of evapotranspiration, transpiration ratio and water use efficiency from a sparse canopy using a compartment model. Agricultural water management 65:173–191.

Clegg, M.D. 1972. Light and yield related aspects of sorghum canopies. In: Sorghum in the seventies. N. Ganga Prasada Rao and L. R. House. (Eds.) Oxford & IBH Publishing Co., Oxford. pp. 279–299.

Table 1. Sorghum height, average distance between leaves (internode length), and crop water productivity in 2009 and 2010 growing seasons at Colby, KS

Line	Photoperiod sensitivity	Stem height, in.		Average internode length, in.		Crop water productivity, lb/a-in.	
		2009	2010	2009	2010	2009	2010
TX 7000	Normal	30.3	30.3	1.71	1.51	977	1535
TX 399	Late	23.6	28.7	1.20	1.28	792	1157
TX 2862	Normal	29.9	33.8	1.54	1.50	896	1529
TX 7078	Normal	28.0	28.3	1.68	1.51	850	993
Liang Tang Ai	Normal	33.8	41.7	2.03	2.10	778	1021
IS 27150	Late	78.0	82.3	4.24	3.96	1125	2114
IS 27111	Sensitive	61.8	124.4	3.01	5.87	1184	1973

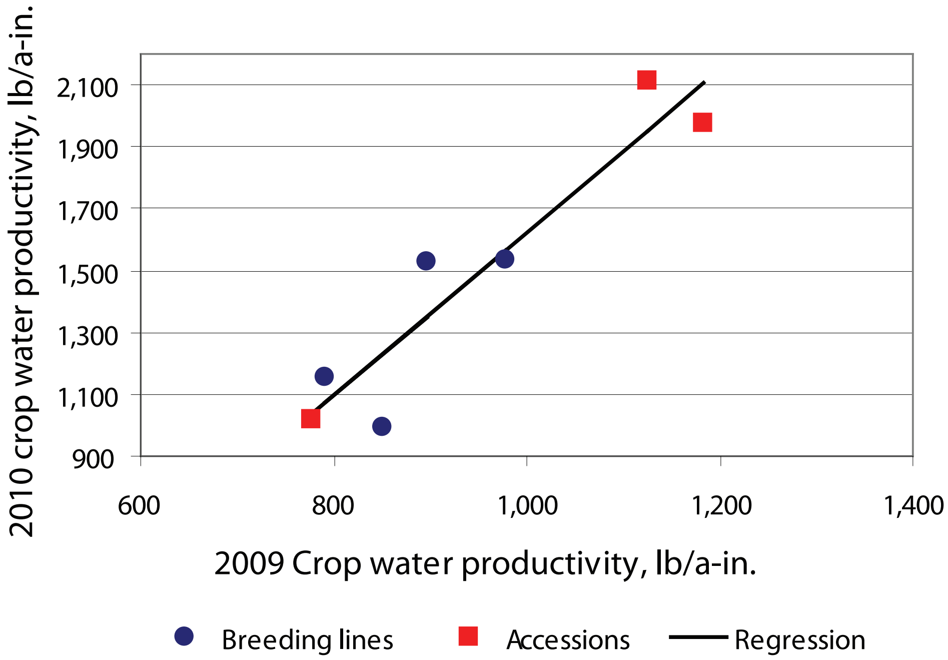

Figure 1. Crop water productivity of four sorghum breeding lines and three exotic accessions is shown for the 2010 growing season in relation to results from the 2009 growing season at Colby, KS. Crop water productivity (also known as biomass-based water use efficiency) is the quantity of biomass produced per unit of crop water use.

Planting Geometry Effects on Sorghum Productivity in the Central High Plains

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Summary

Planting grain sorghum in clumps can increase yield potential under dry conditions. Field studies conducted at Colby, Tribune, and Garden City, KS, in 2009 and 2010 compared clumped and uniform planting geometries for early and medium-early grain sorghum hybrids at low, medium-low, medium-high, and high seeding rates to see if clumped planting reduces yield potential under more favorable growing conditions. Yield advantage to sorghum planted in clumps was greater than 10 bu/a in two of seven growing environments; clumped planting reduced grain yield by 30 bu/a in a high-yielding (187 bu/a) growing environment. No differences were detected between clumped and uniform planting geometries in the remaining environments.

Introduction

Clumped planting can increase grain sorghum yield up to 45% under dry conditions, possibly by reducing tiller number, increasing radiation use efficiency, and preserving soil water for grain fill. In semi-arid regions, more utilization of water at early vegetative stage by producing tillers can lead to water deficits at the grain filling stage, resulting in yield loss. By planting grain sorghum in clumps, the fraction of tillers that produce heads may increase, increasing yield potential under dry conditions. Possible losses in yield potential under more favorable growing conditions are unknown. The objective of this study was to evaluate effects of planting geometry on sorghum grain yield formation.

Procedures

Field studies were conducted at Colby, Garden City, and Tribune in 2009 and 2010 as randomized complete block (four replicates) with factorial treatments consisting of early and medium-early sorghum hybrids, uniform or clumped planting geometries, and low, medium-low, medium-high, and high seeding rates. In Colby in 2009, planting was on May 21 and June 24. Clumped planting was achieved using plates for cotton hill seeders in a John Deere 7300 air planter. At maturity, the crop was hand harvested (1 m row, representative of treatment) to measure yield and yield components. Center rows of plots were machine harvested as well.

Results

Results presented are hand-harvested grain yields. Grain yields were generally similar within growing environments (Table 1). Exceptions to this pattern include a 39% decrease in grain yield due to delayed planting in 2009 at Colby; the medium-early hybrid had 11% greater yield than the early hybrid for the May 21 planting date at Colby. Considering results from studies conducted at Bushland, TX, and Tribune, KS, in 2004 (Bandaru et al., 2006), the yield advantage of clumped planting occurred in environments with yield potential ranging from 40 to 140 bu/a (Figure 1). A 17% yield reduction resulted from clumped planting for the high-yielding (187 bu/a) growing conditions at Colby (May 21 planting date). No differences were detected due to planting geometry in four of seven environments with yield potential from 80 to 140 bu/a. Sorghum crops generally compensated for differences in population and planting geometry with differences in yield components (heads/a, seeds/head, and/or seed weight).

References

Bandaru, V., B.A. Stewart, R.L. Baumhardt, S. Ambati, C.A. Robinson, and A. Schlegel. 2006. Growing dryland grain sorghum in clumps to reduce vegetative growth and increase yield. Agron. J. 98:1109–1120.

Table 1. Sorghum grain yield (bu/a), as affected by hybrid maturity, planting geometry, or seeding rate, for seven growing environments in the Kansas High Plains

Treatment	Colby May 21, 2009	Colby June 24, 2009	Colby June 25, 2010	Garden City May 29, 2009	Garden City June 9, 2010	Tribune June 9, 2009	Tribune 2010
Variety							
Early	148	106	134	76	147	82	126
Medium-Early	185	104	141	89	146	85	131
Planting geometry							
Uniform	174	98	134	79	140	79	126
Clumped	151	120	139	86	153	88	131
Seeding rate							
Low	185	96	140	75	145	83	129
Medium-low	177	101	135	88	167	88	133
Medium-high	164	116	132	88	136	83	129
High	149	106	142	79	138	80	122

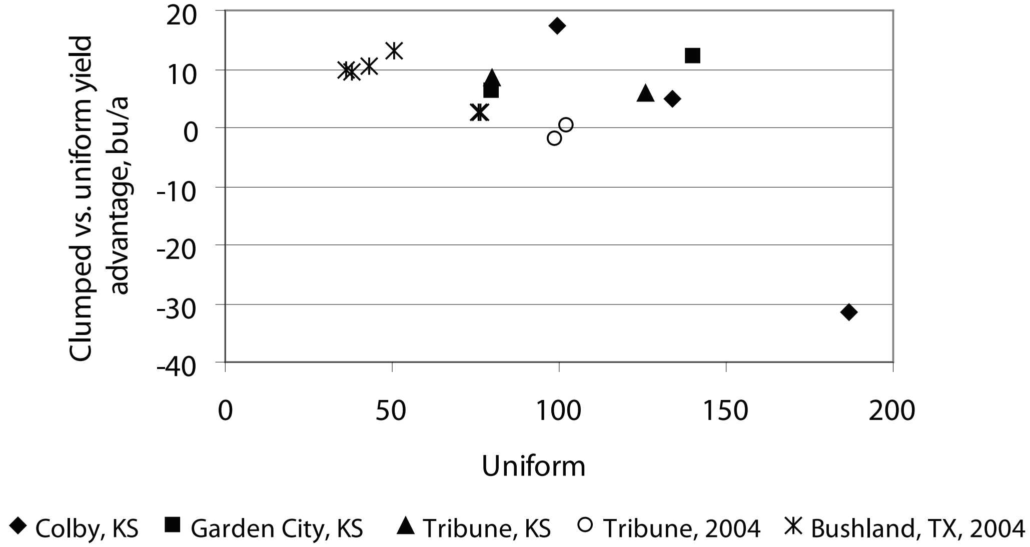

Figure 1. Yield advantage of clumped planting is shown in relation to grain sorghum grown in nine environments of the central and southern High Plains. Yield advantage is calculated as the difference in yield between sorghum planted in clumps and sorghum planted with uniform within-row spacing. Results from Tribune, KS, and Bushland, TX, in 2004 are taken from Bandaru et al., 2006.

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