KANSAS STATE UNIVERSITY
Agronomy

KANSAS FIELD RESEARCH 2014

REPORT OF PROGRESS 1102

K·STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Kansas
Field Research
2014

Contents

2 Contributors

3 *East Central Kansas Experiment Field*

4 Soybean Pest Management

8 Control of Glyphosate-Resistant Waterhemp in Corn

11 *Kansas River Valley Experiment Field*

13 Irrigation Regimes and Soil Oxygen Content: Investigating Environmental Parameters Associated with Soybean Sudden Death Syndrome in Kansas

17 Effects of Seed Treatment on Sudden Death Syndrome Symptoms and Soybean Yield

21 Tillage Study for Corn and Soybean: Comparing Vertical, Deep, and No-Till

23 Drought-Tolerant Corn Hybrids: Yield Benefits

28 *Southeast Agricultural Research Center*

28 Fungicide and Insecticide Use on Wheat in Southeast Kansas

30 Wheat Response to Fungicides in Southeast Kansas

33 *Department of Agronomy*

33 Agronomic Maximization of Soybean Yield and Quality: Row Spacing and Management

40 Improving the Performance of Winter Wheat Planted Without Tillage after Grain Sorghum

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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 top performing varieties and hybrids of wheat, corn, soybean, and grain sorghum; (2) establish the amount of tillage 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 proficiency and environmental stewardship.

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.

2013 Weather Information

Precipitation during 2013 totaled 28.91 in., which was 7.9 in. below the 35-year average (Table 1). Overall, the 2013 growing season was cooler and wetter than 2012. Average rainfall for the months of August and October were the only months receiving above the average. During the summer of 2013, 37 days had temperatures exceeding 90.0°F and no days had temperatures exceeding 100.0°F. The coldest temperatures occurred in January, February, and December, with 15 days in single digits. The last freezing temperature in the spring was May 4 (average = April 18), and the first killing frost in the fall was October 19 (average = October 21). There were 168 frost-free days, which is fewer than the long-term average of 185. Some earlier-pollinating corn hybrids were hurt by the heat during pollination, but some later-pollinating hybrids were able to take advantage of the cooler temperatures and rain in August. As a result, the corn averaged near 140 bu/a. Soybean was also able to take advantage of August rains and produce very respectable yields above 45 bu/a.

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

Month	2013	35-year avg.	Month	2013	35-year avg.
	------------ in. ------------			------------ in. ------------	
January	2.14	1.03	July	1.51	3.37
February	2.27	1.32	August	5.29	3.59
March	1.84	2.49	September	1.42	3.83
April	3.29	3.50	October	4.73	3.43
May	3.77	5.23	November	1.10	2.32
June	0.92	5.21	December	0.63	1.45
			Annual total	28.91	36.78

Soybean Pest Management

D.E. Shoup and E.A. Adee

Summary

With the increase in commodity prices in recent years, producers are turning their focus to increased pest management throughout the growing season. A three-year study was conducted to evaluate soybean yield response to herbicides with preemergence residual weed control, foliar fungicides, and foliar insecticides. Preemergence herbicides provided excellent control of glyphosate-resistant common waterhemp, resulting in a significant soybean yield increase of 4.6 bu/a in 2013. Soybean yield was significantly increased with the addition of a foliar fungicide and foliar fungicide + insecticide applied at the R3 growth stage in 2010. Yield increases of 5.1 and 7.5 bu/a were observed for the fungicide and fungicide + insecticide treatments, respectively.

Introduction

Soybean yield can be affected by various pests, including weeds, diseases, and insects. The economics of soybean production have changed in the last decade, so more attention is being focused on saving soybean yield from these factors through pesticide applications. A three-year study was conducted at the East Central Experiment Field in Ottawa to evaluate soybean response to preemergence herbicides with residual weed control, foliar fungicides, and foliar insecticides.

Procedures

The experimental site was located on a Woodson silt loam. Soybean were no-till planted on 30-in. rows into sorghum stubble in 2010, corn stubble in 2011, and soybean stubble in 2013. Soybean were planted on June 21, 2010; June 9, 2011; and May 29, 2013, with soybean varieties AG4606, S47-R3, and S46-G9, respectively. The experiment was a randomized complete block design with six replications of four treatments. Treatments included: (1) burndown herbicide without residual; (2) burndown herbicide with residual; (3) burndown herbicide with residual + foliar fungicide at R3; and (4) burndown herbicide with residual + foliar fungicide and insecticide at R3. All pesticides, rates, and application dates are listed in Table 1. Common waterhemp weed control ratings were evaluated at the V4 soybean growth stage on a scale of 0 = no control and 100 = complete control. All treatments received 0.75 lb a.i./a glyphosate application at the V4 soybean growth stage. Fungicide and insecticide treatments were applied at the R3 reproductive stage (beginning of pod formation). No significant foliar disease pressure was observed in the trial across all three years, but some insect pressure was noted at the time of the R3 insecticide application. In 2010, one bean leaf beetle and one stinkbug per 100 ft of soybean row were noted at the time of the R3 application. In 2011, two bean leaf beetles and one corn earworm per ft of row were observed at the R3 stage. In 2013, two green clover worms and two grasshoppers per 100 ft of row were observed at R3. Soybean plots were harvested by plot combine, plot weights were determined, and yields were adjusted to 13% moisture.

Results

Soybean in 2010 were planted at a site with glyphosate-susceptible common waterhemp. As a result, excellent weed control was received across all herbicide treatments, and no significant differences were observed in soybean yield between herbicide treatments in 2010. In 2011 and 2013, soybean were planted at a site with glyphosate-resistant common waterhemp; consequently, weed control ratings at the V4 growth stage were poor for the glyphosate and the glyphosate + 2,4-D burndown treatment compared with treatments that included saflufenacil and pyroxasulfone (Table 2). Treatments that contained saflufenacil in the burndown mixture provided control of small emerged common waterhemp at the time of soybean planting, and the residual of pyroxasulfone maintained excellent weed control through the first 6 weeks of the growing season. Although there was a weed control difference in 2011 between herbicides with and without residual, soybean yield did not differ. In 2013, however, there was a 4.6 bu/a advantage with the residual herbicide treatment due to reduced weed competition.

Only trace levels of frogeye leaf spot disease were present in 2010 and 2013, whereas no foliar disease was observed in 2011. In 2010, soybean treated with a fungicide resulted in a 5.1 bu/a yield increase over the untreated check (Table 2). Insect pressure was below the treatment threshold in 2010, but the addition of an insecticide at the R3 growth stage significantly increased soybean yield by 2.4 bu/a over soybean treated with a fungicide alone. In 2011, insect pressure reached the treatment threshold of one corn earworm per ft of soybean row, but no significant yield increase was observed with the addition of an insecticide. In 2013, insect pressure was low, and the addition of an insecticide did not significantly increase yield.

Table 1. Product names, rates, and dates of herbicides applied prior to soybean emergence (preemergence) and fungicide and insecticides applied at beginning soybean pod formation in 2010, 2011, and 2013; all plots were treated with glyphosate when soybean were at the V4 growth stage

Preemergence herbicide application[1]			Application at beginning pod formation[2]		
Date	Pesticide	Rate	Date	Pesticide	Rate
		--- lb a.i./a ---			--- lb a.i./a ---
June 21, 2010	Glyphosate	0.75			
June 21, 2010	Glyphosate + saflufenacil + imazethapyr	0.75 + 0.02 + 0.06			
June 21, 2010	Glyphosate + saflufenacil + imazethapyr	0.75 + 0.02 + 0.06	August 18, 2010	Pyraclostrobin	0.10
June 21, 2010	Glyphosate + saflufenacil + imazethapyr	0.75 + 0.02 + 0.06	August 18, 2010	Pyraclostrobin + zeta-cypermethrin	0.10 + 0.03
June 9, 2011	Glyphosate	0.75			
June 9, 2011	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13			
June 9, 2011	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13	August 9, 2011	Fluxapyroxad + pyraclostrobin	0.04 + 0.09
June 9, 2011	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13	August 9, 2011	Fluxapyroxad + pyraclostrobin + alpha-cypermethrin	0.04 + 0.09 + 0.03
May 24, 2013	Glyphosate + 2,4-D	0.75 + 0.50			
May 24, 2013	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13			
May 24, 2013	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13	August 15, 2013	Fluxapyroxad + pyraclostrobin	0.04 + 0.09
May 24, 2013	Glyphosate + saflufenacil + pyroxasulfone	0.75 + 0.02 + 0.13	August 15, 2013	Fluxapyroxad + pyraclostrobin + alpha-cypermethrin	0.04 + 0.09 + 0.03

[1] Herbicides with extended residual activity include imazethapyr and pyroxasulfone. Saflufenacil is considered to have limited residual activity.

[2] Fungicides include pyraclostrobin and fluxapyroxad. Insecticides include zeta-cypermethrin and alpha-cypermethrin.

Table 2. Soybean yield response and common waterhemp control to residual herbicides prior to soybean emergence (preemergence) and foliar fungicides and insecticides applied at beginning pod formation in 2010, 2011, and 2013; all plots were treated with glyphosate when soybean were at the V4 growth stage

Year	Preemergence herbicide[1]	Beginning pod formation[2]	Common waterhemp[3]	Soybean yield
			-- % control --	--- bu/a ---
2010	Glyphosate		96.7	45.2
	Glyphosate + saflufenacil + imazethapyr		92.3	44.9
	Glyphosate + saflufenacil + imazethapyr	Pyraclostrobin	90.8	50.0
	Glyphosate + saflufenacil + imazethapyr	Pyraclostrobin + zeta-cypermethrin	96.7	52.4
	LSD (0.05)		8.9	2.1
2011	Glyphosate		15.0	24.6
	Glyphosate + saflufenacil + pyroxasulfone		88.3	23.5
	Glyphosate + saflufenacil + pyroxasulfone	Fluxapyroxad + pyraclostrobin	89.7	24.8
	Glyphosate + saflufenacil + pyroxasulfone	Fluxapyroxad + pyraclostrobin + alpha-cypermethrin	92.7	26.3
	LSD (0.05)		12.5	3.4
2013	Glyphosate + 2,4-D		6.7	29.2
	Glyphosate + saflufenacil + pyroxasulfone		89.3	33.8
	Glyphosate + saflufenacil + pyroxasulfone	Fluxapyroxad + pyraclostrobin	93.3	36.4
	Glyphosate + saflufenacil + pyroxasulfone	Fluxapyroxad + pyraclostrobin + alpha-cypermethrin	93.3	35.7
	LSD (0.05)		9.9	3.3

[1] Herbicides with extended residual activity include imazethapyr and pyroxasulfone. Saflufenacil is considered to have limited residual activity.

[2] Fungicides include pyraclostrobin and fluxapyroxad. Insecticides include zeta-cypermethrin and alpha-cypermethrin.

[3] Common waterhemp in 2010 was susceptible to glyphosate, but common waterhemp in 2011 and 2013 was resistant to glyphosate.

Control of Glyphosate-Resistant Waterhemp in Corn

C.R. Thompson, E.A. Adee, D.E. Peterson, J. Kimball, and C. Minihan

Summary

An experiment was conducted at the Ottawa Experiment Field to compare single-pass herbicide tank mixes applied to V2-stage corn for control of glyphosate-resistant waterhemp. Visual crop injury and waterhemp control was evaluated 1, 2, and 4 weeks after treatment (WAT). Balance Flexx (Bayer CropScience, Research Triangle Park, NC) tank mixes caused the most crop injury, 10% at 1 WAT, and injuries remained through the 3 WAT evaluation; however, grain yield was not reduced. Corvus (Bayer CropScience) tank mixes caused slight injury 1 WAT, but no injury was observed 4 WAT. Anthem ATZ (FMC Corporation Agricultural Products Group, Philadelphia, PA) caused slight leaf speckling, but no injury remained 4 WAT, and grain yield was not reduced. Sufficient weed competition reduced grain yield nearly 50% in the untreated check treatment compared with the best treatments. Corn treated with Durango (Dow AgroSciences LLC, Indianapolis, IN) alone yielded less than all other herbicide-treated corn. The lack of residual control and the glyphosate-resistant waterhemp led to yield reductions. All other treatments provided some residual control, thus no yield differences were observed among the treatments. All of the treatments, except Durango alone, had sufficient residual to provide very good (91% to 100%) waterhemp control 4 WAT. Sufficient herbicide programs exist to effectively manage glyphosate-resistant waterhemp.

Introduction

Glyphosate-resistant waterhemp continues to increase in the eastern third of Kansas. Continuous use of glyphosate in the absence of soil-active herbicides has led to the development of these resistant populations. The use of preemergence-applied herbicides or properly timed postemergence-applied herbicides is required to prohibit the development of glyphosate-resistant waterhemp or to manage a glyphosate-resistant population. This experiment evaluates waterhemp control with 20 different herbicide combinations applied to corn at the V2 stage of growth.

Procedures

The experiment was conducted on a Woodson silt loam soil, previously cropped to soybean at the Ottawa Experiment Field. This soil had 2.5% organic matter and 6.5 pH. Corn hybrid Pioneer 636 HRLLRR (Pioneer HI-Bred, Johnston, IA) was planted on May 15, 2013, over strip-till-applied fertilizer of 120 lb nitrogen (N), 40 lb phosphorus (P), and 13 lb potassium (K). Herbicide treatments were applied with a backpack sprayer equipped with AIXR 110015 nozzles set to deliver 15 gpa at 46 psi and traveling 3 mph to corn at the V2 stage (2 collars visible) on May 28. Eighty percent of the waterhemp was 2 in. tall or less. Twenty percent of the waterhemp population was 3 to 5 in. tall. Waterhemp populations were approximately 30 plants/ft^2. Visual evaluations of weed control and crop injury were made on June 4, June 13, and June 26, approximately 1, 2, and 4 weeks after the herbicide application, respectively. Two 30-in. rows of corn were harvested from the center of a 10-ft.-wide plot on September 27.

Results

Injury ratings from 1 WAT and 4 WAT and weed control ratings from 2 WAT and 4 WAT are shown in Table 1. Anthem ATZ, which is a premix of Pyroxasulfone (Zidua; BASF Corp., Research Triangle Park, NC), Cadet (FMC Corp.), and atrazine, caused leaf speckling 1 WAT; however, corn grew out of the injury very quickly. Balance Flexx with and without atrazine applied with Durango caused bleaching 1 WAT; slight symptoms remained 4 WAT, but corn yield was not reduced. Corvus and Durango tank mixes caused some bleaching, but with less frequency than the Balance Flexx treatments, and corn recovered completely by 4 WAT.

Corn yield from the untreated check treatment yielded less than all corn receiving herbicide treatment. Only corn treated with Durango plus adjuvants and no additional herbicides yielded less than all other herbicide-treated corn. This was due to glyphosate-resistant waterhemp and the fact that no residual herbicide was used to provide extended control. Crabgrass came into this treatment following the Durango application, competing with the corn for moisture and other resources (not shown).

Treatments containing Surestart (Dow AgroSciences LLC), Corvus, Balance Flexx, Zidua + Status (BASF Ag Products), Anthem ATZ, or Halex GT (Syngenta Crop Protection LLC, Greensboro, NC) provided excellent control of waterhemp 2 and 4 WAT. The two-week rating suggests that the tank mixes had sufficient activity on the waterhemp to provide adequate control and provided additional residual control through the 4 WAT rating. All herbicide containing an HPPD inhibitor, Balance Flexx, Corvus, and Callisto (Syngenta Crop Protection LLC) all provided their best control when tank mixed with atrazine. Halex GT is a premix of Callisto, Dual II Magnum, and atrazine. Although Durango alone provided some control of waterhemp, 68% 4 WAT, surviving waterhemp along with newly emergent waterhemp and crabgrass following application of Durango alone provided sufficient competition with the corn to cause some yield reduction. Sufficient herbicide programs are available to growers to manage glyphosate-resistant waterhemp in corn.

Table 1. Effects of Surestart and other herbicides with and without atrazine tank-mixed with Durango to manage glyphosate-resistant waterhemp in corn[1]

		Corn			Waterhemp	
			Injury		Control	
Treatment[2]	Rate	Yield[3]	1 WAT[4]	4 WAT	2 WAT	4 WAT
	-------- product/a --------	--- bu/a ---	-------- % --------		-------- % --------	
Untreated check		55				
Surestart + Durango	2 pt + 2 pt	89	0	0	97	93
Surestart + Durango + Callisto	2 pt + 2 pt + 1 fl oz	93	0	0	100	99
Surestart + Durango + Callisto	2 pt + 2 pt + 2 fl oz	90	0	0	100	100
Surestart + Durango + atrazine	2 pt + 2 pt + 0.5 pt	99	0	0	99	94
Surestart + Durango + atrazine	2 pt + 2 pt + 1 pt	91	0	0	100	99
Surestart+ Durango + Callisto + atrazine	2pt + 2pt + 1 fl oz + 0.5 pt	95	0	0	100	100
Surestart + Durango + Callisto + atrazine	2 pt + 2pt + 2 fl oz + 0.5 pt	90	0	0	100	100
Surestart + Durango + Callisto + atrazine	2 pt + 2pt + 1 fl oz + 1 pt	97	0	0	100	100
Surestart + Durango + Callisto + atrazine	2pt + 2pt + 2 fl oz + 1 pt	89	0	0	100	100
Corvus+ Durango + AMS + NIS	5.6 fl oz + 2 pt + 8.5lb + 2%	98	1	0	100	98
Corvus + Durango[5]	5.6 fl oz + 2 pt	101	0	0	99	94
Corvus + Durango + atrazine	5.6 fl oz + 2 pt + 1 pt	92	1	0	100	100
Balance Flexx + Durango[5]	6 fl oz + 2 pt	104	10	6	97	91
Balance Flexx+ Durango + atrazine[5]	6 fl oz + 2 pt + 1 pt	87	10	5	99	98
Zidua + Durango + Status	3 oz + 2 pt + 5 oz	102	0	0	100	100
Zidua + Durango + Status+ atrazine	3 oz + 2 pt + 5 oz + 1 pt	100	0	0	100	100
Anthem ATZ + Durango	2 pt + 2 pt	99	4	0	100	97
Halex GT	3.6 pt	103	0	0	100	100
Durango	2 pt	71	0	0	78	68
LSD (0.05)		12	1	2	7	9

[1] Surestart and Durango, Dow AgroSciences LLC, Indianapolis, IN; Callisto and Halex GT, Syngenta Crop Protection LLC, Greensboro, NC; Corvus and Balance Flexx, Bayer CropScience, Research Triangle Park, NC; Zidua and Status, BASF Corp., Research Triangle Park, NC; Anthem ATZ, FMC Corporation Agricultural Products Group, Philadelphia, PA.

[2] Treatments were applied with 8.5 lb NPAK ammonium sulfate (2.5 gallons) per 100 gallons of spray solutions and 0.25% v/v NIS (Preference) unless otherwise designated.

[3] Yield adjusted to 15.5% grain moisture with all treatments.

[4] Weeks after treatment.

[5] Treatments had no additional adjuvants applied with the herbicides.

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 (KRV). 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.

2013 Weather Information

The year was cooler and wetter than the previous year. The frost-free season was 172 and177 days at the Paramore and Rossville units, respectively (average = 173 days), and 19 days in single digits. The last spring freeze was May 2 (average = April 21), and the first fall freeze was October 22 (average = October 11). There were 36 days above 90°F and 2 days above 100°F. Precipitation was below normal at both fields for the growing season (Table 1) but was above average for several months during the growing season. For the year, the rainfall deficit for Rossville was 5.2 in., and the deficit was 5.7 in. for Paramore. Irrigation requirements were less than half of 2012. Estimated corn and soybean yields were 170 and 45 bpa, respectively. Sudden death syndrome was the major yield-limiting factor in soybean at KRV.

Table 1. Precipitation at the Kansas River Valley Experiment Field

	Rossville Unit		Paramore Unit	
Month	2013	30-year avg.	2013	30-year avg.
	------------ in. ------------		------------ in. ------------	
January	0.50	3.18	0.35	3.08
February	0.73	4.88	0.73	4.45
March	1.41	5.46	1.67	5.54
April	4.45	3.67	2.82	3.59
May	6.20	3.44	7.45	3.89
June	2.82	4.64	1.77	3.81
July	2.46	2.97	2.12	3.06
August	3.39	1.90	3.85	1.93
September	3.05	1.24	3.19	1.43
October	4.23	0.95	4.39	0.95
November	0.90	0.89	0.96	1.04
December	0.29	2.42	0.19	2.46
Total	30.43	35.64	29.49	35.23

Irrigation Regimes and Soil Oxygen Content: Investigating Environmental Parameters Associated with Soybean Sudden Death Syndrome in Kansas

C.R. Little, E.A. Adee, and D. Presley

Introduction

Sudden death syndrome (SDS) in soybean is caused by the fungus *Fusarium virguiliforme*, which infects soybean through the roots, primarily before the plants start to flower. Saturated soils have been implicated as contributing to the development of SDS. Irrigation of soybeans at the wrong time could increase the severity of SDS, further complicating the production of soybean in the Kansas River Valley, where irrigation is often necessary to produce a profitable crop. Irrigation timing and amount were treatments applied to SDS-susceptible and -tolerant varieties. Abiotic and biotic factors were measured to determine which might relate to the development of the disease and subsequent yield loss. We had three objectives. First, we wanted to determine the amounts and intervals of sprinkler irrigation treatments associated with the onset, development, and severity of SDS. Second, we wanted to determine if soil oxygen content influences SDS disease development and severity. Finally, we hoped to determine if either irrigation treatment, soil oxygen, or both influence soil populations of the SDS pathogen.

Procedures

Plots (360 ft × 310 ft) were planted on May 16, 2013, at the Rossville Unit of the Kansas River Valley Experiment Field. The soil is a Eudora series silt loam to sandy loam. The field has a well-established history of SDS caused by *Fusarium virguiliforme*. It was planted with Golden Harvest 9138 corn in 2012. Plots were planted with KS3406 (susceptible to SDS) and Pioneer 93Y40 (moderately resistant to SDS). Three irrigation timings (late vegetative, vegetative to flowering transition, and beginning pod stage) and three irrigation levels (low, no irrigation until R3; medium, normal irrigation regime; and high, soil saturation) were implemented during the experiment. The three irrigation times were June 25, July 8, and July 18 for the late vegetative (V4), the vegetative to flowering transition (R1), and beginning pod stage (R3), respectively. The experimental design was a split-split plot, where irrigation timing was the whole plot and irrigation levels were the subplots. Varieties are the sub-subplots. Border rows for each subplot were used to prevent overlap of irrigation treatments. Data were collected from plots for disease severity and yield, and normalized difference vegetation index (NDVI) ratings were collected at the end of the season.

The data logger and oxygen sensor array was completed and was placed in the field on June 14, 2013. Preplant, midseason, and postharvest soil samples were collected on May 15, August 6, and October 31, respectively. Total fungal colony-forming units, *F. virguiliforme* CFUs and *M. phaseolina* CFUs, were collected. Native streptomycete pathogen antagonistic bacteria CFUs were collected from soil samples, and soybean cyst nematode (SCN) eggs and J2 juveniles (per gram of soil) were collected from plots. Soil was tested for texture, organic matter, and other abiotic characteristics.

Results

Seasonal air temperatures averaged 16.4 to 29.1°C, with the highest temperature in July and the lowest in September. Soil temperatures were highest in July and lowest in May, with seasonal averages from 22.0 to 28.0°C. A total of over 400 mm of precipitation fell during the 2013 season, with the most in May and a seasonal average of approximately 81 mm per month. Relative humidity ranged from 63.6 to 76.1% during the growing season; August was the most humid month. Peak solar radiation (21.7 MJ/m^2) was observed in June. Winds averaged 2.6 m/s during the season, with gusts averaging 8.7 m/s. Wind speeds were the lowest in August, which coincided with the highest relative humidities. On average, monthly evapotranspiration was 175 mm across the season and more than twice the observed precipitation.

Soil oxygen (O_2) concentrations were measured in one block of the experiment at Rossville. O_2 concentration in soil ranged from 18.0 to 19.7% and averaged 19.0%, which is approximately 1.9% less than atmospheric O_2 concentration at ground-level elevations and atmospheric pressure. This result was expected because soil O_2 content may be as low as 5–10% and nearly as high as atmospheric concentrations and depends on numerous factors, including moisture content, texture, respiration, and fermentation activities by biological components of the soil and/or other abiotic factors.

Soil abiotic factors were obtained prior to planting and tested by the K-State Soil Testing Lab in the Department of Agronomy (Table 1). Numerous significant relationships were observed between environmental/weather parameters and soil oxygen content. In general, significant positive correlations were observed between maximum air temperature, solar radiation, average daily/maximum wind speed, and evapotranspiration and soil oxygen content; however, significant negative correlations were observed between relative humidity and soil oxygen content (not shown).

No correlations were observed between soil oxygen content and SDS severity (not shown), but preplanting pH and sand content were significant and negatively correlated to SDS severity at two of the census dates. Silt and clay content were positively and significantly correlated to SDS severity at two of the census dates. This result suggests that planting on heavier soil types results in greater SDS severity (not shown).

Irrigation treatments (interval and amount) did not have a significant effect upon SDS severity, but genotype (SDS-tolerant vs. SDS-susceptible) was significant ($P < 0.0001$) (Table 2). Unexpected negative and significant correlations were observed between *F. virguiliforme* populations and SDS severity when measured at two census dates and overall (AUDPC, area under the disease progress curve, a unitless number describing the development of defoliation effects over time; not shown). Correlations between soil abiotic and biotic properties were complex and will require additional years to bear out (not shown).

In the 2013 experiment, data for charcoal rot severity were also acquired. Among the treatments, irrigation interval had a significant effect ($P = 0.0060$) upon charcoal rot severity, but amount and soybean variety did not. Specifically, charcoal rot increased significantly when irrigation was delayed until R3. Early irrigation intervals at V4–V5 and R1 resulted in reduced charcoal rot severity (not shown).

Relationships between biotic properties in soil and charcoal rot severity revealed a significant, positive correlation between postharvest soil populations of *M. phaseolina* and *F. virguiliforme* and preplanting *F. virguiliforme* populations and charcoal rot disease severity at R7–R8 (not shown). No significant relationships were found between *M. phaseolina*, *F. virguiliforme*, and *H. glycines* eggs and juveniles.

Yield obtained from plots at the Rossville SDS experiment site at the end of the 2013 growing season were significantly lower in the SDS-susceptible variety regardless of irrigation treatment; i.e., 51–54% of the SDS-resistant variety ($P < 0.0001$). As with charcoal rot, interval/timing of irrigation has a significant effect on yield ($P = 0.0074$), with V4–V5 irrigation having the greatest impact (Table 3a). In general, when NDVI measurements were obtained from plots, the SDS-tolerant variety had significant higher ($P < 0.0001$) values than the SDS-susceptible variety (Table 3b).

Table 1. Soil abiotic properties obtained prior to planting at the Rossville, Kansas, experimental site

Factor	Field mean[1]	Factor	Field mean	Factor	Field mean
pH	6.78 ± 0.56	NH_4^+ (ppm)	3.00 ± 0.57	Sand (%)	71.08 ± 7.38
Melich-3 P (ppm)	12.33 ± 6.06	NO_3^- (ppm)	2.30 ± 0.84	Silt (%)	20.14 ± 5.55
K (ppm)	102.04 ± 24.23	OM (%)	0.78 ± 0.23	Clay (%)	8.78 ± 2.16

[1] Averaged across all plots.

Table 2. Sudden death syndrome (SDS) disease severity observed at the experimental plots in Rossville, Kansas, during the 2013 growing season

	SDS disease severity			
Variety	August 12, 2013	August 19, 2013	August 26, 2013	AUDPC[1]
SDS-susceptible mean	**44.36%**	**61.10%**	**64.06%**	**48.34**
SDS-tolerant mean	**1.55%**	**6.58%**	**16.41%**	**12.42**
Overall fixed effects[z]				
Irrigation interval *P*	0.4244	0.6149	0.4915	0.5621
Irrigation amount *P*	0.9732	0.3746	0.8667	0.7165
Variety *P*	<0.0001***	<0.0001***	<0.0001***	<0.0001***

[1] Area under the disease progress curve, a unitless number describing the development of defoliation effects over time.

*** $P < 0.001$.

Table 3a. Yield (bu/a) obtained from plots at the Rossville, Kansas, soybean sudden death syndrome (SDS) experimental site at the end of the 2013 growing season

	SDS-susceptible			SDS-tolerant		
Irrigation amount/timing	V4–V5	R1	R3	V4–V5	R1	R3
Low	22.03	19.08	20.63	45.58	35.55	36.93
Medium	24.28	21.05	15.93	42.08	47.83	29.75
High	23.83	24.25	17.53	49.98	39.60	32.63
Mean	23.38	21.46	18.03	45.88	40.99	33.10
Proportion of the tolerant variety	0.51	0.52	0.54	--	--	--

Fixed effects

Interval $P = 0.0074^{**}$

Amount $P = 0.8297$

Variety $P < 0.0001^{***}$

** $P < 0.05$; *** $P < 0.001$.

Table 3b. Normalized difference vegetation index readings from plots at Rossville sudden death syndrome (SDS) experimental site at the end of the 2013 growing season

	SDS-susceptible			SDS-tolerant		
Irrigation amount	V4–V5	R1	R3	V4–V5	R1	R3
Low	0.62	0.60	0.59	0.79	0.74	0.69
Medium	0.65	0.59	0.52	0.76	0.78	0.66
High	0.62	0.60	0.57	0.78	0.71	0.70
Mean	0.63	0.60	0.56	0.77	0.74	0.68

Fixed effects

Interval $P = 0.0003^{**}$

Amount $P = 0.7536$

Variety $P < 0.0001^{***}$

** $P < 0.05$; *** $P < 0.001$.

Effects of Seed Treatment on Sudden Death Syndrome Symptoms and Soybean Yield

E.A. Adee

Summary

Sudden death syndrome (SDS) is a soybean disease that perennially limits yields in the Kansas River Valley. Soybean cyst nematode (SCN) and saturated soils have been implicated as contributing to the severity of the disease. Selecting varieties with some degree of tolerance to SDS is the only cultural practice that can potentially reduce the severity of SDS and improve yields. Variety selection alone, however, cannot improve the production of soybeans to make them profitable. The challenge of trying to manage irrigation scheduling and prevent saturated soils has further complicated trying to increase productivity with irrigation while avoiding SDS. A study with seed treatments applied to soybean was conducted at the Kansas River Valley Experiment Field in 2013, with treatments applied to three soybean varieties with different levels of tolerance to SDS. The study was irrigated earlier and more often than normal for soybean to promote the disease. The most severely infested plots had over 80% of the leaf area expressing symptoms of SDS by the R6 growth stage. Treatments with ILeVO from Bayer CropScience (Research Triangle Park, NC) reduced the amount of foliar disease in all varieties and increased yields up to 16 bu/a, or over 40%. Caution should be used in interpreting these data, which are from only one location for one year, but the results show some promising products may be available to help manage SDS.

Introduction

Soybean SDS is caused by the fungus *Fusarium virguiliforme*, which infects plants through the roots, primarily before they start to flower. Foliar symptoms generally begin to show up as interveinal chlorosis and necrosis in the leaves at growth stage R3, after the seed has started to develop in the pods.

An interaction between SDS and SCN has been reported, and SCN is prevalent in the soils of the Kansas River Valley. Saturated soils have also been implicated as contributing to the development of SDS. Depending on how early the symptoms begin to be visible and the symptoms' severity, yield losses can be very significant. In severe cases, plants in which the symptoms begin early (i.e., before seed development stage) can fail to produce any seed.

This disease has been a perennial problem in the Kansas River Valley, causing severe yield reductions in soybean to the point that the crop cannot be profitably produced in some fields. Crop rotations and tillage have had little effect on reducing the severity of the disease and reducing the subsequent yield loss. No soybean varieties are totally resistant to the fungus, but some varieties have varying degrees of tolerance that can reduce yield losses. Irrigating soybean at the wrong time also could increase the severity of SDS, further complicating production in the Kansas River Valley, where irrigation is often necessary to produce a profitable crop.

Another method of trying to increase soybean productivity in fields with a risk of SDS is seed treatment applied to the seeds at planting. Seed treatments could help protect the roots against initial infection by *F. virguiliforme.*

Procedures

Soybean were planted into a field with a history of SDS at the Rossville Unit of the Kansas River Valley Experiment Field in 2013. Three soybean varieties of varying levels of resistance to SDS were provided by Dennis Scott of Bayer Chemical Company. Seed from each variety was treated with three seed treatments: ILeVO at a higher rate, ILeVO at a lower rate, and a competitor's product with an untreated check. The soybean were planted May 17 at 140,000 seeds/a into 10- × 30-ft plots, with four replications in a randomized complete block design. The soil was Eudora silt loam, and the previous crop was soybean. Irrigation with a linear-move sprinkler irrigation system was started on June 24. Total irrigation was 5.13 in., and 14.2 in. of rain was received during the growing season. Preemergent herbicide applied at planting was Authority XL (FMC Corporation Agricultural Products Group, Philadelphia, PA) (5 oz) and Dual II Mag (Syngenta Crop Protection LLC, Greensboro, NC) (1.5 pt). Postemergent herbicide was Roundup PowerMax (Monsanto, St. Louis, MO) (22 oz) and Warrant (Monsanto) (1.5 qt). Foliar symptoms of SDS were rated weekly starting August 12, when soybean were at the R4 (pods full length) to R5 (beginning seed formation) growth stages. Ratings were based on incidence and severity of the symptoms. An area under the disease progress curve (AUDPC), a unitless number describing the development of defoliation effects over time, was derived by plotting periodic measurements of disease over time and integrating the area under the disease curve. A GreenSeeker meter (Trimble Navigation, Ag Division, Westminster, CO) was also used to collect normalized difference vegetation index (NDVI) readings from each plot at the R6 (full seed) growth stage. The NDVI readings are higher when there are abundant, green leaves to absorb the light used in photosynthesis. The plots were harvested September 30.

Results

The severity of the disease ratings, using both the AUDPC and the NDVI, explained much of the yield difference between treatments (Figures 1 and 2). These two graphs also show that the more "traditional" ratings with the AUDPC and the NDVI are nearly equal in relating to yield. As the AUDPC increased, the yield decreased, with the AUDPC explaining more than 50% of the change in yield. The NDVI readings explained more than 60% of the change in yields, with soybean yields increasing as the NDVI increased. The improvement in NDVI explaining more of the yield variation may be a result of what the readings are measuring: NDVI takes into account the amount of foliage as well as the greenness, whereas the AUDPC is looking at the amount of green and diseased leaf tissue in a plot.

The seed treatments with ILeVO increased yields from 5 to 16 bu/a, depending on the rate of the product and the level of resistance in the soybean variety (Table 1). The greatest yields were with the two varieties that had a higher level of resistance.

Yield results show the benefit of planting varieties with some level of tolerance to SDS. In addition, increased tolerance to SDS reduced disease severity (Table 1). Disease severity ratings show that the environment this study was conducted in was very favorable for SDS, with nearly 90% of the leaves showing symptoms in the most affected plots (Table 1). To have over a 40% yield increase due to seed treatment with this level of severity is promising. These data are from a single location for one year, however, so further research needs to confirm if this product will be effective in a predictable manner.

Table 1. Influence of variety and seed treatment for sudden death syndrome (SDS) on yield of soybean, Kansas River Valley Experiment Field, Rossville, 2013

Soybean varieties:	Most resistant	Moderately resistant	Susceptible	Most resistant	Moderately resistant	Susceptible
Seed treatments		bu/a			Percentage of leaf area with SDS at R6	
Check	28.6	29.2	21.3	18	44	63
Competitor's product	32.1	33.2	15.4	21	33	88
ILeVO[1] at higher rate	41.6	39.7	37.4	4	28	45
ILeVO at lower rate	42.9	41.0	26.2	5	28	72
LSD 0.05		8.3 bu/a			17.4%	

[1] Bayer CropScience (Research Triangle Park, NC).

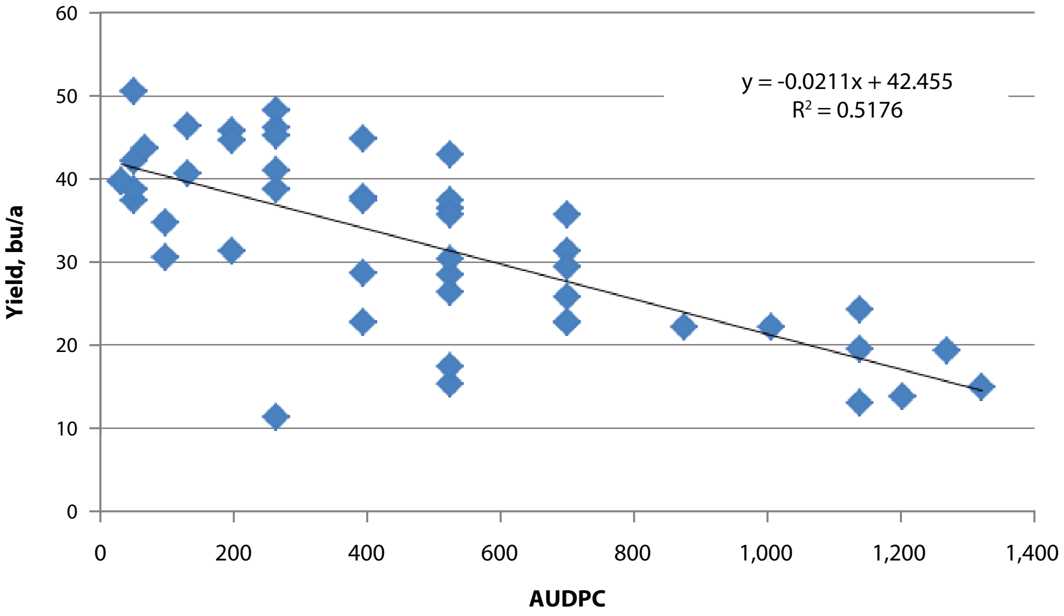

Figure 1. Relationship between area under disease progress curve (AUDPC) for SDS and yield, Kansas River Valley Experiment Field, 2013.

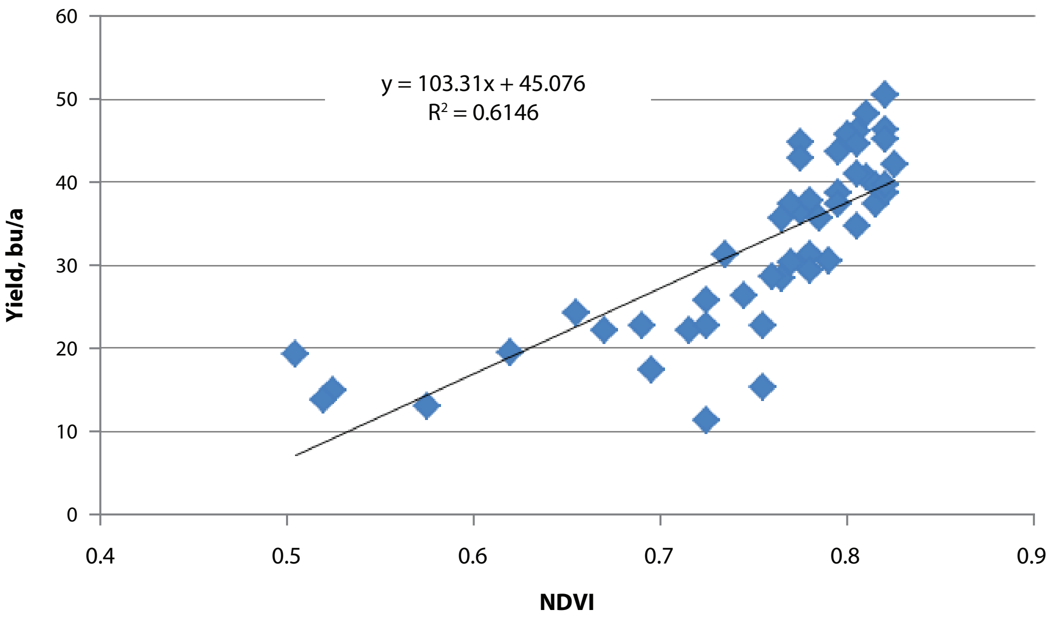

Figure 2. Relationship between normalized difference vegetation index (NDVI) readings taken with a GreenSeeker meter (Trimble Navigation, Ag Division, Westminster, CO) from plots with SDS foliar symptoms at R6 and soybean yield, Kansas River Valley Experiment Field, 2013.

Tillage Study for Corn and Soybean: Comparing Vertical, Deep, and No-Till

E.A. Adee

Introduction

The need for tillage in corn and soybean production in the Kansas River Valley continues to be debated. The soils of the Kansas River Valley are highly variable, with much of the soil sandy to silty loam in texture. These soils tend to be relatively low in organic matter (<2%) and susceptible to wind erosion. Although typically well drained, these soils can develop compaction layers under certain conditions. A tillage study was initiated in the fall of 2011 at the Kansas River Valley Experiment Field near Topeka to compare deep vs. shallow vs. no-till vs. deep tillage in alternate years. Corn and soybean crops will be rotated annually. This is intended to be a long-term study to determine if soil characteristics and yields change in response to the history of each tillage system.

Procedures

A tillage study was laid out in the fall of 2011 in a field that had been planted with soybean. The tillage treatments were (1) no-till, (2) deep tillage in the fall and shallow tillage in the spring every year, (3) shallow tillage in the fall following both crops, and (4) deep tillage followed by a shallow tillage in the spring only after soybean, and shallow-tilled in the fall after corn. The fall of 2010, prior to the soybean crop, the entire field was subsoiled with a John Deere V-ripper. After soybean harvest, 30-ft × 100-ft individual plots were tilled with a Great Plains TurboMax (Great Plains MFG, Salina, KS) vertical tillage tool at 3 in. deep or a John Deere V-ripper (Deere & Company, Moline, IL) at 14 in. deep. Spring tillage was with a field cultivator. In the fall of 2012, the treatments were with the TurboMax or a Great Plains Sub-Soiler Inline Ripper SS0300. Spring tillage in 2013 was with the TurboMax on the required treatments. Each tillage treatment had four replications. Dry fertilizer (11-50-0 and 0-0-60 nitrogen-phosphorus-potassium, or NPK) was applied at 200 lb/a for each product to the entire field prior to fall tillage. Nitrogen (150 lb) was applied in March prior to corn planting. Corn hybrid Pioneer (Pioneer HI-Bred, Johnston, IA)1395 was planted at 30,600 seeds/a on April 12, 2012, and P1498HR on April 30, 2013. Soybean variety Pioneer 93Y92 was planted at 155,000 seeds/a on May 14, 2012, and P94Y01 on May 15, 2013. Soybean were planted after soybean in this setup year. Irrigation to meet evapotranspiration (ET) rates started May 26 and concluded August 1 for corn and August 23 for soybean in 2012. Irrigation for corn started June 24, 2013, and concluded August 1. Irrigation for soybean in 2013 started June 30 and concluded September 8. Two yields were taken from each plot from the middle two rows of planter passes. Corn was harvested on August 31, 2012, and September 25, 2013. Soybean were harvested on October 5, 2012, and October 10, 2013.

Results

Yields of corn or soybean did not differ due to tillage in this setup year of the study (Table 1). The yields were respectable considering the extreme heat and drought experienced this growing season. Growing conditions were better in 2013, resulting in higher yields in both corn and soybean, but no significant differences between tillage treatments were observed (Table 2). We anticipate that it will take several years for any characteristics of a given tillage system to build up to the point of influencing yields.

Table 1. Effects of tillage treatments on corn and soybean yields in 2012 at Kansas River Valley Experiment Field

Tillage treatment	Corn yield	Soybean yield
	-------------------- bu/a	--------------------
No-till	196	57.2
Fall subsoil/spring field cultivation	202	58.1
Fall vertical till	198	58.1
LSD 0.05	NS	NS

Table 2. Effects of tillage treatments on corn and soybean yields in 2013 at Kansas River Valley Experiment Field

Tillage treatment	Corn yield	Soybean yield
	-------------------- bu/a	--------------------
No-till	221	62.4
Fall subsoil/spring field cultivate	217	64.3
Fall vertical till	196	64.4
Fall subsoil after soybean/vertical till after corn	219	66.3
LSD 0.05	NS	NS

Drought-Tolerant Corn Hybrids: Yield Benefits

I. Campitti, E.A. Adee, K. Roozeboom, A. Schlegel, and G. Cramer

Summary

General observations from this analysis employing six site-years across the state of Kansas and two growing seasons (2012–2013) are:

1) Performance of individual hybrids within the drought-tolerant and regular categories may vary. Some regular hybrids can perform nearly as well as the drought-tolerant hybrids even in stressful conditions, and drought-tolerant hybrids have the potential to yield with regular hybrids when water isn't limiting.

2) The advantage of the drought-tolerant hybrids became more evident when the water stress increased to the point of leaves rolling most days.

3) From the information at hand, it is reasonable to expect a drought-tolerant hybrid to serve as a type of insurance policy to sustain yield potential under water-limited environments. No yield penalty appears to be associated with drought-tolerant hybrids if water-limiting conditions do not occur.

4) Lastly, it is critical to understand that these corn genetic materials will not produce yield if the environment is subjected to terminal drought; thus, we cannot expect them to thrive when moisture is severely limited, especially in dryland systems. As properly and explicitly stated by all seed companies, these drought-tolerant materials have demonstrated the ability to maintain yields to a certain degree in water-limited situations, likely in the range of 5 to 15% higher than conventional hybrids.

Introduction

In the last few years, drought conditions have raised questions about the utilization of corn as the main crop for maximizing yield production per unit of available water in dryland environments.

Non-transgenic (conventionally bred, Pioneer and Syngenta) corn hybrids, or so-called drought-tolerant (DT) hybrids, came to the market with the expectation of increasing corn production in water-limited regions. In the last growing season, Monsanto released its new biotech transgenic-DT hybrid. Overall, the information from seed companies indicate that DT hybrids could provide from 2% to more than 15% yield increase over "competitor hybrids" in non-limiting and water-limiting environments, respectively.

At present, "public" information supporting the data presented by the private seed companies is limited; thus, the Kansas State University research data summarized in this article provides some guidance on the expected response of the DT corn hybrids when grown in diverse water regimes across the Kansas.

Data from the last two growing seasons (2012–2013) in east central, north central, south central, and west central Kansas (six site-years) are presented in an effort to provide an overview of the DT vs. non-DT responses to management practices (i.e., plant population and irrigation) and to help farmers, consultants, and agronomists select corn hybrids. In addition, we hope to develop a better understanding of the kinds of environments in which DT hybrids could be most likely to result in a yield benefit. These hybrids are generally targeted for water-limited environments in the western Great Plains.

Results

Our research compared DT hybrids from diverse companies with a standard non-DT counterpart of similar maturity. The tests also evaluated the yield response to varying plant population and irrigation levels.

Our analysis did not reveal plant-scale differences in response to plant population between DT and non-DT hybrids. This result indicates no need to change plant population when using DT hybrids. This conclusion was briefly introduced in a previous eUpdate article on corn seeding rates (eUpdate 447, March 28, 2014[1]).

We also analyzed yields obtained at the plot level for DT vs. comparable DT hybrids with similar maturity. The information presented in Figure 1 depicts the association of the yields for the DT vs. non-DT corn hybrids in research and on-farm plots.

Overall, the analysis found a yield benefit of 3% for DT vs. non-DT hybrids under diverse environments and stress conditions across Kansas during the 2012–2013 seasons. In absolute terms, the yield advantage of using DT hybrids was around 7 bu/a compared with non-DT material. Similar yield trends were observed in research plots and on-farm demonstration plots. A great proportion of the yield response, positive or negative for DT vs. non-DT, occurred in the 5% confidence interval highlighted in Figure 1, except at low-yielding environments (<150 bu/a). In these environments, DT outyielded non-DT corn hybrids in a greater proportion of observations compared with higher-yield environments (>150 bu/a).

DT vs. non-DT corn hybrids: Yield Environment Analysis

The analysis of information across diverse yielding environments allows us to more clearly visualize where yield advantage from planting DT hybrids would occur. Figure 2 shows that the yield advantage of DT corn hybrids increases as the yield potential of the crop decreases. This graph shows basically no yield difference when yields are around 170 bu/a or greater. The yield advantage for DT hybrids gradually increases as the yield of the regular hybrids decreases from 170 bu/a.

It is important to note, however, that these are generalized relationships, and varied responses occur at each yield level. Some individual points show no difference between DT vs. non-DT hybrids at yields of 100 bu/a. Other points show a 30 bu/a yield advantage for non-DT hybrids at 160 to 170 bu/a, and still others show a 60 bu/a yield advantage for DT hybrids when non-DT hybrid yields were near 70 bu/a. How individual hybrids respond to a specific environment is influenced by a number of factors, including the timing and duration of the stress.

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[1] Available at https://webapp.agron.ksu.edu/agr_social/eu_issue.throck?eu_id=35.

One more technical clarification is important to note. The linear response and plateau (LRP model) function fitted in Figure 2 presented a coefficient of determination (R^2) of 0.26 units, which can be interpreted to indicate that this function is accounting for slightly more than one-fourth of the total variation presented in the data.

DT vs. non-DT corn hybrids: Yield Winners Analysis

An extra step in our analysis can be taken by identifying the individual data points where the DT hybrids outyielded non-DT hybrids of similar maturity (DT Winners observations) and the opposite situation, in which non-DT hybrids had greater yield than the DT hybrids (non-DT Winners observations). The analysis of the dataset using this approach shows a similar and consistent difference: DT hybrids outyielded non-DT hybrids when the yield for the non-DT corn material was below 171 bu/a (Figure 2).

When the yield environment was higher — above the 50th percentile for both DT and non-DT Winners — yields of the two types of hybrids were comparable. But the DT hybrids had higher yields more often than the non-DT hybrids (n = 106 for DT Winners and n = 68 for non-DT Winners; Table 1).

We need to remain cautious about using and interpreting this information. More experiments and research data need to be collected, and a deeper understanding is needed to more properly comprehend the main causes of the yield benefits for the DT vs. the non-DT corn genotypes. Potential interpretations offered for the yield advantage for the DT corn hybrids are related to:

- Slower vegetative growth, saving water for reproductive stages (stress avoidance);
- Greater root biomass with superior water uptake;
- Differential regulation in the stomata opening, controlling water and CO_2 exchange processes; and
- Other potential physiological modifications.

Water use efficiency data are still being accumulated and analyzed.

Table 1. Yield winners for drought-tolerant (DT) and non-DT corn hybrids under diverse yield environments across 6 site-years for the 2012–2013 growing seasons

Yield winners	Yield environment for non-DT	Data points	Mean DT yield	Mean non-DT yield
	bu/a	percentile	------------- bu/a -------------	
DT	<146	54 (25th)	149	124
	146–161	54 (50th)	169	155
	161–182	52 (75th)	183	171
	182–241	54 (100th)	221	210
Non-DT	<165	33 (25th)	143	152
	165–181	34 (50th)	162	171
	181–197	34 (75th)	175	187
	187–255	34 (100th)	208	216

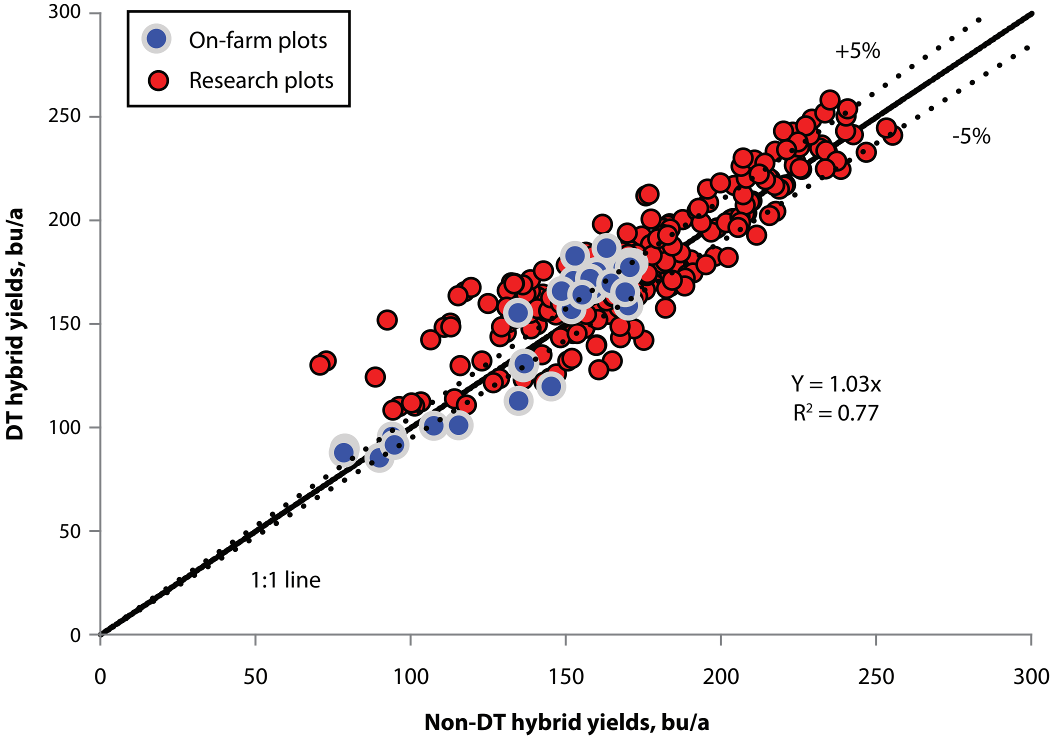

Figure 1. Yield for the drought-tolerant (DT) versus non-DT corn hybrids across 6 site-years for the 2012–2013 growing seasons.

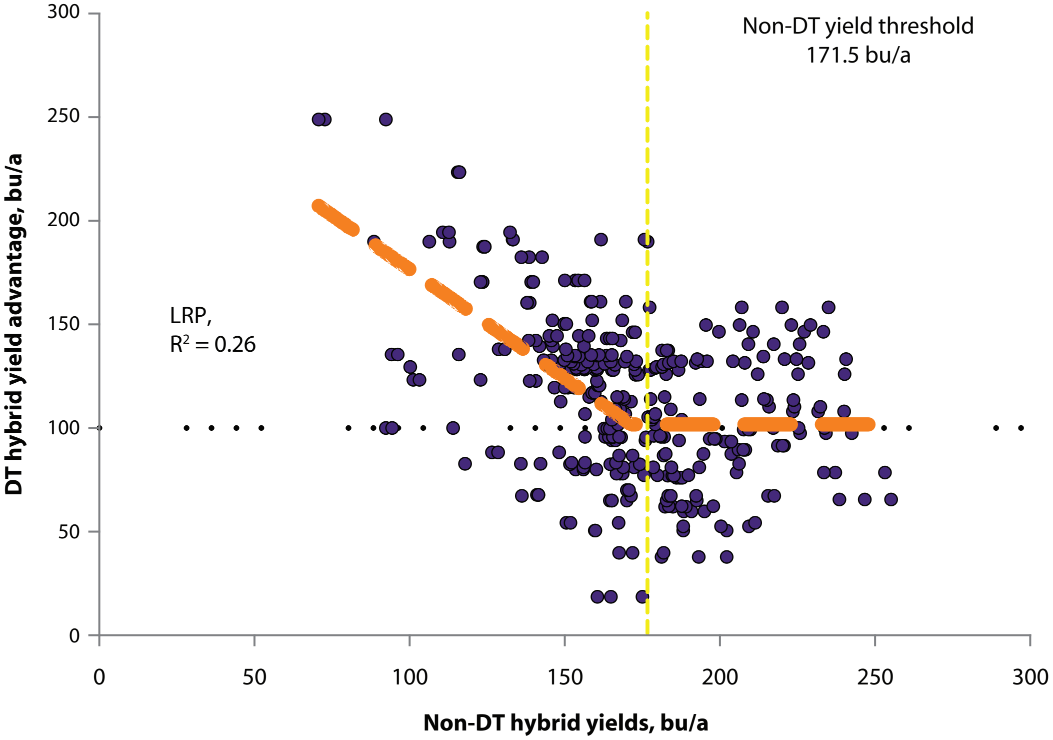

Figure 2. Yield advantage for drought-tolerant (DT) compared with non-DT corn hybrids at the same environment and population, ranging from low-yielding environments to high-yielding environments across 6 site-years for the 2012–2013 growing seasons. LRP = linear response and plateau.

Fungicide and Insecticide Use on Wheat in Southeast Kansas

K. Kusel, D. Shoup[1], and G. Sassenrath

Summary

Producers have increased management of wheat in recent years in response to higher commodity prices. Wheat response to fungicide and insecticide application was evaluated in 2012 and 2013. Treatments included an untreated check, Mustang Maxx (FMC, Philadelphia, PA) insecticide at 3.2 fl oz/a, Headline (BASF Research Triangle Park, NC) fungicide at 6.0 fl oz/a, and Headline at 6.0 fl oz/a + Mustang Maxx at 3.2 fl oz/a. Treatments were applied to Everest wheat at complete flag leaf emergence in 2012 and heading in 2013. No treatment × year interaction was detected, so data were combined across years. Good wheat yields were achieved, and the addition of any pesticide increased yield over the untreated check. The addition of insecticide, fungicide, and fungicide + insecticide increased wheat yields by 5.4, 9.0, and 12.1 bu/a, respectively.

Introduction

Wheat fungicide use across the state of Kansas historically has resulted in an approximate 10% yield increase when disease was present on a susceptible variety. Yield response of wheat to insecticides has not been well documented in southeast Kansas. With the change in economics of wheat production in recent years, producers are considering increased use of pesticides to improve wheat yield and quality. A two-year study was initiated to evaluate the yield response of wheat to fungicide and insecticide applications in southeast Kansas.

Experimental Procedures

The experimental site was located on a Parsons silt loam planted in tilled ground after corn harvest. The experiment utilized a randomized complete block design with four replications of four treatments. Everest wheat was planted on October 25, 2011, and October 3, 2012, at 75 lb/a in 7-in.-spaced rows. Plots were 8 ft × 275 ft in 2012 and 8 ft × 40 ft in 2013. Treatments included an untreated check, Mustang Maxx insecticide at 3.2 fl oz/a, Headline fungicide at 6.0 fl oz/a, and combined Mustang Maxx at 3.2 fl oz/a + Headline at 6.0 fl oz/a. Treatments were applied to wheat at the complete flag leaf emergence stage (Feekes 9) on March 3, 2012, and wheat at the heading stage (Feekes 10.1) on May 7, 2013. Wheat was harvested by plot combine on May 30, 2012, and June 24, 2013, and plot weights were adjusted to 13.5% moisture.

Results and Discussion

Favorable growing conditions resulted in above-average yields in both years. No year × treatment interaction was detected, so data were combined across years (Table 1). The untreated wheat averaged 61.6 bu/a. The addition of Mustang Maxx increased yield to 67.0 bu/a, and the addition of Headline increased yield to 70.6 bu/a. The fungicide treatment in this trial increased yield 9.0 bu/a, greater than the 10% yield increase response traditionally observed in Kansas. The highest-yielding treatment was

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[1] Kansas State University Southeast Area Extension.

the combined Headline + Mustang Maxx treatment at 73.7 bu/a. Disease and insect pressure were not recorded in this study, but common pests in the area during the years the trial was conducted were Septoria and stripe rust fungal pathogens and several aphid species, including bird cherry-oat aphid and English grain aphid. The enhanced response to fungicide and insecticide treatments observed in this study may indicate a greater pressure from these pathogens in these years.

Table 1. Wheat yield response to fungicide and/or insecticide in 2012 and 2013; data were combined across years

Treatment[1]	Rate	Yield[2]
	------- fl oz/a -------	------- bu/a -------
Untreated		61.6
MustangMax[3] insecticide	3.2	67.0
Headline[4] fungicide	6.0	70.6
MustangMax + Headline	3.2 + 6.0	73.7
LSD (0.05)		4.6

[1] Applications in 2012 were made to wheat at complete flag leaf emergence and in 2013 to wheat at heading.

[2] Yields adjusted to 13.5% moisture.

[3] FMC, Philadelphia, PA.

[4] BASF, Research Triangle Park, NC.

Wheat Response to Fungicides in Southeast Kansas

D. Shoup[1]*, K. Kusel, G. Sassenrath, and E. DeWolf*[2]

Summary

Fungicide use on wheat has become a more common occurrence in recent years. To evaluate wheat response to fungicide applications under southeast Kansas conditions, three wheat varieties were planted following corn for two years (Everest, Endurance, and Overley in 2010 and Everest, Armour, and Fuller in 2012). Prosaro (Bayer CropScience, Research Triangle Park, NC) at 6.5 fl oz/a was applied at Feekes 10.5.1 in 2011, and Headline (BASF, Research Triangle Park, NC) at 6.0 fl oz/a was applied at Feekes 10.1 in 2013. Foliar disease was evaluated after application. No significant yield increase was observed in 2011; however, little to no disease was observed in 2011 following fungicide application. In 2013, heavier disease pressure was observed, and fungicide applications significantly increased yield across all three varieties. Fungicide application increased yield 10.3, 13.7, and 19.5 bu/a for Armour, Everest, and Fuller, respectively.

Introduction

Wheat fungicide use across the state of Kansas historically has resulted in approximately 10% yield increase when disease is present on a susceptible variety. With the change in economics of wheat production in recent years, producers are looking more intensively at the use of fungicides to improve wheat yield and quality. A two-year study was initiated to evaluate the yield response of fungicide applications to wheat varieties with varying levels of fungal disease resistance.

Experimental Procedures

The experimental site was located on a Parsons silt loam planted in tilled ground after corn harvest. The experiment utilized a randomized complete block design with four replications of six treatments consisting of three wheat varieties applied with and without fungicide. Varieties Everest, Endurance, and Overley were planted on October 7, 2010, and Everest, Armour, and Fuller were planted on October 19, 2012, at 75 lb/a in 7-in.-spaced rows. Prosaro 421 SC was applied at 6.5 fl oz/a on May 5, 2011 when wheat was at the Feekes 10.5.1 stage. Headline SC was applied on May 8, 2013, to wheat at the Feekes 10.1 stage. Wheat fungal diseases on the flag leaf were evaluated by visual inspection after applications. Wheat was harvested by plot combine on June 15, 2011, and June 24, 2013.

Results and Discussion

Wheat was planted in a timely manner both years and adequate fall tillering occurred, promoting average to above-average yields. Moisture was abundant in 2011, totaling 14.8 in. during the critical foliar disease months of March, April, and May; however, no significant fungal disease pressure was observed after fungicide application. Precipita-

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tion in 2013 totaled 17.0 in. during March, April, and May and promoted the occurrence of stripe rust (*Puccinia striiformis* f. sp. *tritici*) and septoria tritici blotch (*Mycosphaerella graminicola*) (Table 2).

In 2011, yields ranged from 46.5 to 58.8 bu/a (Table 1). Although the highest-yielding treatment was 58.8 bu/a for Everest treated with a fungicide, no significant differences were observed between treated and untreated plots. In 2013, significant reductions in stripe rust and septoria were observed for plots treated with a fungicide (Table 2); consequently, yield differences between varieties and fungicide treatments were significant. Fungicide increased yield of all three varieties by 10.3, 13.7, and 19.5 bu/a for Armour, Everest, and Fuller, respectively. Yield increases with fungicide treatment were expected because of the high number of fungal lesions on the flag leaves of untreated plots, but yield increases of this magnitude are greater than typical responses to fungicides applied to wheat in Kansas.

Table 1. Wheat yield response to fungicide in 2011, when no significant fungal disease was present between application and harvest

Variety	Treatment[1]	Yield[2]
		------- bu/a -------
Endurance	Untreated	46.5
	Treated	49.4
Everest	Untreated	57.4
	Treated	58.8
Overley	Untreated	48.0
	Treated	51.6
LSD (0.05)		8.9
Main effect means:		
Endurance		48.0
Everest		58.1
Overley		49.8
LSD (0.05)		6.3
	Untreated	50.6
	Treated	53.2
	LSD (0.05)	NS

[1] Application of 6.5 fl oz/a Prosaro 421 SC (Bayer CropScience, Research Triangle Park, NC) to wheat at Feekes 10.5.1.

[2] Yields adjusted to 13.5% moisture.

Table 2. Wheat disease ratings and yield response to fungicide in 2013

Variety	Treatment[1]	Stripe rust[2]	Septoria leaf blotch	Yield[3]
		------- % flag leaf infected -------		------- bu/a -------
Armour	Untreated	4.0	5.0	61.1
	Treated	0.0	1.0	71.4
Everest	Untreated	1.0	22.0	56.5
	Treated	0.0	7.0	70.2
Fuller	Untreated	0.0	11.0	48.4
	Treated	0.0	4.0	67.9
LSD (0.05)		1.9	4.9	6.7
Main effect means:				
Armour		2.0	2.9	66.2
Everest		0.4	14.5	63.3
Fuller		0.0	7.6	58.2
LSD (0.05)		1.4	3.5	4.8
	Untreated	1.5	12.8	55.3
	Treated	0.1	3.9	69.8
	LSD (0.05)	1.1	2.8	3.9

[1] Application of 6.0 fl oz/a Headline SC (BASF, Research Triangle Park, NC) to wheat at Feekes 10.1.

[2] Leaf ratings evaluated on May 22.

[3] Yields adjusted to 13.5% moisture.

Agronomic Maximization of Soybean Yield and Quality: Row Spacing and Management

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Summary

Yield-enhancing products in soybean have become increasingly popular in recent years in response to higher commodity prices; however, little research has been done on combinations of these products with different production practices. Narrow row spacing along with these yield-enhancing products may be an effective way of maximizing soybean yield. The objective of this study was to evaluate the interaction of aggressive and standard soybean management systems with different row spacings. Three row spacings, narrow (7.5 or 10 in.), medium (15 or 20 in.), and wide (30 in.), and four management systems, untreated control, fungicide and insecticide seed treatment plus foliar fungicide, SOYA Complete (combination of several seed treatments, nitrogen (N), and numerous foliar products), and SOYA Complete minus foliar fungicide were evaluated at five locations (three in Kansas and two in Minnesota) in 2012 and 2013. No significant row spacing × management interactions with yield were found in either year across all five locations. Averaged across 2012 and 2013, narrow row spacing significantly outyielded medium and wide row spacings by 4.2 and 3.9 bu/a, respectively, in Kansas. Row spacing had no effect in Minnesota. Aggressive management systems showed a positive yield response in Kansas, with the two SOYA treatments increasing yield in most environments. Management also significantly increased yield in Minnesota, with the two aggressive managements outyielding the fungicide and insecticide seed treatment plus foliar fungicide and untreated managements by 3.1 and 5.8 bu/a, respectively. Fractional canopy coverage data in 2013 indicated that row spacings of less than 30 in. closed the canopy 10–16 days sooner than with 30-in. rows. Normalized difference vegetation index (NDVI) captured late in the 2013 season suggested that aggressive management systems delay canopy senescence. Overall, narrow row spacings, 7.5 or 10 in. in Kansas, increase yield regardless of management systems, and intensive management was more responsive in Minnesota than in Kansas across all row spacings.

Introduction

Numerous studies have evaluated the effect of soybean row spacing on yield. Most findings suggest that narrow row spacings (less than 30 in.) tend to yield more than wide row spacings, indicating increased light interception as one of the reasons. Other studies have looked at the interaction of row spacing with production practices, such as plant population, but few have looked at the interaction of row spacing with different management systems. Aggressive management systems that include multiple yield-enhancing inputs have become increasingly popular in recent years due to higher commodity prices. Yield improvements from claims such as improved plant health, "stay-greenness," and increased drought-hardiness are just a few used by makers of these intensive inputs. Little research has been done on combinations of these products with different row spacings to understand each one's unique contribution to increasing

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[1] Kansas State University.

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soybean yield. Narrow row spacing combined with an aggressive management system may be an effective approach for maximizing soybean yield. The objective of this study was to evaluate the interaction of aggressive and standard soybean management systems with different row spacings.

Procedures

Experiments were conducted in 2012 and 2013 at three locations in Kansas (Scandia, Rossville, and Manhattan) and two locations in Minnesota (St. Paul and Waseca). Each experiment was arranged in a randomized complete block with a split-plot design. The whole plot factor was three row spacings. 10-, 20-, and 30-in. row spacings were used in Kansas in 2012 and Minnesota in 2012 and 2013, and 7.5-, 15-, and 30-in. row spacings were used in Kansas in 2013. For the remainder of this discussion, narrow (7.5 or 10 in.), medium (15 or 20 in.), and wide (30 in.) will be used when discussing the three row spacings.

The split-plot factor was management systems. The four systems used both years across all locations were untreated control (UTC), fungicide and insecticide seed treatment plus foliar fungicide (F+I ST + Foliar F), SOYA Complete, and SOYA minus foliar fungicide. SOYA stands for "systematic optimization of yield-enhancing applications" and includes the combination of fungicide, insecticide, and LCO seed treatments and LCO, N, micronutrients, antioxidant, fungicide, and insecticide foliar applications. SOYA Complete is the combination of all of these products, whereas SOYA minus foliar fungicide is everything except the foliar fungicide application. The two SOYA treatments will be referred to as aggressive management systems.

Soybeans were planted in early to mid-May in 2012 and mid-May to early June in 2013 at a rate of 175,000 seeds/a across all row spacings. Growth stage application timings for the various treatments were V4 for foliar LCO and N, R1 for foliar micronutrients, and R3 for foliar antioxidant, fungicide, and insecticide. Data collected to characterize soybean growth parameters on all plots were stand counts at V2–V3 and R8; disease and insect assessments prior to and following fungicide and insecticide applications; plant heights, lodging scores, and pod counts at R8; and digital photos and NDVI measured weekly. Digital photos were analyzed for fractional canopy coverage using the SigmaScan software, which converted green pixels (soybean leaves) into red pixels and divided the number of red pixels by the total number of pixels in the picture. Plots were harvested for grain in early October in 2012 and mid-October in 2013. Seed samples were then analyzed for seed mass, protein content, and oil content.

Results

Row Spacing × Management

Across both years, management had similar responses across all row spacings, and yield increased due to narrow row spacing regardless of the management system used in Kansas (Figure 1). In Minnesota, aggressive management systems increased yield across all row spacings but with a slightly greater response in the wider row spacings (Figure 1). The yield gap differential between narrow, medium, and wide row spacings decreased with the more aggressive management systems.

The only significant row spacing × management interaction occurred in the early season (V2–V3) stand counts taken in Kansas (data not shown). All row spacings had similar stand counts in the UTC and F+I ST + Foliar F managements. In the aggressive management systems, however, stand counts for the medium and wide row spacings dropped, whereas stand counts in the narrow row spacing increased slightly.

Row Spacing

In Kansas, narrow rows outyielded the medium and wide rows by 4.2 and 3.9 bu/a, respectively (Figure 2). This may be attributed to the greater late-season stand counts observed in the narrow rows (Table 1). Also, canopy development data at Manhattan in 2013, measured by fractional canopy coverage (Figure 3), indicated that narrow and medium row spacings reached canopy closure 10 to 16 days earlier than wide rows.

No row spacing effect was observed in Minnesota (Figure 2, Table 2).

Management

Yields in Kansas showed a positive response to more aggressive management systems, with the SOYA Complete management having the greatest yield (Figure 4). An explanation for this slight increase in yield may be tied to the greater seed mass seen in the SOYA Complete management system compared with the UTC (Table 1). Data for NDVI captured at Rossville in 2013 (Figure 5) indicated a delayed senescence in the aggressive management systems, which could further explain the increase in seed mass and thus the slight increase in yield.

Stands in Kansas also showed a response to management systems, with the F+I St + Foliar F management having the greatest number of plants/a at both the early and late season stand counts (Table 1). However, recent and ongoing research indicates that soybean stands above 100,000–115,000 plants/a are acceptable for achieving maximum yields in Kansas.

In Minnesota, the two aggressive management systems, SOYA Complete and SOYA minus Foliar F, significantly outyielded the UTC management by 5.6 and 5.9 bu/a, respectively, and the F+I ST + Foliar F management by 3 and 3.3 bu/a, respectively (Figure 3). Similar to results from Kansas, seed mass in the two aggressive management systems was significantly greater than the F+I ST + Foliar F management, which was significantly higher than the UTC (Table 2). As mentioned earlier, this may be an explanation for the increase in yield observed in the more aggressive management systems.

Conclusion

No row spacing × management interaction was observed for yield in either Kansas or Minnesota. Yield increased due to narrow rows in Kansas across all management systems. Aggressive management systems were more responsive in Minnesota than in Kansas and increased yield in all row spacings.

Table 1. Effects of row spacing and management on growth parameters of soybean in Kansas

Treatments	V2–V3 stand	R8 stand	Number of pods	Seed mass	Postharvest protein
	Growth parameters[1]				
	------------ plants/a ------------		pods/plant	oz/100 seeds	---- % ----
Row spacing					
Narrow	144537 a	125357 a	47.2 a	0.527 a	34.3 a
Medium	138261 a	118214 ab	45.7 a	0.531 a	34.3 a
Wide	136932 a	115285 b	48.2 a	0.531 a	34.4 a
Management					
UTC	140815 b	118895 b	44.6 b	0.521 c	34.3 a
F+I ST + Foliar F	151896 a	128372 a	46.5 ab	0.529 b	34.4 a
SOYA Complete	132503 b	116177 b	48.3 a	0.538 a	34.3 a
SOYA minus Foliar F	134426 b	115030 b	48.7 a	0.530 b	34.3 a

[1] Column means within row spacing and management followed by the same letter are not significantly different (α = 0.05).

Table 2. Effects of row spacing and management on growth parameters of soybean in Minnesota

Treatments	V2–V3 stand	R8 stand	Number of pods	Seed mass	Postharvest protein
	Growth parameters[1]				
	------------ plants/a ------------		pods/plant	oz/100 seeds	---- % ----
Row spacing					
Narrow	156,167 a	141,084 a	33.8 a	0.550 a	34.6 a
Medium	147,867 a	135,150 a	35.4 a	0.555 a	34.5 a
Wide	152,058 a	137,392 a	35.7 a	0.559 a	34.6 a
Management					
UTC	154,106 a	139,536 a	33.1 a	0.537 c	34.8 a
F+I ST + Foliar F	152,722 a	136,934 a	34.1 a	0.551 b	34.7 ab
SOYA Complete	150,177 a	137,045 a	36.9 a	0.568 a	34.3 c
SOYA minus Foliar F	151,118 a	137,986 a	35.7 a	0.563 a	34.5 bc

[1] Column means within row spacing and management followed by the same letter are not significantly different (α = 0.05).

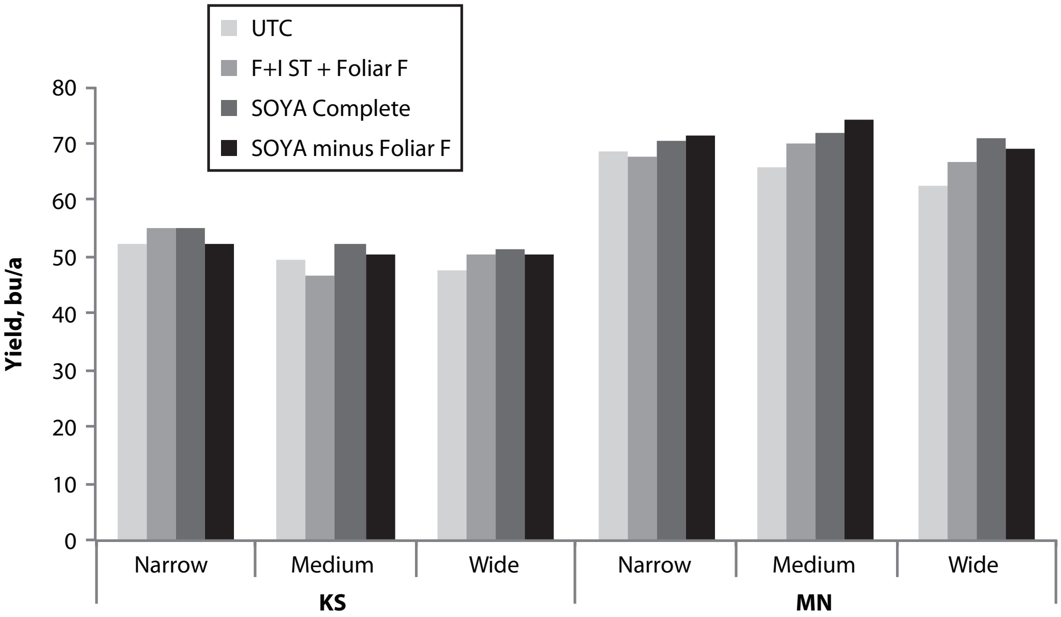

Figure 1. Yields for row spacing by management averaged across both years and all locations within Kansas and Minnesota

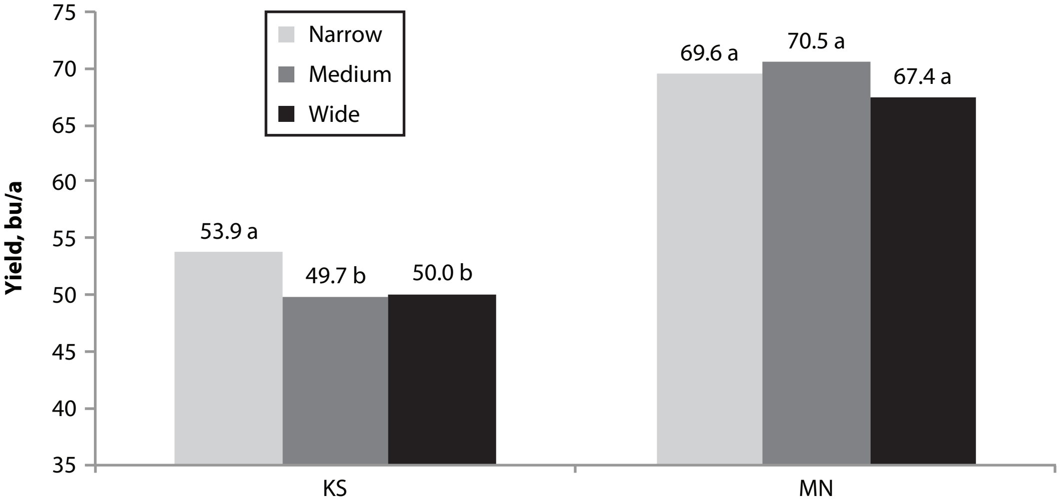

Figure 2. Yield response to row spacing averaged across both years and locations within Kansas and Minnesota.

Within each state, means followed by the same letter are not significantly different ($\alpha = 0.05$)

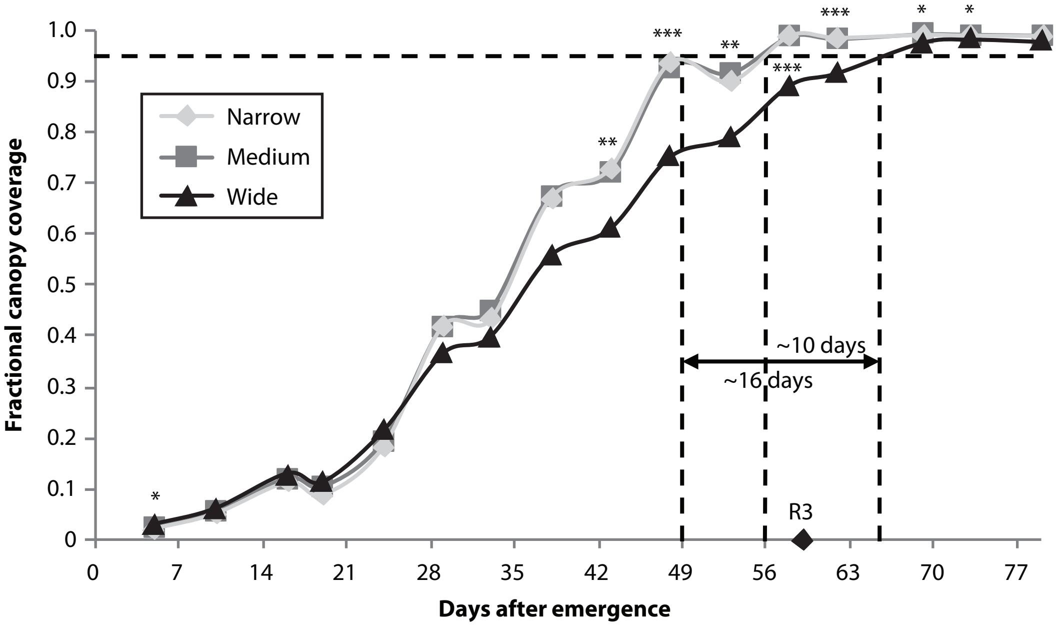

Figure 3. Fractional canopy coverage at Manhattan, KS in 2013.
* Significant at α = 0.05, ** Significant at α = 0.01, *** Significant at α = 0.001

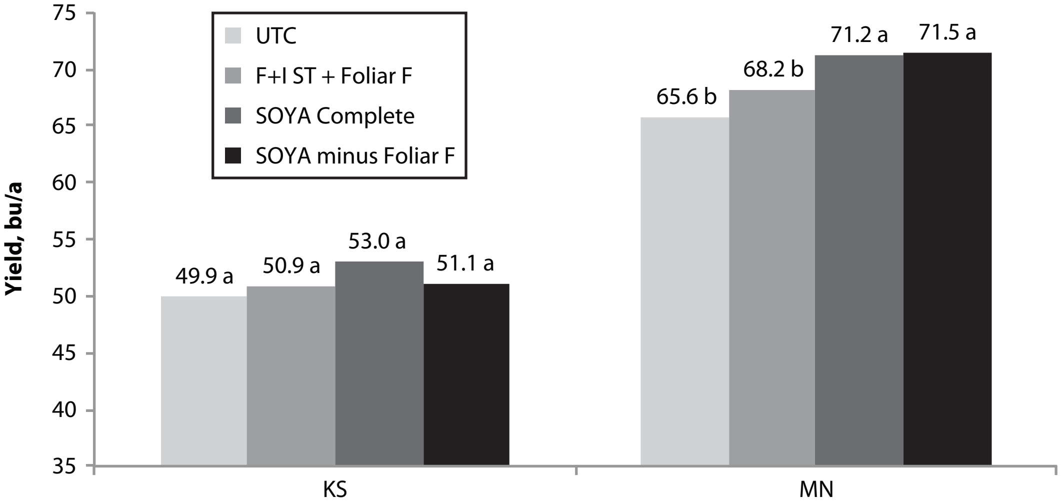

Figure 4. Yield response to management systems averaged across both years and locations within Kansas and Minnesota.
Within each state, means followed by the same letter are not significantly different (α = 0.05)

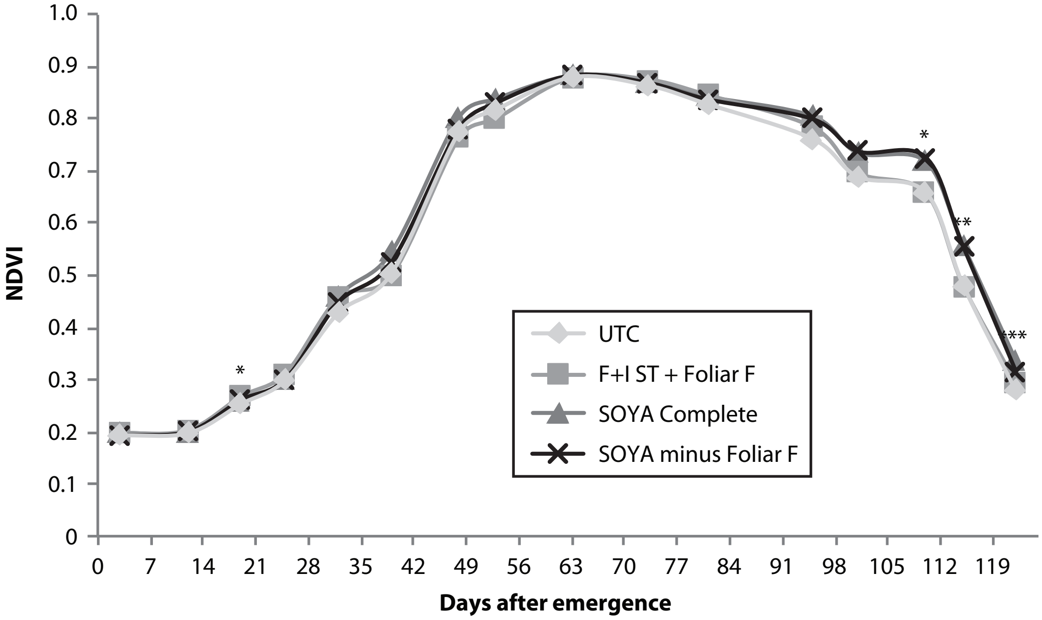

Figure 5. Normalized difference vegetation index (NDVI) at Rossville, KS, in 2013.
* Significant at α = 0.05, ** Significant at α = 0.01, *** Significant at α = 0.001

Improving the Performance of Winter Wheat Planted Without Tillage after Grain Sorghum

J. Jennings, K. Roozeboom, J. Shroyer, P.V.V. Prasad, and C.B. Rajashekar

Summary

In the past two decades, no-till cropping systems have increased in acreage throughout the Central Plains. No-till has improved soil water conservation and allowed growers to intensify and diversify their crop rotations, which results in more acres of winter wheat (*Triticum aestivum*) planted following summer row crops. Previous research has revealed that wheat yields are often reduced following grain sorghum (*Sorghum bicolor L.*) compared with wheat after other summer row crops. The objective of this study was to evaluate grain sorghum residue and harvest management strategies in no-till systems to improve yields of the following winter wheat crop. Three management factors were evaluated: glyphosate application (preharvest, postharvest, none), residue (removed, chopped, left standing), and nitrogen (N; 30 lb/a applied to residue, none). Treatment structure was a 3-way factorial with treatment combinations arranged in a randomized complete block design with four replications. The study was conducted in six different environments during the 2011–2012 and 2012–2013 growing seasons. Wheat yields increased in two environments by 2 to 10 bu/a when glyphosate was applied to the sorghum preharvest. Residue treatments either had no effect or a negative effect on wheat yields compared with residue left standing. Additional N applied to the sorghum residue increased wheat yields in only one environment. These results indicate that wheat yield after a sorghum crop was maximized with a preharvest glyphosate application if applied 7 weeks before a frost, but residue management and additional N application to speed residue breakdown had no benefits.

Introduction

Grain sorghum and winter wheat are two major crops produced in Kansas. Previous research has revealed that wheat yields following grain sorghum often are reduced compared with wheat yields following other summer row crops grown in the state. Sorghum and wheat are grown in semi-arid regions where no-till has become popular due its ability to conserve soil moisture. Determining effective management strategies for grain sorghum to improve yields of the subsequent wheat crop in no-till is essential for improving cropping system productivity in the Great Plains Region.

The objective of this study was to identify combinations of grain sorghum harvest and residue management techniques that are effective for improving success of wheat planted after sorghum in no-till systems.

Procedures

Experiments were conducted over a 2-year period at three Kansas locations each year. Year 1 included 2011–2012 growing seasons and field locations at Belleville, Manhattan, and Ottawa. Year 2 consisted of the 2012–2013 growing seasons with locations at Belleville, Manhattan, and Hutchinson. Plots were 300 ft^2 except at the Manhattan location in year 1, where plots were 500 ft^2. The experiment was arranged in a randomized complete block design with four replications and a three-way factorial treatment structure. Three management factors evaluated were glyphosate applications (preharvest, postharvest, and none), residue (removal, chopped, and left standing), and N (additional 30 lb/a applied to residue, none).

Grain sorghum hybrids suitable to the areas of interest were selected. A medium-early season hybrid, DKS 36-06, was planted at the Manhattan, Ottawa, and Hutchinson sites, and an early season hybrid, DKS 28-05, was used at Belleville. Preharvest applications of glyphosate to the sorghum crop were performed when grain moisture was 18 to 22%. In the first year of the study (2011–2012), preharvest glyphosate treatments were applied 7–8 weeks prior the first frost date at the Manhattan and Ottawa locations. Within all other environments, preharvest glyphosate treatments were applied 4 weeks or less before the first frost. Glyphosate applied to the sorghum residue postharvest was completed 1 to 3 days following harvest. Residue and N treatments were applied approximately 7 days after the postharvest glyphosate treatment. Nitrogen was applied to the sorghum residue as urea-ammonium nitrate (UAN; 28-0-0) following the residue treatments.

Wheat was planted within the dates recommended by Kansas State University. Yield components observed throughout the growing season were population, fall and spring tiller numbers, head numbers, spikelets per head (2011–2012), and seed number per head (2012–2013). Fall tiller counts were not taken at the Manhattan and Hutchinson locations in 2012–2013 due to delayed development. Grain was harvested from the middle 5 ft of each plot using a small plot combine.

Results

Grain sorghum yield and moisture are shown in Figure 1. No environmental interaction was observed, so yield data are combined across all six environments. Preharvest applications of glyphosate to the sorghum crop did not significantly reduce sorghum yields or harvest grain moisture.

Treatments did influence winter wheat development. Plant density numbers (Table 1) of winter wheat were significantly increased following pre-harvest glyphosate treatments at the Ottawa location. Removing sorghum residue reduced plant populations at Belleville in both growing seasons as well as at the Hutchinson site in 2012–2013. At the Ottawa location, plant density was greatest following chopped residue compared with residue left standing. Nitrogen applied to the grain sorghum residue did not influence plant density of winter wheat.

Fall tiller development (Table 2) was improved by pre- and postharvest glyphosate treatments at the Ottawa site. In 2012–2013 at Belleville, fall tiller numbers were reduced when sorghum residue was removed. Chopping or removing the sorghum residue decreased fall tiller numbers at Manhattan. Additional N did not influence fall tiller development.

Spring tiller numbers (Table 3) were increased at both the Belleville (2012–2013) and the Manhattan (2011–2012) locations when following grain sorghum that was treated with glyphosate preharvest. In 2012–2013 at Belleville, sorghum residue that was treated with glyphosate following fall harvest increased spring tiller numbers compared with residue that was untreated. Spring tiller numbers were decreased when sorghum residue was removed at Belleville both years, and at the Manhattan and Hutchinson locations in 2012–2013. In 2012–2013 at Belleville, spring tillers were reduced when residue was chopped compared with residue was left standing. Spring tiller numbers were not influenced by additional N applications to the sorghum residue.

Total head numbers (Table 4) were increased by preharvest glyphosate treatments at Belleville both years and at the Manhattan location in 2011–2012. Head numbers following postharvest glyphosate treatments were increased at Belleville in 2012–2013. When sorghum residue was removed, head numbers were decreased at Belleville both years, as well as Manhattan and Hutchinson in 2012–2013 compared with residue left standing. When sorghum residue was chopped, head numbers were reduced at Belleville and Hutchinson in 2012–2013. Additional N increased total head number at the Ottawa site.

Spikelet number, seeds per head, and seed size were not influenced by any treatment or combination of treatments, so data are not presented.

Wheat yields (Table 5) were increased following grain sorghum that was treated with glyphosate prior to harvest at the Manhattan and Ottawa locations in 2011–2012. When sorghum residue was removed, the following wheat crops yield was reduced at Belleville both years, plus Manhattan and Hutchinson in 2012–2013. Wheat yields were decreased when following chopped grain sorghum residue at Belleville both years, Manhattan (2011–2012), and Hutchinson (2012). When additional N was applied to the sorghum residue, the following wheat yields were increased at one of the six environments (Ottawa, 2011).

Conclusion

Wheat yields in this study were maximized following grain sorghum that was treated with preharvest glyphosate if the application was done at least seven weeks before the first frost. Wheat yields were greatest when the previous sorghum crop's residue was left standing. Responses of wheat yields to additional N applied to the sorghum residue were not economical based on current wheat and fertilizer prices.

Table 1. Mean plant density of winter wheat

Treatments		Belleville (2011–2012)	Belleville (2012–2013)	Manhattan (2011–2012)	Manhattan (2012–2013)	Ottawa (2011–2012)	Hutchinson (2012–2013)
		Environment					
		plants/a					
Glyphosate	Preharvest	174,015a[1]	242,812a	178,062a	137,593a	190,202a	234,718a
	Postharvest	178,062a	226,624a	182,109a	133,546a	178,062ab	226,624a
	Untreated	165,921a	218,531a	182,109a	129,500a	165,921b	226,624a
Residue	Chopped	178,062a	238,765a	182,109a	145,687a	190,202a	230,671ab
	Removed	153,781b	198,296b	182,109a	125,453a	178,062ab	214,484b
	Untreated	190,202a	250,905a	182,109a	129,500a	165,921b	238,765a
Nitrogen	Applied	174,015a	226,624a	182,109a	133,546a	178,062a	230,671a
	Untreated	174,015a	230,671a	182,109a	129,500a	178,062a	226,624a

[1] Column means within treatments followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 2. Mean fall tiller numbers of winter wheat

Treatments		Belleville (2011–2012)	Belleville (2012–2013)	Manhattan (2011–2012)	Ottawa (2011–2012)
		Environment			
		tillers/a			
Glyphosate	Preharvest	188,172a[1]	410,588a	498,110a	391,424a
	Postharvest	179,910a	386,391a	484,283a	383,752a
	Untreated				
	183,788a	386,897a	471,468a	323,049b	
Residue	Chopped	176,538a	418,344a	471,468b	383,836a
	Removed	191,545a	357,473b	476,358b	374,984a
	Untreated				
	183,788a	408,058a	506,035a	339,405a	
Nitrogen	Applied	185,784a	383,609a	475,009a	357,054a
	Untreated	182,130a	405,642a	494,232a	375,096a

[1] Column means within treatments followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 3. Mean spring tiller numbers of winter wheat

		Environment					
Treatments		Belleville (2011–2012)	Belleville (2012–2013)	Manhattan (2011–2012)	Manhattan (2012–2013)	Ottawa (2011–2012)	Hutchinson (2012–2013)
		tillers/a					
Glyphosate	Preharvest	636,116a[1]	672,200a	884,639a	568,694a	1,135,189a	739,732a
	Postharvest	611,835a	673,971a	843,749ab	578,694a	1,116,557a	688,304a
	Untreated	646,064a	624,565b	825,370b	588,474a	1,096,407a	727,002a
Residue	Chopped	682,739a	693,699b	842,653a	616,887a	1,116,978a	726,833a
	Removed	551,132b	545,483c	831,524a	525,242b	1,122,458a	656,266b
	Untreated	660,144a	731,554a	879,581a	593,701a	1,108,716a	771,939a
Nitrogen	Applied	660,875a	657,671a	849,173a	575,884a	1,125,213a	735,686a
	Untreated	601,802a	656,153a	853,332a	581,336a	1,106,889a	701,006a

[1] Column means within treatments followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 4. Mean head numbers of winter wheat

		Environment					
Treatments		Belleville (2011–2012)	Belleville (2012–2013)	Manhattan (2011–2012)	Manhattan (2012–2013)	Ottawa (2011–2012)	Hutchinson (2012–2013)
		heads/a					
Glyphosate	Preharvest	441,271a[1]	921,335a	338,419a	826,571a	543,857a	895,465a
	Postharvest	416,062ab	924,876a	321,473ab	822,187a	539,725a	768,326a
	Untreated	406,451b	854,562b	299,720b	836,520a	521,093a	827,343a
Residue	Chopped	427,697a	932,464b	308,320a	878,000a	549,758a	792,101b
	Removed	389,336b	772,276c	323,665a	768,398b	531,885a	762,256b
	Untreated	446,751a	996,034a	327,627a	838,881ab	523,032a	936,777a
Nitrogen	Applied	430,479a	884,351a	322,569a	843,770a	549,224a	847,690a
	Untreated	412,043a	916,164a	317,173a	813,082a	520,559a	813,066a

[1] Column means within treatments followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 5. Mean winter wheat yields

Treatments		Belleville (2011–2012)	Belleville (2012–2013)	Manhattan (2011–2012)	Manhattan (2012–2013)	Ottawa (2011–2012)	Hutchinson (2012–2013)
		Environment					
		bu/a					
Glyphosate	Preharvest	40a[1]	39a	45a	51a	54a	34a
	Postharvest	37a	39a	36b	49a	52b	36a
	Untreated	38a	38a	36b	49a	51b	35a
Residue	Chopped	41b	38b	35b	50ab	52a	35b
	Removed	30c	36b	43a	48b	52a	31c
	Untreated	45a	42a	41a	51a	52a	40a
Nitrogen	Applied	39a	39a	40a	49a	54a	35a
	Untreated	38a	39a	39a	50a	51a	35a

[1] Column means within treatments followed by the same letter are not significantly different ($\alpha = 0.05$).

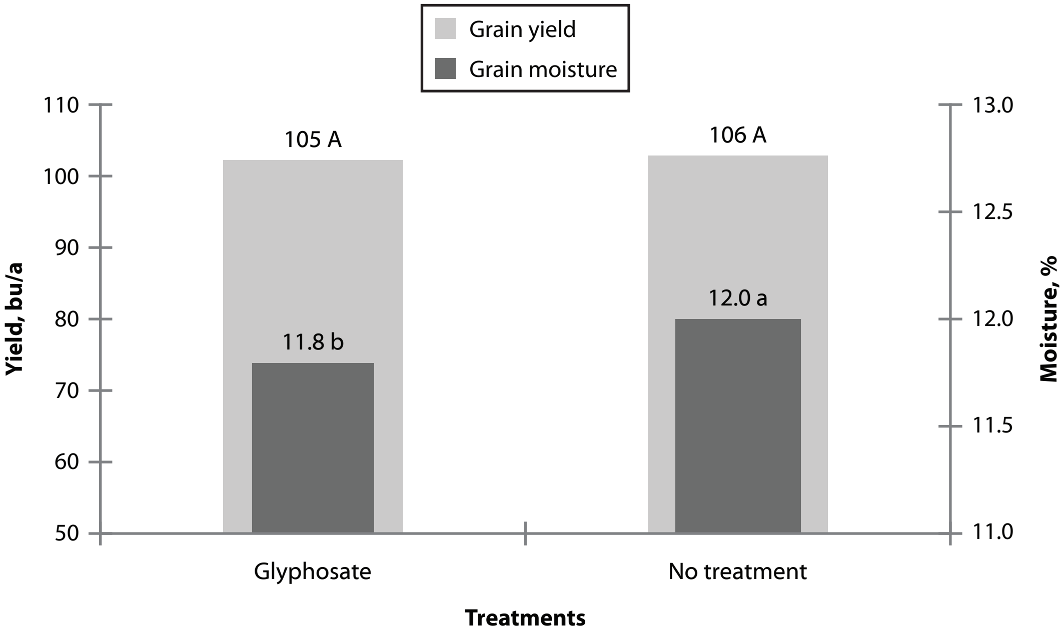

Figure 1. Grain sorghum yields and moisture following glyphosate treatment, 2011 and 2012.

Treatment means followed by the same letter are not significantly different ($\alpha = 0.05$; capital letters indicate grain yield differences, lowercase letters indicate grain moisture differences).

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2014

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AND COOPERATIVE EXTENSION SERVICE

SRP1102 April 2014