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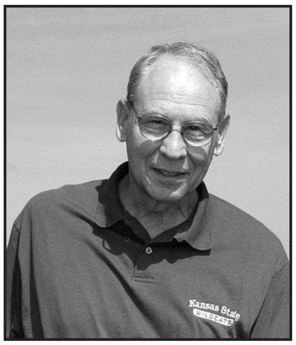

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Effects of Supplementation with Corn or Dried Distillers Grains on Gains of Heifer Calves Grazing Smooth Bromegrass Pastures

L.W. Lomas and J.L. Moyer

Summary
A total of 90 heifer calves grazing smooth bromegrass pastures were used to compare supplementation with 0.5% of body weight per head daily of corn or dried distillers grains (DDG) in 2014, 2015, and 2016. Daily gains of heifers supplemented with corn or DDG were similar ($P > 0.05$).

Introduction
Distillers grains, a by-product of the ethanol industry, have tremendous potential as an economical and nutritious supplement for grazing cattle. Distillers grains contain a high concentration of protein (25 to 30%), with more than two-thirds escaping degradation in the rumen, which makes it an excellent supplement for younger cattle. Recent advancements in the ethanol manufacturing process have resulted in extraction of a greater amount of fat; therefore, creating distillers grains that may contain less energy than corn. This research was conducted to compare performance of stocker cattle supplemented with corn or DDG at 0.5% body weight per head daily while grazing smooth bromegrass pastures.

Experimental Procedures
Thirty heifer calves were weighed on two consecutive days, stratified by weight, and randomly allotted to six 5-acre smooth bromegrass pastures on April 8, 2014 (423 lb), April 7, 2015 (438 lb), and April 6, 2016 (408 lb). Three pastures of heifers were randomly assigned to one of two supplementation treatments (three replicates per treatment) and grazed for 142, 182, and 197 days in 2014, 2015, and 2016, respectively. Supplementation treatments were ground corn or DDG at 0.5% body weight per head daily. DDG used in this study contained 25% protein and 6% fat. Corn was estimated to contain 10% protein and a similar level of energy as DDG. Pastures were fertilized with 100 lb/a nitrogen and P_2O_5 and K_2O as required by soil test on February 21, 2014; March 11, 2015; and February 17, 2016. Pastures were stocked with 1 heifer/a and grazed continuously until August 28, 2014; October 6, 2015; and October 20, 2016, when heifers were weighed on two consecutive days and grazing was terminated.

Cattle in each pasture were group-fed corn or DDG in meal form in bunks on a daily basis, and pasture was the experimental unit. No implants or feed additives were used. Weight gain was the primary measurement. Cattle were weighed every 28 days; quantity of supplement fed was adjusted at that time. Cattle were treated for internal and external parasites before being turned out to pasture and later vaccinated for protection from pinkeye. Heifers had free access to commercial mineral blocks that contained 12% calcium, 12% phosphorus, and 12% salt.

Results and Discussion

Cattle gains and supplement intake are presented in Tables 1, 2, and 3, for 2014, 2015, and 2016, respectively. Grazing gains and supplement intake were 2.00 and 2.8 lb/head daily, 2.10 and 2.9 lb/head daily, 1.69 and 3.0 lb/head daily, 1.61 and 3.0 lb/head daily, 1.65 and 2.8 lb/head daily, and 1.64 and 2.9 lb/head daily for heifers supplemented with corn and DDG in 2014, 2015, and 2016, respectively. Gains and supplement intake of heifers supplemented with corn were similar ($P > 0.05$) to those of heifers that were supplemented with DDG. This would suggest that protein was not limiting performance of heifers grazing these pastures, as heifers fed corn received a similar amount of supplemental energy but less supplemental protein than those fed DDG.

Table 1. Effects of supplementation with corn or dried distillers grains (DDG) on gains of heifer calves grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2014

	Supplement	
Item	Corn	DDG
Number of days	142	142
Number of head	15	15
Initial weight, lb	423	423
Final weight, lb	706	720
Gain, lb	284	298
Daily gain, lb	2.00	2.10
Gain/a, lb	284	298
Total supplement consumption, lb/head	397	409
Average supplement consumption, lb/head per day	2.8	2.9

Table 2. Effects of supplementation with corn or dried distillers grains (DDG) on gains of heifer calves grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2015

	Supplement	
Item	Corn	DDG
Number of days	182	182
Number of head	15	15
Initial weight, lb	438	438
Final weight, lb	746	731
Gain, lb	308	293
Daily gain, lb	1.69	1.61
Gain/a, lb	308	293
Total supplement consumption, lb/head	539	537
Average supplement consumption, lb/head per day	3.0	3.0

Table 3. Effects of supplementation with corn or dried distillers grains (DDG) on gains of heifer calves grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2016

	Supplement	
Item	Corn	DDG
Number of days	197	197
Number of head	15	15
Initial weight, lb	408	408
Final weight, lb	733	731
Gain, lb	324	323
Daily gain, lb	1.65	1.64
Gain/a, lb	324	323
Total supplement consumption, lb/head	558	562
Average supplement consumption, lb/head per day	2.8	2.9

Evaluation of Supplemental Energy Source for Grazing Stocker Cattle

L.W. Lomas, J.K. Farney, and J.L. Moyer

Summary
A total of 108 steers grazing smooth bromegrass pastures were used to evaluate the effects of supplemental energy source on available forage, grazing gains, subsequent finishing gains, and carcass characteristics in 2014, 2015, and 2016. Supplementation treatments evaluated were: no supplement, a supplement with starch as the primary source of energy, and a supplement with fat as the primary source of energy. Supplements were formulated to provide the same quantity of protein and energy per head daily. Supplementation with the starch-based or fat-based supplement during the grazing phase resulted in higher ($P < 0.05$) grazing gains than feeding no supplement during all three years. In 2014 and 2016, grazing gains of steers supplemented with the starch-based or fat-based supplement were similar ($P > 0.05$). In 2015, steers supplemented with the fat-based supplement had greater ($P < 0.05$) grazing gains than those that received the starch-based supplement. In 2014, supplementation during the grazing phase had no effect ($P > 0.05$) on finishing gain, feed intake, and feed:gain. Steers supplemented with the starch-based supplement had greater ($P < 0.05$) final finishing liveweight, and greater ($P < 0.05$) hot carcass weight than those that received no supplement. In 2015, steers fed the fat-based supplement had higher ($P < 0.05$) final finishing liveweight, greater ($P < 0.05$) hot carcass weight, and lower ($P < 0.05$) finishing gain than those supplemented with the starch-based supplement or fed no supplement.

Introduction
Supplementation of grazing cattle is most economically feasible when cattle prices are high relative to the price of grain. Energy supplementation of grazing ruminants may reduce forage intake and digestibility, but energy supplementation at low levels (less than 0.4% bodyweight) has been shown to have little effect on forage intake when crude protein was not limiting. Several studies have evaluated the effect of supplementation on stocker cattle gains and forage utilization during the grazing phase, but few have evaluated the effects of supplementation during the grazing phase on subsequent finishing performance and carcass traits. This research seeks to obtain a more thorough understanding of the interactions among grazing nutrition and management, finishing performance, and carcass traits to facilitate greater economic utilization of these relationships.

Experimental Procedures
Steers (108) of predominately Angus breeding were weighed on two consecutive days, stratified by weight, and randomly allotted to nine 5-acre smooth bromegrass pastures on April 9, 2014 (446 lb); April 7, 2015 (488 lb); and April 6, 2016 (444 lb). Three pastures of steers were randomly assigned to one of three supplementation treatments (3 replicates per treatment) and were grazed for 181, 224, and 223 days in 2014, 2015, and 2016, respectively. Supplementation treatments in 2014 and 2015 were: no supplement, 4.25 lb per head daily of a starch-based supplement, or 4.5 lb per head daily of a

fat-based supplement. In 2016, the starch-based supplement and fat-based supplement were both fed at 4.25 lb per head daily. Supplements were formulated to provide the same amount of protein (0.7 lb in 2014 and 2015 and 0.4 lb in 2016) and energy (3.3 lb of TDN in 2014 and 2015 and 3.4 lb of TDN in 2016) per head daily. Pastures were fertilized with 100 lb/a of nitrogen (N) on February 24, 2014; February 12, 2015; and February 11, 2016. Pastures were stocked with 0.8 steers/a and grazed continuously until October 7, 2014 (181 days); November 10, 2015 (224 days); and November 15, 2016 (223 days); when steers were weighed on two consecutive days and grazing was ended.

Cattle in each pasture were group-fed supplement in meal form on a daily basis in metal feed bunks, and pasture was the experimental unit. No implants or feed additives were used during the grazing phase. Weight gain was the primary measurement. Cattle were weighed every 28 days. Cattle were treated for internal and external parasites before being turned out to pasture and later were vaccinated for protection from pinkeye. Cattle had free access to commercial mineral blocks that contained 12% calcium, 12% phosphorus, and 12% salt. Forage availability was measured approximately every 28 days with a disk meter calibrated for smooth bromegrass.

After the grazing period, cattle were shipped to a finishing facility, implanted with Synovex S, and fed a diet of 80% whole-shelled corn, 15% corn silage, and 5% supplement (dry matter basis) for 125 and 97 days in 2014 and 2015, respectively. All cattle were slaughtered in a commercial facility at the end of the finishing period, and carcass data were collected. Cattle that grazed these pastures in 2016 were being finished for slaughter at the time that this report was written.

Results and Discussion

Average available forage for the smooth bromegrass pastures during the grazing phase, and grazing and subsequent finishing performance of grazing steers are presented by supplementation treatment for 2014 and 2015 in Tables 1 and 2, respectively. Grazing performance only is presented for 2016 in Table 3. Supplementation treatment had no effect ($P > 0.05$) on the quantity of forage available for grazing in any year. Pastures grazed by supplemented steers might be expected to have greater available forage DM as consumption of supplement by steers grazing these pastures would likely reduce forage intake thereby resulting in more residual forage. However, the levels of supplement fed in this study were likely small enough that they did not affect forage consumption.

Supplemented steers had greater ($P < 0.05$) weight gain, daily gain, and steer gain/a than those that received no supplement in all three years. In 2014 and 2016, grazing weight gain, daily gain, and gain/a were not different ($P > 0.05$) between steers that were supplemented with the starch-based or fat-based supplement. In 2014, steers fed the starch-based supplement had greater ($P < 0.05$) final finishing liveweight, greater ($P < 0.05$) hot carcass weight, greater ($P < 0.05$) overall (grazing + finishing) gain, and greater ($P < 0.05$) overall daily gain than those that received no supplement. Supplementation during the grazing phase had no effect ($P > 0.05$) on finishing weight gain, feed intake, feed:gain, backfat, ribeye area, yield grade, or marbling score.

In 2015, steers supplemented with the fat-based supplement had greater ($P < 0.05$) grazing gains than those that received the starch-based supplement. Steers supplemented with the fat-based supplement had higher ($P < 0.05$) slaughter weight, higher hot ($P < 0.05$) carcass weight, and lower ($P < 0.05$) finishing gain than those fed no supplement or supplemented with the starch-based supplement.

Under the conditions of this study, supplementation of stocker cattle grazing smooth bromegrass pasture improved grazing performance and increased slaughter weight and carcass weight. Most of the increase in slaughter weight and carcass weight can be attributed to greater gains of supplemented cattle during the grazing phase. Supplemental energy source while grazing had no effect on carcass quality.

Table 1. Effect of supplemental energy source on grazing and subsequent finishing performance of steers grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2014

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (181 days)			
Number of head	12	12	12
Initial weight, lb	446	446	446
Final weight, lb	706a	817b	810b
Gain, lb	260a	371b	364b
Daily gain, lb	1.43a	2.05b	2.01b
Gain/a, lb	208a	296b	291b
Supplement consumption, lb/head per day	0	4.25	4.5
Supplement, lb/additional gain	---	6.9	7.8
Average available forage dry matter, lb/a	7,140	7,128	6,985
Finishing phase (125 days)			
Beginning weight, lb	706a	817b	810b
Ending weight, lb	1241a	1338b	1307ab
Gain, lb	535	522	497
Daily gain, lb	4.28	4.17	3.98
Daily dry matter intake, lb	26.1	27.0	24.7
Feed:gain	6.11	6.49	6.20
Hot carcass weight, lb	769a	830b	810ab
Backfat, in.	0.45	0.50	0.47
Ribeye area, sq. in.	11.2	12.1	12.1
Yield grade	2.8	3.0	2.8
Marbling score[1]	630	648	650
Percentage USDA grade choice	100	100	100
Overall performance (grazing plus finishing; 306 days)			
Gain, lb	795a	892b	861ab
Daily gain, lb	2.60a	2.92b	2.81ab

[1] 600 = modest, 700 = moderate.

Means within a row followed by the same letter are not significantly different ($P < 0.05$).

Table 2. Effect of supplemental energy source on grazing and subsequent finishing performance of steers grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2015

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (224 days)			
Number of head	12	12	12
Initial weight, lb	489	488	488
Final weight, lb	753a	833b	886c
Gain, lb	264a	345b	398c
Daily gain, lb	1.18a	1.54b	1.78c
Gain/a, lb	211a	276b	318c
Supplement consumption, lb/head per day	0	4.25	4.5
Supplement, lb/additional gain	---	11.8	7.5
Average available forage dry matter, lb/a	6,601	6,644	6,484
Finishing phase (97 days)			
Beginning weight, lb	753a	833b	886c
Ending weight, lb	1169a	1208a	1307b
Gain, lb	417a	374b	420a
Daily gain, lb	4.30a	3.86b	4.33a
Daily dry matter intake, lb	26.2	26.0	26.3
Feed:gain	6.09	6.74	6.08
Hot carcass weight, lb	725a	749a	810b
Backfat, in.	0.42	0.46	0.49
Ribeye area, sq. in.	11.7	11.7	12.2
Yield grade	2.3	2.8	2.8
Marbling score[1]	639	631	639
Percentage USDA grade choice	100	100	100
Overall performance (grazing plus finishing; 321 days)			
Gain, lb	681a	719a	818b
Daily gain, lb	2.12a	2.24a	2.55b

[1] 600 = modest, 700=moderate.
Means within a row followed by the same letter are not significantly different ($P < 0.05$).

Table 3. Effect of supplemental energy source on grazing performance of steers grazing smooth bromegrass pastures, Southeast Agricultural Research Center, 2016

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (223 days)			
Number of head	12	12	12
Initial weight, lb	445	444	444
Final weight, lb	754a	871b	856b
Gain, lb	309a	426b	412b
Daily gain, lb	1.39a	1.91b	1.85b
Gain/a, lb	247a	341b	329b
Supplement consumption, lb/head per day	0	4.25	4.25
Supplement, lb/additional gain	---	8.2	9.2
Average available forage dry matter, lb/a	7,403	7,402	7,309

Means within a row followed by the same letter are not significantly different ($P < 0.05$).

Effects of Interseeding Ladino Clover into Tall Fescue Pastures of Varying Endophyte Status on Grazing Performance of Stocker Steers

L.W. Lomas and J.L. Moyer

Summary
Sixty-four yearling steers grazing tall fescue pastures were used to evaluate the effects of fescue cultivar and interseeding ladino clover on grazing gains and available forage. Fescue cultivars evaluated were high-endophyte 'Kentucky 31,' low-endophyte 'Kentucky 31,' 'HM4,' and 'MaxQ.' Steers that grazed pastures of low-endophyte 'Kentucky 31,' 'HM4,' or 'MaxQ' gained significantly more ($P < 0.05$) and produced more ($P < 0.05$) gain/a than those that grazed high-endophyte 'Kentucky 31' pastures. Gains of cattle that grazed low-endophyte 'Kentucky 31,' 'HM4,' or 'MaxQ' were similar ($P > 0.05$). High-endophyte 'Kentucky 31' pastures had more ($P < 0.05$) available forage than low-endophyte 'Kentucky 31,' 'HM4,' or 'MaxQ' pastures.

Introduction
Tall fescue, the most widely adapted cool-season perennial grass in the United States, is grown on approximately 66 million acres. Although tall fescue is well adapted in the eastern half of the country between the temperate north and mild south, presence of a fungal endophyte results in poor performance of grazing livestock, especially during the summer. Until recently, producers with high-endophyte tall fescue pastures had two primary options for improving grazing livestock performance. One option was to destroy existing stands and replace them with endophyte-free fescue or other forages. Although it supports greater animal performance than endophyte-infected fescue, endophyte-free fescue has been shown to be less persistent under grazing pressure and more susceptible to stand loss from drought stress. In locations where high-endophyte tall fescue must be grown, the other option was for producers to adopt management strategies that reduce the negative effects of the endophyte on grazing animals, such as diluting the effects of the endophyte by incorporating legumes into existing pastures or providing supplemental feed. In recent years, new tall fescue cultivars have been developed with a non-toxic endophyte that provides vigor to the fescue plant without negatively affecting performance of grazing livestock. Interseeding legumes into tall fescue cultivars with the toxic endophyte should be an effective way of increasing gains of cattle grazing tall fescue. However, these cultivars lack the competitiveness of high-endophyte 'Kentucky 31' and their competitiveness with legumes could be a potential problem. Objectives of this study were to evaluate forage availability, stand persistence, and performance of stocker steers grazing tall fescue cultivars with non-toxic endophyte and high- and low-endophyte 'Kentucky 31' with and without ladino clover.

Experimental Procedures

On March 30, 2016, 64 mixed black yearling steers were weighed (535 lb) on two consecutive days and allotted to sixteen 5-acre established pastures of high-endophyte 'Kentucky 31' or low-endophyte 'Kentucky 31,' 'HM4,' or 'MaxQ' tall fescue (4 replications per cultivar). 'HM4' and 'MaxQ' are cultivars with a non-toxic endophyte. Two pastures of each cultivar had been interseeded with 5 lb/a of 'Will' ladino clover on February 22, 2016. Four steers were assigned to each pasture. Pastures without clover were fertilized with 80 lb/a nitrogen (N) on February 10, 2016. All pastures were fertilized with 40 lb/a N and P_2O_5 and K_2O as required by soil test on September 13, 2016.

Pasture was the experimental unit and weight gain was the primary measurement. No implants or feed additives were used. Cattle were weighed and forage availability was measured every 28 days with a disk meter calibrated for tall fescue. Cattle were treated for internal and external parasites before being turned out to pasture and later vaccinated for protection from pinkeye. Steers had free access to commercial mineral blocks that contained 12% calcium, 12% phosphorus, and 12% salt. Two steers were removed from the study for reasons unrelated to experimental treatment and replaced with grazers to maintain equal stocking rates. Pastures were grazed continuously until November 29, 2016 (224 days) when steers were weighed on two consecutive days and grazing was terminated.

After the grazing period, cattle were moved to a finishing facility, implanted with Synovex-S (Zoetis, Madison, NJ), and fed a diet of 80% whole-shelled corn, 15% corn silage, and 5% supplement (dry matter basis). Cattle were being finished for slaughter to determine the effect of grazing treatment on subsequent finishing performance at the time that this report was written.

Results and Discussion

Grazing performance is pooled across legume treatment and presented by tall fescue cultivar in Table 1 and pooled across fescue cultivar and presented by legume treatment in Table 2. There were no significant interactions ($P > 0.05$) between fescue cultivar and legume treatment for cattle performance. However, there was a significant ($P < 0.05$) fescue cultivar × legume interaction for average available forage DM. Steers that grazed low-endophyte Kentucky 31, HM4, or MaxQ were heavier ($P < 0.05$) at the end of the grazing period, had greater ($P < 0.05$) grazing gain, greater ($P < 0.05$) daily gain, and produced greater ($P < 0.05$) gain/a than steers grazing high-endophyte Kentucky 31. Average available forage DM of high-endophyte Kentucky 31 pasture was greater ($P < 0.05$) than that of low-endophyte Kentucky 31, HM4, or MaxQ. MaxQ pasture had greater ($P < 0.05$) available forage DM than low-endophyte Kentucky 31. Average available forage DM of HM4 pasture was similar ($P > 0.05$) to that of low-endophyte Kentucky 31 and MaxQ pastures. Steer gains were similar ($P > 0.05$) between pastures fertilized with an additional 80 lb/a N and those interseeded with ladino clover. Pastures with clover had less ($P < 0.05$) available forage DM than those without clover for all cultivars except high-endophyte Kentucky 31 where available forage DM of pastures with and without clover were similar ($P > 0.05$).

Table 1. Effects of cultivar on performance of steers grazing tall fescue pastures, Southeast Agricultural Research Center, 2016

	Tall fescue cultivar			
Item	High-endophyte Kentucky 31	Low-endophyte Kentucky 31	HM4	MaxQ
Grazing phase (224 days)				
Number of head	14	16	16	16
Initial weight, lb	533	535	535	537
Ending weight, lb	764a	920b	931b	924b
Gain, lb	232a	385b	396b	387b
Daily gain, lb	1.03a	1.72b	1.77b	1.73b
Gain/a, lb	185a	308b	317b	310b
Average available forage dry matter, lb/a*	7,365a	5,944b	6,139bc	6,300c

Means within a row followed by the same letter do not differ ($P < 0.05$).
*There was a significant ($P < 0.05$) fescue cultivar × legume interaction.

Table 2. Effects of interseeding ladino clover on performance of steers grazing tall fescue pastures, Southeast Agricultural Research Center, 2016

	Legume treatment	
Item	No legume	Ladino clover
Grazing phase (224 days)		
Number of head	31	31
Initial weight, lb	534	536
Ending weight, lb	868	902
Gain, lb	334	366
Daily gain, lb	1.49	1.63
Gain/a, lb	267	293
Average available forage dry matter, lb/a*	6,888a	5,986b

Means within a row followed by the same letter do not differ ($P < 0.05$).
*There was a significant ($P < 0.05$) fescue cultivar × legume interaction.

Effects of Various Grazing Systems on Grazing and Subsequent Finishing Performance

L.W. Lomas and J.L. Moyer

Summary

A total of 280 mixed black yearling steers were used to compare grazing and subsequent finishing performance from pastures with 'MaxQ' tall fescue, a wheat-bermudagrass double-crop system, or a wheat-crabgrass double-crop system in 2010, 2011, 2012, 2013, 2014, 2015, and 2016. Daily gains of steers that grazed MaxQ fescue, wheat-bermudagrass, or wheat-crabgrass were similar ($P > 0.05$) in 2010 and 2016. Daily gains of steers that grazed wheat-bermudagrass or wheat-crabgrass were greater ($P > 0.05$) than those that grazed MaxQ fescue in 2011 and 2012. Daily gains of steers that grazed wheat-crabgrass were greater ($P > 0.05$) than those that grazed wheat-bermudagrass and similar ($P > 0.05$) to those that grazed MaxQ fescue in 2013. Daily gains of steers that grazed wheat-crabgrass were greater ($P > 0.05$) than those that grazed wheat-bermudagrass or Max Q fescue in 2014. In 2015, daily gains of steers that grazed wheat-crabgrass were greater ($P < 0.05$) than those that grazed wheat-bermudagrass or Max Q fescue and daily gain of steers grazing wheat-bermudagrass was greater ($P < 0.05$) than that of those that grazed MaxQ fescue. Finishing gains were similar ($P > 0.05$) among forage systems in 2010, 2012, 2013, and 2014. Finishing gains of steers that grazed MaxQ fescue were greater ($P < 0.05$) than those that grazed wheat-bermudagrass in 2011 and greater ($P < 0.05$) than those that grazed wheat-bermudagrass or wheat-crabgrass in 2015.

Introduction

MaxQ tall fescue, a wheat-bermudagrass double-crop system, and a wheat-crabgrass double-crop system have been three of the most promising grazing systems evaluated at the Southeast Agricultural Research Center in the past 20 years, but these systems have never been compared directly in the same study. The objective of this study was to compare grazing and subsequent finishing performance of stocker steers that grazed these three systems.

Experimental Procedures

From 2010-2016, 40 mixed black yearling steers were weighed on two consecutive days and allotted on April 6, 2010 (633 lb); March 23, 2011 (607 lb); March 22, 2012 (632 lb); April 4, 2013 (678 lb); April 1, 2014 (636 lb); March 31, 2015 (644 lb); and March 30, 2016 (600 lb) to three 4-acre pastures of 'Midland 99' bermudagrass, three 4-acre pastures of 'Red River' crabgrass and four 4-acre established pastures of MaxQ tall fescue (4 steers/pasture). The bermudagrass and crabgrass pastures had previously been no-till seeded with approximately 120 lb/a of 'Fuller' hard red winter wheat on September 30, 2009, and September 22, 2010; and 130 lb/a, 95 lb/a, 85 lb/a, 180 lb/a, and 100 lb/a of 'Everest' hard red winter wheat on September 27, 2011, September 25, 2012, September 23, 2013, September 29, 2014, and September 22, 2015, respectively.

All pastures were fertilized with 80-40-40 lb/a of N-P_2O_5-K_2O on March 3, 2010; January 27, 2011; January 25, 2012; February 19, 2013; January 28, 2014; February 10, 2015; and February 11, 2016. Bermudagrass and crabgrass pastures received an additional 46 lb/a of nitrogen (N) on May 28, 2010; June 10, 2011; May 18, 2012; July 3, 2013; June 2, 2014; June 8, 2015; and May 23, 2016. Fescue pastures received an additional 46 lb/a of N on August 31, 2010; September 15, 2011; September 18, 2013; September 4, 2014; October 7, 2015; and September 7, 2016. An additional 5 lb/a, 4 lb/a, 4 lb/a, 4 lb/a, 4 lb/a, and 4 lb/a of crabgrass seed was broadcast on crabgrass pastures on April 8, 2011, April 4, 2012, May 7, 2013, April 18, 2014, June 4, 2015, and April 12, 2016, respectively.

Pasture was the experimental unit. No implants or feed additives were used. Weight gain was the primary measurement. Cattle were weighed every 28 days, and forage availability was measured approximately every 28 days with a disk meter calibrated for wheat, bermudagrass, crabgrass, or tall fescue. Cattle were treated for internal and external parasites before being turned out to pasture and later were vaccinated for protection from pinkeye. Steers had free access to commercial mineral blocks that contained 12% calcium, 12% phosphorus, and 12% salt. Wheat-bermudagrass and wheat-crabgrass pastures were grazed continuously until September 14, 2010 (161 days); September 7, 2011 (168 days); September 10, 2013 (159 days); September 3, 2014 (155 days); September 15, 2015 (168 days); and September 15, 2016 (169 days). The fescue pastures were grazed continuously until November 9, 2010 (217 days); October 21, 2011 (212 days); October 29, 2013 (208 days); October 14, 2014 (196 days); November 10, 2015 (224 days); and November 15, 2016 (230 days). In 2012, all pastures were grazed continuously until August 23 (144 days), when grazing on all pastures was terminated due to limited forage availability because of below-average precipitation. Steers were weighed on two consecutive days at the end of the grazing phase.

After the grazing period, cattle were moved to a finishing facility, implanted with Synovex-S (Zoetis, Madison, NJ), and fed a diet of 80% whole-shelled corn, 15% corn silage, and 5% supplement (dry matter basis). Finishing diets were fed for 94 days (wheat-bermudagrass and wheat-crabgrass) or 100 days (fescue) in 2010, 98 days (wheat-bermudagrass and wheat-crabgrass) or 96 days (fescue) in 2011, 105 days in 2012, 105 days (wheat-bermudagrass and wheat-crabgrass) or 91 days (fescue) in 2013, 119 days (wheat-bermudagrass and wheat-crabgrass) or 106 days (fescue) in 2014, and 99 days (wheat-bermudagrass and wheat-crabgrass) or 97 days (fescue) in 2015. All steers were slaughtered in a commercial facility, and carcass data were collected. Cattle that grazed these pastures in 2016 were being finished for slaughter at the time that this report was written.

Results and Discussion

Grazing and subsequent finishing performance of steers that grazed MaxQ tall fescue, a wheat-bermudagrass double-crop system, or a wheat-crabgrass double-crop system are presented in Tables 1, 2, 3, 4, 5, and 6 for 2010, 2011, 2012, 2013, 2014, and 2015, respectively. Grazing performance only for 2016 is presented in Table 7. Daily gains of steers that grazed MaxQ tall fescue, wheat-bermudagrass, or wheat-crabgrass were similar ($P > 0.05$) in 2010, but total grazing gain and gain/a were greater ($P < 0.05$) for MaxQ tall fescue than wheat-bermudagrass or wheat-crabgrass because steers grazed

MaxQ tall fescue for more days. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 362, 286, and 258 lb/a, respectively. MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage dry matter (DM) than wheat-bermudagrass or wheat-crabgrass. Grazing treatment in 2010 had no effect ($P > 0.05$) on subsequent finishing gains. Steers that grazed MaxQ were heavier ($P < 0.05$) at the end of the grazing phase, maintained their weight advantage through the finishing phase, and had greater ($P < 0.05$) hot carcass weight than those that grazed wheat-bermudagrass or wheat-crabgrass pastures. Steers that previously grazed wheat-bermudagrass or wheat-crabgrass had lower ($P < 0.05$) feed:gain than those that had grazed MaxQ.

In 2011, daily gains, total gain, and gain/a of steers that grazed wheat-bermudagrass or wheat-crabgrass were greater ($P < 0.05$) than MaxQ fescue. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 307, 347, and 376 lb/a, respectively. MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage DM than wheat-bermudagrass or wheat-crabgrass. This was likely due to greater forage production by MaxQ and/or greater forage intake by steers grazing wheat-bermudagrass and wheat-crabgrass. Steers that grazed MaxQ had greater ($P < 0.05$) finishing gain than those that grazed wheat-bermudagrass and lower ($P < 0.05$) feed:gain than those that grazed wheat-bermudagrass or wheat-crabgrass. Carcass weight was similar ($P > 0.05$) among treatments.

In 2012, daily gains, total gain, and gain/a of steers that grazed wheat-bermudagrass or wheat-crabgrass were greater ($P < 0.05$) than MaxQ fescue. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 226, 325, and 313 lb/a, respectively. MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage DM than wheat-bermudagrass or wheat-crabgrass. Grazing treatment had no effect ($P > 0.05$) on subsequent finishing performance or carcass characteristics.

In 2013, daily gain was greater ($P < 0.05$) for steers that grazed wheat-crabgrass than for those that grazed wheat-bermudagrass, and daily gain from MaxQ fescue and wheat-bermudagrass were similar ($P > 0.05$). Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 338, 244, and 316 lb/a, respectively. Gain/a was greater ($P < 0.05$) for MaxQ fescue and wheat-crabgrass than for wheat-bermudagrass. Overall gain was not different between forage systems; however, steers grazed MaxQ fescue for 49 more days than wheat-bermudagrass or wheat-crabgrass. Overall daily gain was greater ($P < 0.05$) for wheat-crabgrass than for MaxQ tall fescue. MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage DM than wheat-bermudagrass or wheat-crabgrass and wheat-bermudagrass pastures had more ($P < 0.05$) available forage DM than wheat-crabgrass. Grazing treatment had no effect ($P > 0.05$) on subsequent finishing daily gain or carcass characteristics.

In 2014, daily gain was greater ($P < 0.05$) for steers that grazed wheat-crabgrass than for those that grazed wheat-bermudagrass or 'Max Q' fescue, and daily gain from MaxQ fescue and wheat-bermudagrass were similar ($P > 0.05$). Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 370, 282, and 383 lb/a, respectively. Gain/a was greater ($P < 0.05$) for MaxQ fescue and wheat-crabgrass than for wheat-bermudagrass. Overall gain and overall daily gain for wheat-crabgrass were greater ($P < 0.05$) than for wheat-bermudagrass or MaxQ fescue, while overall gain and overall daily gain for MaxQ fescue and wheat-bermudagrass were similar ($P > 0.05$). MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage DM than wheat-bermudagrass or wheat-crabgrass and wheat-bermudagrass pastures had more ($P < 0.05$) available forage DM than wheat-crabgrass. Grazing treatment had no effect ($P > 0.05$) on subsequent finishing daily gain or carcass characteristics.

In 2015, daily gain was greater ($P < 0.05$) for steers that grazed wheat-crabgrass than for those that grazed wheat-bermudagrass or MaxQ fescue, and daily gain from wheat-bermudagrass was greater ($P < 0.05$) than for those that grazed MaxQ fescue. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 291, 337, and 396 lb/a, respectively. Gain/a was greater ($P < 0.05$) for wheat-crabgrass than for wheat-bermudagrass and MaxQ fescue and greater ($P < 0.05$) for wheat-bermudagrass than MaxQ fescue. Overall gain for Max Q fescue was greater ($P < 0.05$) than for wheat-bermudagrass or wheat-crabgrass, while overall gain for wheat-bermudagrass and wheat-crabgrass were similar ($P > 0.05$). Overall daily gains were similar ($P > 0.05$) among forage systems. MaxQ tall fescue pastures had greater ($P < 0.05$) average available forage DM than wheat-bermudagrass or wheat-crabgrass and wheat-bermudagrass pastures had more ($P < 0.05$) available forage DM than wheat-crabgrass. Slaughter weight, finishing gains, hot carcass weight, and ribeye area of steers that grazed MaxQ fescue were greater ($P < 0.05$) and feed:gain was less ($P < 0.05$) than those that grazed wheat-bermudagrass or wheat-crabgrass. Much of this difference in finishing performance can be attributed to muddier feedlot conditions during the time that the wheat-bermudagrass and wheat-crabgrass steers were being finished for slaughter than for the MaxQ fescue cattle.

In 2016, daily gains were similar ($P > 0.05$) for steers that grazed MaxQ tall fescue, a wheat-bermudagrass double-crop system, or a wheat-crabgrass double-crop system. However, MaxQ tall fescue pastures were grazed 61 days longer and as a result produced greater ($P < 0.05$) steer grazing gain, heavier ($P < 0.05$) steer ending weight, and greater ($P < 0.05$) gain per acre than wheat-bermudagrass or wheat-crabgrass pastures. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 368, 280, and 287 lb/a, respectively. Average available forage DM for MaxQ tall fescue was greater ($P < 0.05$) than for the wheat-bermudagrass double-crop system or wheat-crabgrass double-crop system and average available forage DM for the wheat-bermudagrass double-crop system was greater ($P < 0.05$) than for the wheat-crabgrass double-crop system.

Hotter, drier weather during the summer of 2011 and 2012 likely provided more favorable growing conditions for bermudagrass and crabgrass than for fescue, which was reflected in greater ($P < 0.05$) gains by cattle grazing those pastures. Lack of precipitation also reduced the length of the grazing season for MaxQ fescue pastures in 2012, which resulted in less fall grazing and lower gain/a than was observed for those pastures in 2010, 2011, 2013, 2014, 2015, and 2016.

Table 1. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2010

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	217	161	161
Number of head	16	12	12
Initial weight, lb	633	633	633
Ending weight, lb	995a	919b	891b
Gain, lb	362a	286b	258b
Daily gain, lb	1.67	1.78	1.60
Gain/a, lb	362a	286b	258b
Average available forage dry matter, lb/a	6214a	3497b	3174c
Finishing phase			
Number of days	100	94	94
Beginning weight, lb	995a	919b	891b
Ending weight, lb	1367a	1281b	1273b
Gain, lb	372	361	382
Daily gain, lb	3.72	3.84	4.07
Daily dry matter intake, lb	27.3a	24.6b	25.2b
Feed:gain	7.35a	6.42b	6.22b
Hot carcass weight, lb	847a	794b	790b
Backfat, in.	0.43	0.38	0.35
Ribeye area, sq. in.	12.5	12.5	12.2
Yield grade	2.8	2.5	2.5
Marbling score[1]	649	590	592
Percentage USDA choice grade	100	92	83
Overall performance (grazing plus finishing)			
Number of days	317	255	255
Gain, lb	734a	648b	640b
Daily gain, lb	2.32a	2.54b	2.51ab

[1] 500 = small, 600 = modest, 700 = moderate.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 2. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2011

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	212	168	168
Number of head	16	12	12
Initial weight, lb	607	607	607
Ending weight, lb	914a	954b	982b
Gain, lb	307a	347b	376b
Daily gain, lb	1.45a	2.07b	2.24b
Gain/a, lb	307a	347b	376b
Average available forage dry matter, lb/a	5983a	4172b	3904c
Finishing phase			
Number of days	96	98	98
Beginning weight, lb	914a	954b	982b
Ending weight, lb	1355	1344	1385
Gain, lb	442a	389b	403ab
Daily gain, lb	4.60a	3.97b	4.11ab
Daily dry matter intake, lb	27.9	28.0	29.3
Feed:gain	6.09a	7.07b	7.13b
Hot carcass weight, lb	841	833	859
Backfat, in.	0.41	041	0.44
Ribeye area, sq. in.	12.9	13.0	13.3
Yield grade	2.6	2.7	2.8
Marbling score[1]	619	640	612
Percentage USDA choice grade	100	92	92
Overall performance (grazing plus finishing)			
Number of days	308	266	266
Gain, lb	749	737	779
Daily gain, lb	2.43a	2.77b	2.93b

[1] 600 = modest, 700 = moderate.

Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 3. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2012

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	144	144	144
Number of head	16	12	12
Initial weight, lb	632	632	632
Ending weight, lb	858a	957b	945b
Gain, lb	226a	325b	313b
Daily gain, lb	1.57a	2.26b	2.17b
Gain/a, lb	226a	325b	313b
Average available forage dry matter, lb/a	5983a	4172b	3904c
Finishing phase			
Number of days	105	105	105
Beginning weight, lb	858a	957b	945b
Ending weight, lb	1355	1409	1431
Gain, lb	497	451	486
Daily gain, lb	4.73	4.30	4.63
Daily dry matter intake, lb	30.7	28.3	29.1
Feed:gain	6.53	6.61	6.28
Hot carcass weight, lb	840	873	887
Backfat, in.	0.44	0.38	0.45
Ribeye area, sq. in.	12.6	12.8	13.3
Yield grade	2.8	2.7	2.8
Marbling score[1]	625	591	603
Percentage USDA choice grade	100	83	92
Overall performance (grazing plus finishing)			
Number of days	249	249	249
Gain, lb	722	776	799
Daily gain, lb	2.90	3.12	3.21

[1] 500 = small, 600 = modest, 700 = moderate.

Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 4. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2013

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	208	159	159
Number of head	16	12	12
Initial weight, lb	678	678	678
Ending weight, lb	1017a	923b	994a
Gain, lb	338a	244b	316a
Daily gain, lb	1.63ab	1.54a	1.99b
Gain/a, lb	338a	244b	316a
Average available forage dry matter, lb/a	6290a	3590b	2980c
Finishing phase			
Number of days	91	105	105
Beginning weight, lb	1017a	923b	994a
Ending weight, lb	1390	1387	1480
Gain, lb	374a	464b	486b
Daily gain, lb	4.11	4.42	4.63
Daily dry matter intake, lb	27.1	27.7	28.1
Feed:gain	6.64	6.29	6.09
Hot carcass weight, lb	862	860	918
Backfat, in.	0.40	0.38	0.46
Ribeye area, sq. in.	12.7	13.6	13.5
Yield grade	2.6	2.2	2.4
Marbling score[1]	594	599	612
Percentage USDA choice grade	94	100	92
Overall performance (grazing plus finishing)			
Number of days	299	264	264
Gain, lb	712	708	802
Daily gain, lb	2.38ac	2.68bc	3.04b

[1] 500 = small, 600 = modest, 700 = moderate.

Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 5. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2014

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	196	155	155
Number of head	16	12	12
Initial weight, lb	636	636	636
Ending weight, lb	1006a	918b	1019a
Gain, lb	370a	282b	383a
Daily gain, lb	1.89a	1.82a	2.47b
Gain/a, lb	370a	282b	383a
Average available forage dry matter, lb/a	5733a	3344b	2509c
Finishing phase			
Number of days	106	119	119
Beginning weight, lb	1006a	918b	1019a
Ending weight, lb	1461a	1405a	1548b
Gain, lb	455a	487ab	529b
Daily gain, lb	4.29	4.09	4.45
Daily dry matter intake, lb	28.9	29.0	29.2
Feed:gain	6.80	7.08	6.57
Hot carcass weight, lb	906a	871a	960b
Backfat, in.	0.48a	0.49a	0.61b
Ribeye area, sq. in.	13.3a	12.4b	12.7b
Yield grade	2.6	2.7	3.3
Marbling score[1]	648	639	648
Percentage USDA choice grade	100	100	100
Overall performance (grazing plus finishing)			
Number of days	302	274	274
Gain, lb	825a	769a	912b
Daily gain, lb	2.73a	2.81a	3.33b

[1] 600 = modest, 700 = moderate.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 6. Effects of forage system on grazing and subsequent performance of stocker steers, Southeast Agricultural Research Center, 2015

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	224	168	168
Number of head	16	12	12
Initial weight, lb	644	644	644
Ending weight, lb	934a	982b	1040c
Gain, lb	291a	337b	396c
Daily gain, lb	1.30a	2.01b	2.36c
Gain/a, lb	291a	337b	396c
Average available forage dry matter, lb/a	6911a	3507b	3154c
Finishing phase			
Number of days	97	99	99
Beginning weight, lb	934a	982b	1040c
Ending weight, lb	1359a	1230b	1264b
Gain, lb	425a	248b	224b
Daily gain, lb	4.38a	2.51b	2.26b
Daily dry matter intake, lb	26.9a	25.4a	29.5b
Feed:gain	6.19a	10.29b	13.26c
Hot carcass weight, lb	843a	762b	784b
Backfat, in.	0.44	0.45	0.41
Ribeye area, sq. in.	12.6a	11.1b	11.2b
Yield grade	2.7	2.7	2.7
Marbling score[1]	635	599	597
Percentage USDA choice grade	94	100	100
Overall performance (grazing plus finishing)			
Number of days	321	267	267
Gain, lb	715a	586b	620b
Daily gain, lb	2.23	2.19	2.32

[1] 500 = small, 600 = modest, 700 = moderate.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 7. Effects of forage system on grazing performance of stocker steers, Southeast Agricultural Research Center, 2016

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	230	169	169
Number of head	16	12	12
Initial weight, lb	600	600	600
Ending weight, lb	968a	880b	887b
Gain, lb	368a	280b	287b
Daily gain, lb	1.60	1.66	1.70
Gain/a, lb	368a	280b	287b
Average available forage dry matter, lb/a	7613a	4008b	3750c

Means within a row followed by the same letter do not differ ($P < 0.05$).

Comparison of Two Organic Trace Mineral Supplements for Cows Grazing Tall Fescue

J.K. Farney

Summary

The purpose of this study was to determine the effects of two sources of organic trace mineral and two sources of magnesium supplementation on cow performance of spring-calving cows on K31 endophyte-infected fescue. The two treatments were organic trace minerals (zinc (Zn), copper (Cu), and manganese (Mn)) offered free choice as an amino-acid chelate with magnesium (Mg) as an amino acid chelate (CHEL) or organic trace mineral supplement with amino-acid complex with magnesium supplied as magnesium oxide (COMP). Mineral was offered free-choice beginning 30 days before breeding season on 4 ranches with 6 pastures per treatment (cows n = 203). Blood samples were collected prior to mineral supplementation and at pregnancy evaluation and serum was analyzed for Mg, Zn, Cu, and Mn. One ranch had an anaplasmosis event, therefore analysis was completed with and without this ranch. Pregnancy rate was not different ($P = 0.46$) when all 4 ranches were analyzed even though pregnancy rates were 89.3 and 92.9% for COMP and CHEL, respectively. Cows on the COMP mineral calved 6 days earlier ($P = 0.04$). When removing the anaplasmosis ranch, pregnancy rate was closer to approaching a tendency for a difference ($P = 0.15$) with pregnancy rates of 95.5 and 87.2% for CHEL and COMP, respectively, with a tendency ($P = 0.12$) for COMP cows to calve 5 days earlier. All serum mineral levels were lower at pregnancy detection than initial blood draw primarily due to reduction in mineral levels in fescue late in summer and a reduction in intake at the end of the project. Serum Mg tended ($P = 0.11$) to stay more stable with the CHEL mineral such that the difference in final and initial Mg were similar. Serum Zn, Cu, and Mn were not different ($P > 0.10$) with the exception of some ranch-to-ranch variations. Additionally, CHEL intake was 6% lower than COMP. Even with the lower intake of the CHEL mineral, serum mineral levels were similar between both treatments; this indicates that CHEL minerals are more bioavailable. Overall, chelated minerals appear to provide an advantage to spring-calving cows on K31 fescue especially from a chelated magnesium source.

Introduction

Failure to breed is the number one culling criteria for beef cattle operations. One of the most difficult management systems to breed cows is spring-calving operations on endophyte-infected fescue. One issue with endophyte-infected fescue is that it can raise the body temperature of the cow, which negatively impacts cow breeding success. Conception issues automatically arise due to the effect of hot weather while breeding, and the increase in body temperature associated with cattle grazing endophyte-infected K-31 fescue. Incorporating management practices to improve reproductive success should lead to increased revenue and sustainability for cattle producers.

Organic forms of mineral have already been established to improve reproductive success, versus non-organic forms. This study will look at the ability of metal amino acid complex versus chelates to offset some of the production issues associated with high-endophyte fescue. Therefore, the objective of this study is to determine the performance effects of supplementing cows on K-31 fescue with metal amino acid chelates (CHEL) versus a metal amino acid complex (COMP).

Experimental Procedures

This experiment was approved by Kansas State University Institutional Animal Care and Use Committee prior to project being completed. Four ranches with a total of 203 spring-calving cows in southeast Kansas and southwest Missouri were used in a completely randomized block design where cows were offered one of two different organic mineral supplements beginning 30 days prior to breeding season and ending at pregnancy exam. The two treatments were free-choice mineral supplied where the copper (Cu), zinc (Zn), and manganese (Mn) are offered in the complex form (Availa-4, Zinpro Corp, Eden Prairie, MN; COMP) or mineral supplied where the Cu, Zn, and Mn are offered in the chelate form (Mineralate-3ChelateBlend, Nutech Biosciences, Inc, Oneida, NY; CHEL). Additionally, magnesium source was different for the two minerals: magnesium (Mg) offered in COMP was magnesium oxide while magnesium in CHEL was amino acid chelated magnesium (Mineralate-Mg 10, Nutech Biosciences, Inc, Oneida, NY). Mineral supplements were balanced to provide equal amounts of all required macro and trace minerals and vitamins with the addition of chlortetracycline (CTC; 0.5 mg/hd/d) for anaplasmosis control (Table 1) and formulated for a 4 ounce/head/day intake. Pregnancy evaluation was completed in the fall of 2015 where three of the four ranches' pregnancy determination was completed by manual palpation and one of the ranches utilized an initial screening blood pregnancy test, then followed that test with manual palpation by a veterinarian.

All mineral was offered to cows using ground mineral feeders (Dura-Bull Mineral Feeder, Pride of Farm, Houghton, IA). Mineral feeders were placed near a water source at all locations. Mineral intake was calculated for each ranch based on amount offered through the project period. Fescue samples were collected (n = 10) in each pasture in June then evaluated for endophyte presence using aniline blue staining of the epidermal strip under a microscope.

Calving dates were recorded for spring-calving cows in 2016 to determine calving distribution.

Results and Discussion

Pasture endophyte infection levels were low in 2015 for all pastures tested. The endophyte levels ranged from 10-25% infection rate with very little variation between pastures within ranches. Mineral intake was higher with the COMP mineral (5% greater) than CHEL mineral (3.2 oz/hd/d vs. 3.0 oz/hd/d, respectively). Water quality was similar between pastures and did not impact overall mineral intake.

Pregnancy Evaluations

Overall pregnancy rate was not different ($P = 0.46$) for COMP or CHEL, with 89.3% and 92.9% pregnancy rates, respectively (Table 2). Biologically and economically, a 4% difference in pregnancy rate is significant. In two of the four ranches, pregnancy rate was numerically higher for CHEL mineral (Ranch B had a significantly higher pregnancy rate, ~23% - $P < 0.05$), and at one ranch the pregnancy rates were the same

(100% for both minerals). For the Ranch D, there was an anaplasmosis event in the cows receiving the CHEL mineral and subsequently that herd was the only one where pregnancy rates were higher in the COMP treatment (95 vs. 84% for COMP vs. CHEL). There was no significant ranch ($P = 0.81$) nor ranch by treatment interaction ($P = 0.14$). Interestingly, cows on the COMP mineral calved 6 days earlier than cows receiving the CHEL mineral ($P = 0.04$) when evaluating all four ranches (Table 3). The lack of significance in pregnancy rate might be explained by still not having enough cows in the study.

When removing the anaplasmosis ranch, treatments are still not statistically significant, but are closer to approaching significance ($P = 0.15$) with an even larger difference in pregnancy rates; 95.5% versus 87.2% for CHEL and COMP respectively (Table 2). When Ranch D was removed from the analysis because of anaplasmosis, there was no difference ($P = 0.12$) in calving distribution even though numerically the cows on COMP mineral calved 5 days earlier (Table 3).

Blood Mineral

Serum blood mineral levels were lower in the second collection period for all minerals measured, which also corresponded to lower mineral intakes later in the season and a reduction in forage Mg concentrations. Typically, when testing lush growing fescue for Mg the value indicated should meet cow requirements, however, it has been reported that only ~30% of that Mg can be utilized. The recommendation for gestating cows is 7 to 9 g/d of Mg to maintain a blood level of 20 ppm which is the ideal serum concentration. Serum Mg tended to be more stable with the CHEL mineral ($P = 0.11$) than the COMP mineral as evidenced by the difference in final and initial Mg levels which were -0.21 ppm in CHEL and -2.60 ppm for cows on the COMP mineral. The greater conception rates suggest CHEL allowed cows to maintain a serum Mg at pregnancy check similar to initial levels, despite the decrease of Mg in forage. Additionally, CHEL cows consumed less mineral while maintaining serum Mg concentration, suggesting that CHEL was more bioavailable (Figure 1).

At the initiation of the study, cows on the COMP treatment group tended to have higher serum Mg concentrations ($P = 0.14$). This might be the explanation for why COMP cows calved earlier in the calving season than cows on CHEL. Additionally, final serum Mg was impacted by ranch and mineral supplementation ($P = 0.03$; Figure 2) where Ranch B COMP cows had the lowest final Mg.

Serum Zn, Cu, and Mn were not different ($P > 0.10$) for any treatments (Figure 1). Manganese was not different by treatment, ranch, or the interaction for serum Mn for initial, final, or the difference ($P > 0.10$) with all levels ~0.04 ppm (~40 ng/mL), which is nutritionally adequate. There was a tendency for a treatment by ranch interaction ($P = 0.09$) for final Zn where Ranches A and B had lower Zn than Ranches C and D (Figure 3). Ranches C and D had adequate (> 0.80 ppm) levels of Zn while Ranches A and B were considered marginal (between 0.50 and 0.79 ppm). There was a treatment by ranch interaction ($P = 0.02$) for final Cu concentration where Ranch C cows on both minerals had greater Cu levels than both minerals for Ranch A and CHEL mineral for Ranches B and D (Figure 4).

At the initiation of the study the average Cu levels would be considered marginal, Zn was adequate, and Mn was adequate. Final Cu levels remained marginal for Ranches A, B, and D while Ranch C had an adequate level according to recommendations. All ranches had adequate final Mn concentrations. Ranch C has the highest levels of Zn and Cu, adequate for both minerals at the end of the study, which might explain the 100% pregnancy rate for cows in all treatments at this ranch. Ranch B had the lowest pregnancy rate for cows on the COMP mineral. The Zn levels were considered marginal for Ranch B COMP cows, and in combination with the lowest Mg levels might potentially explain the reduction in pregnancy rate.

Implications

The amino acid chelated organic trace mineral supplement showed promise to aid in reproductive success for spring-calving producers on K31 endophyte infected fescue. Even though significance was not achieved in this study, economically there was a greater pregnancy rate for cows on chelated trace minerals. Specifically, the amino acid chelated Mg has the potential to be an improved source of Mg in mineral supplements. Magnesium plays a significant role in reproductive success as evidenced by this study. Cattle with higher circulating concentrations of Mg breed earlier; however, a static concentration appears to improve herd-level pregnancy rates, which was observed with the amino acid chelated mineral. Additionally, this study demonstrated that the chelated form of trace minerals were more bioavailable as intake was lower while maintaining serum levels that were equal to or greater than the complex form which had a greater consumption.

Acknowledgments

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Table 1. Calculated nutrient analysis (dry matter basis)

Item	Chelates	Complex
Crude protein (%)	5.36	5.81
NEg (Mcal/cwt)[1]	11.64	12.07
NEm (Mcal/cwt)[2]	16.98	17.62
Fat (%)	1.50	1.56
Acid detergent fiber (%)	2.82	2.80
Calcium (%)	13.41	13.45
Phosphorus (%)	5.83	5.84
Salt (%)	21.66	21.72
Potassium (%)	1.37	1.38
Magnesium (%)	2.79	2.79
Sulfur (%)	0.58	0.65
Cobalt (ppm)	105.84	104.06
Copper (ppm)	932.14	957.01
Zinc (ppm)	3517.64	3527.46
Manganese (ppm)	1722.72	1727.53
Selenium (ppm)	20.63	20.69
Iodine (ppm)	104.19	104.48
Iron (ppm)	5114.03	5144.90
Vitamin A (IU/lb)	190,840	191,373
Vitamin D (IU/lb)	30,946	31,033
Vitamin E (IU/lb)	217	218

[1] NEm = Net energy for maintenance
[2] NEg = Net energy for gain

Table 2. Pregnancy rates by treatment and ranch

Treatment	Ranch A	Ranch B	Ranch C	Ranch D	Total
Chelate % (n)	93.1 (49)	93.3[a] (15)	100 (14)	85.0 (20)	92.9 (98)
Complex % (n)	91.2 (50)	70.6[b] (17)	100 (16)	95.5 (22)	89.3 (105)
Ranch pregnancy rate % (n)	88.9 (99)	84.4 (32)	100 (30)	90.4 (42)	90.1 (203)

Pregnancy rates with Ranch D removed due to anaplasmosis event

Treatment	Ranch A	Ranch B	Ranch C	Ranch D	Total
Chelate % (n)	93.1 (49)	93.3[a] (15)	100 (14)	--	95.5 (78)
Complex % (n)	91.1 (50)	70.6[b] (17)	100 (16)	--	87.2 (83)
Ranch pregnancy rate (%)	92.1 (99)	82.0 (32)	100 (30)	--	91.6 (161)

[ab] Superscripts with different letters differ within column with $P < 0.05$.

Table 3. Average calving date within calving season

Treatment	Ranch A	Ranch B	Ranch C	Ranch D	Average[1]
Chelate	27.8	31.9	27.9[b]	50.4	34.5[b]
Complex	27.7	30.2	13.8[a]	41.5	28.3[a]

Average calving date with Ranch D removed due to anaplasmosis event

Treatment	Ranch A	Ranch B	Ranch C	Ranch D	Average[1]
Chelate	27.9	31.9	27.9[b]	--	29.2
Complex	27.9	30.2	13.9[a]	--	24.0

[ab] Superscripts are treatment differences within column with $P < 0.05$.

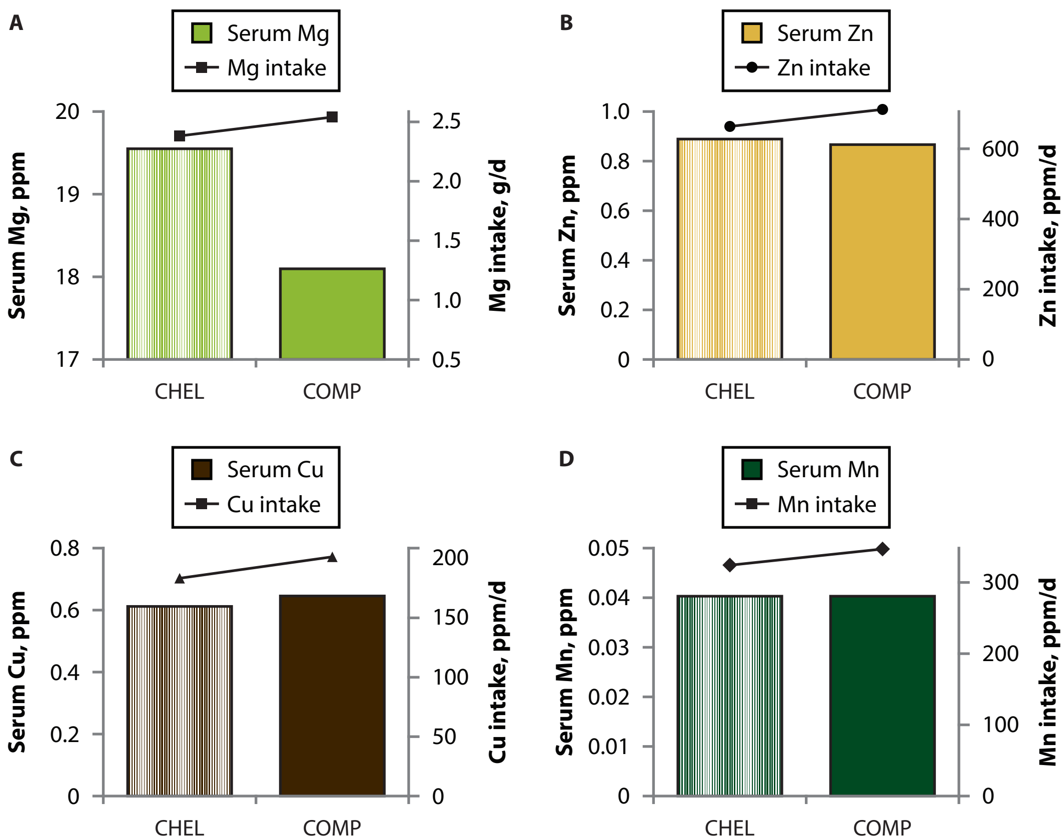

Figure 1. Final serum mineral concentration along with daily mineral intake

There is no difference ($P > 0.10$) in serum minerals by treatment. Daily mineral intakes were lower on CHEL minerals than COMP minerals. The combination of reduced intake and equal to or higher serum levels indicate that CHEL mineral is more bioavailable than COMP mineral for all four minerals measured in serum analysis (Mg, Cu, Zn, and Mn).

* CHEL minerals are recognized by vertical lines within bar and COMP in solid bars

Panel A: Serum magnesium (Mg) is represented by light green (solid) bars and daily Mg intake in g/d is illustrated by the black line with squares.

Panel B: Serum zinc (Zn) is represented by yellow bars (solid) and daily Zn intake in ppm/d is illustrated by the black line with circles.

Panel C: Serum copper (Cu) is represented by brown bars (solid) and daily Cu intake in ppm/d is illustrated by the black line with triangles.

Panel D: Serum manganese (Mn) is represented by green bars (solid) and daily Mn intake in ppm/d is illustrated by the black line with diamonds.

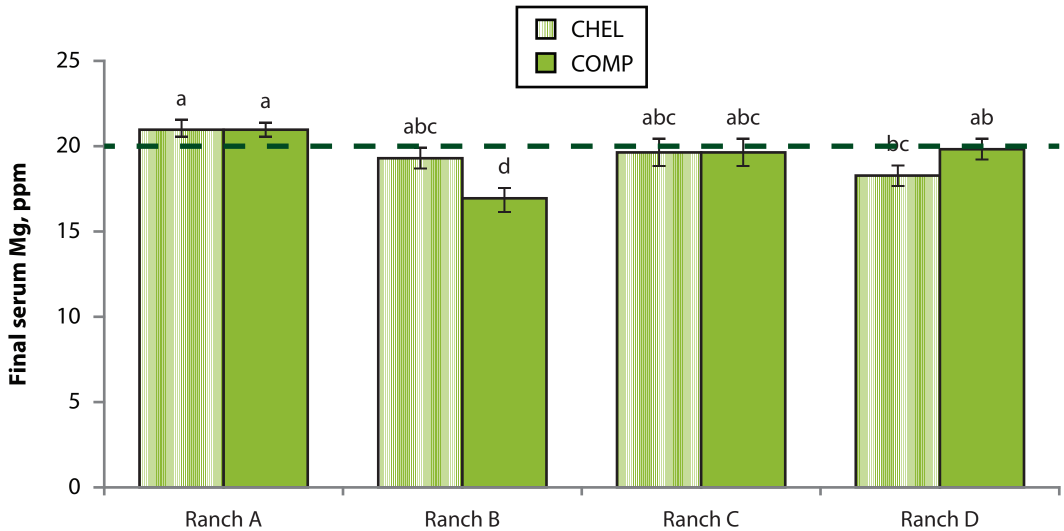

Figure 2. Final magnesium (Mg) concentration by ranch and treatment.
[abcd] Values with different letters differ with $P < 0.05$.
Vertical lines represent chelated (CHEL) mineral. Bars that are solid represent complex (COMP) mineral. The dashed line indicates blood magnesium levels that meet requirements for gestating cows.

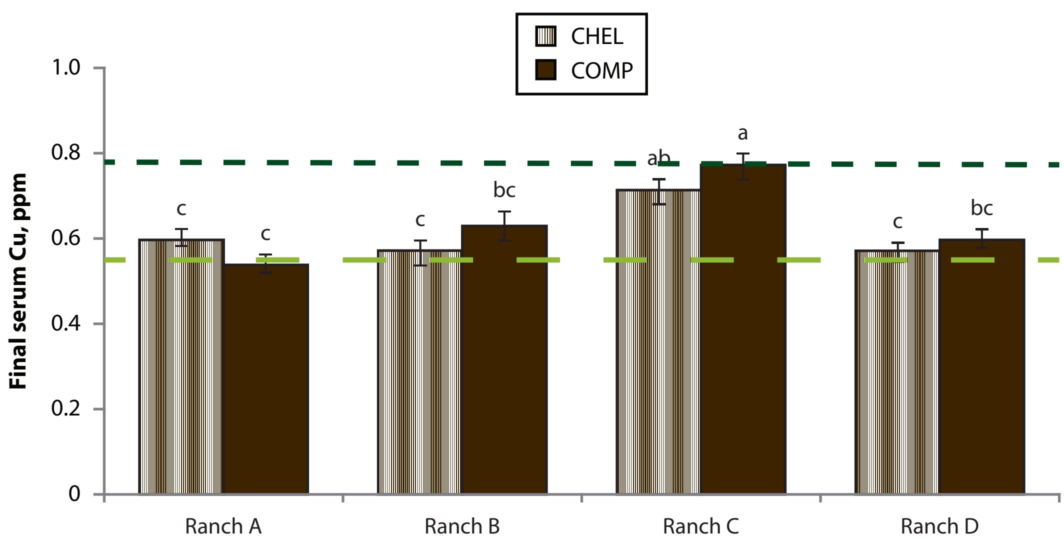

Figure 3. Final serum copper (Cu) concentration by ranch and treatment.
[abc] Values with different letters differ with $P < 0.05$.
Vertical lines represent chelated (CHEL) mineral. Bars that are solid represent complex (COMP) mineral. The short dashed line indicates blood copper levels that meet requirements for gestating cows. Long dashed lines indicate minimal serum levels for "marginal" serum copper status.

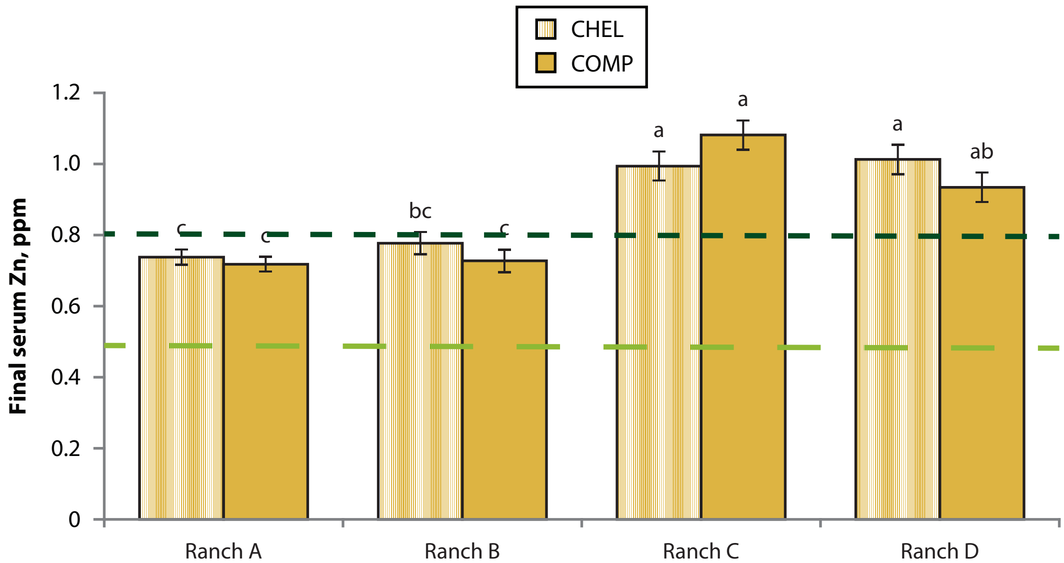

Figure 4. Final serum zinc (Zn) concentration by ranch and treatment.
[abc] Values with different letters differ with $P < 0.05$.
Vertical lines represent chelated (CHEL) mineral. Bars that are solid represent complex (COMP) mineral. The short dotted line indicates blood zinc levels that meet requirements for gestating cows. Long dashed lines indicate minimal serum levels for "marginal" serum zinc status.

Including Legumes in Bermudagrass Pastures

J.L. Moyer and L.W. Lomas

Summary
Use of legumes in bermudagrass pastures did not affect summer cow gains in 2016. Forage availability was also similar where ladino clover was used in the Legume system compared with where Nitrogen (N) alone was used. Estimated forage crude protein (CP) was greater for the Legume than the Nitrogen system in early summer, but was similar by mid-summer.

Introduction
Bermudagrass is a productive forage species when intensively managed. However, it has periods of dormancy and requires proper management to maintain forage quality. Legumes in the bermudagrass sward could improve forage quality and reduce fertilizer usage; however, legumes are difficult to establish and maintain with the competitive grass. Clovers can maintain survival once established in bermudagrass sod, and may be productive enough to substitute for some N fertilization. This study was designed to compare dry cow performance on a bermudagrass pasture system that included ladino and crimson clovers (Legume vs. bermudagrass alone (Nitrogen)).

Experimental Procedures
Eight 5-acre 'Hardie' bermudagrass pastures at the Mound Valley Unit of the Southeast Agricultural Research Center (Parsons silt loam soil) were assigned to Legume or Nitrogen treatments in a completely randomized design with four replications. Legume pastures received crimson clover by interseeding with a no-till drill at 25 lb/a on September 28, 2015, and additional ladino clover (variety 'Will', at 5 lb/a) by broadcast on February 22, 2016. Nitrogen pastures were fertilized with 50 lb/a N as urea on February 10 and May 12, 2016, and all pastures received 50-30-30 of N-P_2O_5-K_2O on July 11.

Thirty-two pregnant fall-calving cows of predominantly Angus breeding were weighed on consecutive days and assigned randomly by weight to pastures on March 22. Final cow weights were taken on consecutive days before removal from the pastures on August 10.

Forage CP, as estimated by the normalized difference vegetation index (NDVI), and available forage were monitored monthly during grazing with an automated instrument incorporating a Greenseeker (Trimble, Sunnyvale, CA), and rising plate meter.

Results and Discussion
Average available forage is plotted by date (Figure 1), since there was no difference ($P > 0.05$) between Nitrogen and Legume treatments. The estimated crude protein concentration was greater ($P < 0.05$) for the Nitrogen than the Legume system in the first sampling, but was higher for the Legume treatment in early summer (Figure 1),

likely because of the presence of legumes that contain more protein. By midsummer, estimated CP was similar for the treatments. This was partially due to effects of N fertilizer treatments, and perhaps reduced legume content later on.

Data for cow performance are in Table 1. Gains during the 2016 season were similar ($P > 0.05$) for the Legume and the Nitrogen systems (Table 1).

Table 1. Performance of cows grazing wheat-bermudagrass pastures interseeded with wheat and fertilized with nitrogen or interseeded with legumes, Mound Valley Unit, Southeast Agricultural Research Center, 2016

	Management system[1]	
Item	Nitrogen	Legumes
Number of cows	15	16
Number of days	141	141
Stocking rate, cows/a	0.8	0.8
Cow initial weight, lb	1284	1284
Cow final weight, lb	1633	1660
Cow gain, lb	349	376
Cow daily gain, lb	2.47	2.67
Cow gain, lb/a	279	301

[1]Means within a row were not significantly different at $P = 0.05$.

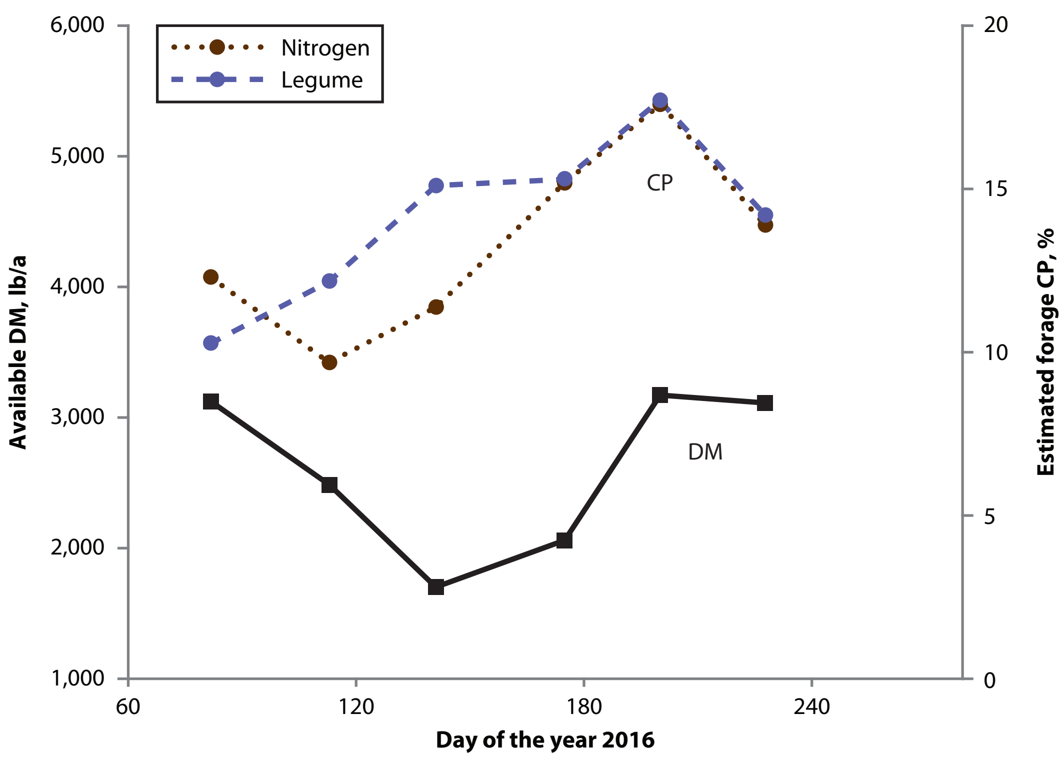

Figure 1. Available forage dry matter (DM) and estimated crude protein (CP) concentration during the grazing season in bermudagrass pastures with or without interseeded legumes, Mound Valley Unit, Southeast Agricultural Research Center, 2016.

Evaluation of Tall Fescue Cultivars

J.L. Moyer

Summary
Spring 2016 yield of tall fescue was higher for 'NFTF 1051' than for 12 of the 19 other cultivar entries. Summer production of 'PBU-B2' was greater than summer production of the three lower-yielding entries. Fall production of 'BarOptima PLUS E34' was higher than that of 12 other cultivar entries, but total 2016 production was greater for PBU-B2, 'PBU-B7', and NFTF 1051 than for eight other cultivars.

Introduction
Tall fescue (*Lolium arundinaceum Schreb*.) is the most widely grown forage grass in southeastern Kansas. Its tolerance to extremes in climate and soils of the region is partly attributable to its association with a fungal endophyte, *Neotyphodium coenophialum*; however, most ubiquitous endophytes are also responsible for production of substances toxic to some herbivores, including cattle, sheep, and horses. Endophytes that purportedly lack toxins but augment plant vigor have been identified and inserted into tall fescue cultivars adapted to the United States. These cultivars and others that are fungus-free or contain a ubiquitous endophyte (i.e. Ky 31 EF and HE, respectively) are included in this test.

Experimental Procedures
The trial was seeded at the Mound Valley Unit of the Southeast Agricultural Research Center in 10-in. rows on Parsons silt loam soil. Plots were 35 × 5 ft and were arranged in four randomized complete blocks. They were fertilized preplant with 20-50-60 lb/a of N-P_2O_5-K_2O and seeded with 20 lb/a of pure, live seed on September 30, 2014. Spring fertilizer (120-50-75 lb/a of N-P_2O_5-K_2O) was applied on February 1, and fall growth was supplemented with 60 lb/a N on August 23, 2015.

Harvest was performed on a 3-ft strip, 16 to 20 ft long from each plot. A flail-type harvester was used to cut to a 3-in. height on May 9, 2016. After harvest, forage was removed from the rest of the plot at the same height. A forage subsample was collected from each plot and dried at 140°F for moisture determination. Summer regrowth was similarly harvested on August 18, and fall growth was harvested on December 6, 2016.

Results and Discussion
Spring 2016 yields ranged from 2.82 tons/a (12% moisture basis) for BarOptima PLUS E34, to 4.77 for NFTF 1051 (Table 1). The latter yielded more ($P < 0.05$) than 12 of the 19 other entries, and six entries yielded more than the four lowest-yielding entries.

Summer forage production averaged 2.35 tons/a (Table 1). This was more than usual because precipitation at Mound Valley during July 2016 was 60% above the 30-year average. PBU-B2 yield was greater than that of 'PBU-B1,' 'Bar FAF 131,' and 'Martin 2 ProTek,' the latter yielding less than eight entries.

Fall production amounted to 1.87 tons/a, with BarOptima PLUS E34 yielding more than 12 other entries. Four entries yielded more in fall than 'AGRFA 148,' Martin 2 ProTek, and 'NFTF 1044.' Total forage production for 2016 was greater for PBU-B2, 'PBU-B7,' and NFTF 1051 than for eight other cultivars.

Spring forage dry matter content (Table 1) may be somewhat related to maturity. In that case PBU-B2, 'PBU-B5,' and PBU-B7 may have been most mature at the first cutting. Forage dry matter content on December 6 was lower in 'LE 14-84,' 'LE 14-86,' 'Tower Pro Tek,' and BarOptima PLUS E34 than in the other 16 entries. Low dry matter content in late fall may indicate frost tolerance of forage, since temperatures below freezing began to occur 23 days before harvest.

Table 1. 2016 Forage yield of three cuttings, and dry matter of first and third cuttings of tall fescue cultivars seeded in 2014, Southeast Agricultural Research Center, Mound Valley Unit.

	Forage yield				Dry matter	
Cultivar	5/9	8/18	12/06	2016 total	5/9	12/06
	------------ tons/a, 12% moisture ------------				---------- % ----------	
BarOptima PLUS E34	2.82	2.37	2.28	7.47	26	32
Bar FAF 131	3.48	2.16	1.84	7.47	25	34
Tower ProTek	3.63	2.17	2.00	7.80	23	31
Martin 2 ProTek	4.36	1.94	1.68	7.97	26	37
AGRFA 148	4.09	2.27	1.52	7.89	24	36
NFTF 1051	4.77	2.46	1.88	9.12	27	38
NFTF 1044	4.14	2.55	1.68	8.37	26	37
NFTF 1411	4.30	2.30	1.80	8.40	26	34
GT 213	3.86	2.28	1.97	8.10	22	33
LE 14-84	3.92	2.41	1.81	8.14	28	31
LE 14-86	3.95	2.44	2.03	8.41	26	32
Teton II	4.02	2.38	2.05	8.44	27	35
Estancia	3.90	2.57	1.89	8.35	25	37
PBU-B1	4.22	2.29	1.77	8.12	26	37
PBU-B2	4.41	2.62	2.08	9.11	29	36
PBU-B5	3.97	2.38	1.97	8.31	28	35
PBU-B7	4.56	2.58	1.96	9.11	29	37
MV 14	3.99	2.24	1.80	8.02	26	37
Ky 31 HE	3.37	2.50	1.77	7.63	25	36
Ky 31 LE	3.60	2.38	1.80	7.78	25	37
Average	3.98	2.35	1.87	8.21	26	35
LSD (0.05)	0.69	0.46	0.33	1.08	1.3	2

Adaptability of Miscanthus Cultivars for Biomass Production

J.L. Moyer

Summary
In 2016, miscanthus dry matter production (DM) averaged 8,890 lb DM/a and did not differ between the two cultivars in production at the Mound Valley Unit of the Southeast Agricultural Research Center. Total three-year production for the cultivars was also similar, averaging 35,050 lb/a.

Introduction
Miscanthus is a productive, efficient genus of warm-season perennial grass. Because of its growth potential and stalk properties, miscanthus has been identified by the U.S. Department of Energy as a possible dedicated energy crop. This study was established to compare cultivars for adaptation in eastern Kansas and to produce biomass to test for suitability as a bioenergy crop.

Experimental Procedures
Two cultivars were planted on 3-ft spacings on May 24, 2012 in four replications at the Mound Valley Unit of the Southeast Agricultural Research Center. The initial soil test indicated 18 and 280 lb/a of available phosphorus (P) and potassium (K), respectively, with 2.0% organic matter and pH 6.2 in a silty clay loam.

Plots were 3 rows, with seven plants per row. Plants were irrigated occasionally in the summer of 2012, but several were replanted in late May through early June 2013. Cultivation was performed for weed control in the summer of 2012 and once in 2013, but no further cultural practices have been performed. The center row of each plot was harvested at 2.5-in. height after each growing season, harvest was conducted on December 1 in 2016. At harvest, biomass was subsampled, dried at 140°F for moisture content, and saved for analysis.

Results and Discussion
Each year, dry matter (DM) production was similar for the cultivars ($P > 0.10$, Table 1). In 2013, average yield was less than 5,000 lb/a, because only 1.40 in. of rainfall was received between June 5 and July 20, and stands were not fully established. In 2014, 2015, and 2016, DM production did not differ between cultivars or years, averaging 10,970; 10,250; and 8,890 lb/a, respectively. The four-year production thus totaled 35,050 lb DM/a, for an average yield of 8,760 lb/a/yr.

Biomass had similar dry matter content for the two cultivars each year, and for the average across years ($P > 0.10$, Table 2). However, dry matter content was higher in 2014 than in the other years, and lower than the rest in 2016. The variation was probably most affected by preharvest weather conditions rather than maturity differences, since harvest dates were weeks after the first killing freeze.

Table 1. Miscanthus yields (lb dry matter/a) for 2013 through 2016, Mound Valley Unit, Southeast Agricultural Research Center

	Year				
Cultivar[1]	2013	2014	2015	2016	Average
Freedom	5,298	11,443	10,750	8,114	8,667
IL clonal	4,586	10,505	9,758	9,656	8,861
Average[2]	4,942a	10,974b	10,254b	8,885b	8,763

[1]No difference (P = 0.10) was found between cultivars within or across years.
[2]Means of a year followed by a different letter were significantly different at P = 0.05.

Table 2. Miscanthus dry matter contents (%) for 2013 through 2016, Mound Valley Unit, Southeast Agricultural Research Center

	Year				
Cultivar[1]	2013	2014	2015	2016	Average
Freedom	72	79	71	62	71
IL clonal	71	79	70	60	70
Average[2]	71b	79c	70b	61a	70

[1]No difference (P = 0.10) was found between cultivars within or across years.
[2]Means of a year followed by a different letter were significantly different at P = 0.05.

Nitrogen, Phosphorus, and Potassium Fertilization for Newly Established Tall Fescue

D.W. Sweeney, J.L. Moyer, and J.K. Farney

Summary
Tall fescue production was studied during a third year at two locations. In 2015, Site 1 was affected by an interaction between nitrogen (N) and phosphorus (P) fertilization rates; while in 2016, Site 2 mainly received production differences by N fertilization rates. Potassium (K) fertilization caused little effect at both sites.

Third-year production of tall fescue was affected by an interaction between nitrogen (N) and phosphorus (P) fertilization rates at Site 1 in 2015, but mainly by N fertilization rates at Site 2 in 2016, with little effect from potassium (K) fertilization at either site.

Introduction
Tall fescue is the major cool-season grass in southeastern Kansas. Perennial grass crops, as with annual row crops, rely on proper fertilization for optimum production; however, meadows and pastures are often under-fertilized and produce low quantities of low-quality forage. This is often true even when new stands are established. The objective of this study was to determine whether nitrogen (N), phosphorus (P), and potassium (K) fertilization improves yields during the early years of a stand.

Experimental Procedures
The experiment was established on two adjacent sites in fall 2012 (Site 1) and fall 2013 (Site 2) at the Parsons Unit of the Kansas State University Southeast Agricultural Research Center. The soil at both sites was a Parsons silt loam soil with initial soil test values of 5.9 pH, 2.8% organic matter, 4.2 ppm P, 70 ppm K, 3.9 ppm NH_4-N, and 37.9 ppm NO_3-N in the top 6 inches at Site 1; and 6.5 pH, 2.2% organic matter, 6.7 ppm P, 58 ppm K, 6.8 ppm NH_4-N, and 12.3 ppm NO_3-N in the top 6 inches at Site 2. The experimental design was a split-plot arrangement of a randomized complete block. The six whole plots were combinations of P_2O_5 and K_2O fertilizer levels allowing for two separate analyses: 1) applying four levels of P_2O_5 consisting of 0, 25, and 50 lb/a each year and a fourth treatment of 100 lb/a only applied at the beginning of the study; and 2) conducted a 2 × 2 factorial combination of two levels of P_2O_5 (0, 50 lb/a) and two levels of K_2O (0, 40 lb/a). Subplots were four levels of N fertilization consisting of 0, 50, 100, and 150 lb/a. Phosphorus and K fertilizers were broadcast applied in the fall as 0-46-0 (triple superphosphate) and 0-0-60 (potassium chloride). Nitrogen was broadcast applied in late winter as 46-0-0 (urea) solid. Second-year samplings and harvests from each site were as follows. Early growth yield as an estimate of grazing potential in early spring was taken at E2 (jointing) growth stage on April 23, 2015, at Site 1 and on April 22, 2016, at Site 2 from a subarea of each plot not used for later spring and fall harvests. Spring yield was measured at R4 (half bloom) on May 19, 2015,

at Site 1 and on May 13, 2016, at Site 2. Fall harvest was taken on September 29, 2015, at Site 1 and on September 21, 2016, at Site 2.

Results and Discussion

Third-year production of tall fescue (Site 1 in 2015 and Site 2 in 2016) was affected by an interaction between N and P fertilization at Site 1, but predominantly by N fertilization at Site 2, with little response to K at either site. At site 1 in 2015, early yield at the E2 (jointing) growth stage, to estimate forage available if grazed early, was increased with 50 lb N/acre without P fertilization, but higher N rates did not increase E2 yield (Table 1). However, with P fertilization, early yield at E2 increased with N rates up to 150 lb/a. At R4 hay harvest in 2015, yield was increased by N additions up to 100 lb/a with no P, but with 25 lb P_2O_5/acre yield was increased to more than 3 ton/acre with 150 lb N. Fall harvest yield was increased by N rates up to 150 lb/a with no P. However, fall yields that were obtained with higher N rates and P fertilization were lower than with no P and high N rates and the response to N was less. This potentially may be because of residual unused N due to lower R4 yields without P fertilization. Total yield ranged up to nearly 4 ton/a with P fertilization and higher N rates.

For the second year of production at Site 2 (2016), yield was mainly affected by N rate. Sampling at E2 and R4 and fall harvest yields were not affected by P fertilization and response to K fertilization was marginal. Increasing N rates tended to increase yield at the E2 sampling and R4 hay harvest, but response was less defined at the fall harvest (Table 2). Total yield averaged less than 3 ton/a, even at the 150 lb/a N rate.

Table 1. Third-year yield of newly established tall fescue in the spring and fall 2015 as affected by the interaction of P_2O_5 and N fertilization rates at Site 1

		Yield			
		Spring			Total
P_2O_5	N	E2 (jointing)	R4 (half-bloom)	Fall harvest	(R4 + Fall)
------------ lb/a ------------		-------------------- ton/a, 12% moisture -----------------			
0	0	0.08	0.50	0.26	0.76
	50	0.49	1.49	0.38	1.87
	100	0.48	1.98	0.70	2.68
	150	0.50	1.76	1.12	2.88
25	0	0.09	0.59	0.36	0.96
	50	0.52	1.83	0.44	2.27
	100	0.81	2.80	0.55	3.35
	150	0.96	3.12	0.69	3.82
50	0	0.12	0.67	0.39	1.06
	50	0.42	1.75	0.39	2.14
	100	0.92	3.02	0.56	3.58
	150	1.25	3.13	0.68	3.81
100†	0	0.13	0.65	0.38	1.03
	50	0.55	2.17	0.55	2.71
	100	0.84	3.03	0.58	3.61
	150	1.11	3.24	0.68	3.92
$LSD_{(0.05)}$		0.04	0.31	0.17	0.35

†The 100 lb P_2O_5/a rate was only applied at the beginning of the study (Fall 2012).

Table 2. Third-year yield of newly established tall fescue in the spring and fall 2016 as affected by P_2O_5 and N fertilization rates at Site 2

	Yield			
	Spring			Total
P_2O_5	E2 (jointing)	R4 (half-bloom)	Fall harvest	(R4 + Fall)
lb/a	---------------------------- ton/a, 12% moisture -------------------------			
0	0.26	1.09	0.84	1.94
25	0.23	1.02	0.79	1.81
50	0.23	1.08	0.82	1.89
100†	0.27	0.99	0.89	1.88
LSD $_{(0.05)}$	NS	NS	NS	NS
N				
0	0.06	0.16	0.84	1.00
50	0.13	0.74	0.63	1.37
100	0.34	1.41	0.81	2.22
150	0.46	1.87	1.06	2.93
LSD $_{(0.05)}$	0.20	0.09	0.13	0.15

†The 100 lb P_2O_5/a rate was only applied at the beginning of the study (Fall 2013).

Tillage and Nitrogen Placement Effects on Yields in a Short-Season Corn/Wheat/ Double-Crop Soybean Rotation

D.W. Sweeney

Summary
In 2016, adding nitrogen (N) greatly improved average wheat yields, but the response to tillage and different N placement methods was minimal. Double-crop soybean yields were unaffected by tillage or the residual from N treatments that were applied to the previous wheat crop.

Introduction
Many crop rotation systems are used in southeastern Kansas. This experiment is designed to determine the long-term effect of selected tillage and N fertilizer placement options on yields of short-season corn, wheat, and double-crop soybean in rotation.

Experimental Procedures
A split-plot design with four replications was initiated in 1983 with tillage system as the whole plot and N treatment as the subplot. In 2005, the rotation was changed to begin a short-season corn/wheat/double-crop soybean sequence. Use of three tillage systems (conventional, reduced, and no-till) continues in the same areas as the previous 22 years. The conventional system consists of chiseling, disking, and field cultivation. Chiseling occurs in the fall preceding corn or wheat crops. The reduced-tillage system consists of disking and field cultivation prior to planting. Glyphosate is applied to the no-till areas prior to planting. The four N treatments for the crop are: no-N (control), broadcast urea-ammonium nitrate (UAN; 28% N) solution, dribble UAN solution, and knife UAN solution at 4 inches deep. The N rate for the corn crop grown in odd-numbered years is 125 lb/a. The N rate of 120 lb/a for wheat is split as 60 lb/a applied preplant as broadcast, dribble, or knifed UAN. All plots except for the no-N controls are top-dressed in the spring with broadcast UAN at 60 lb/a N.

Results and Discussion
In 2016, conventional tillage resulted in 2 bu/a greater yield than with no-till (Table 1). Overall, fertilizing with N quadrupled wheat yield, but preplant application method (broadcast, dribble, or knife) did not affect yields. Average yield of soybean planted doublecrop after wheat harvest was nearly 40 bu/a in 2016, but was not affected by tillage systems or the residual from N fertilizer treatments that were applied to the wheat.

Table 1. Effect of tillage and fall N fertilization on yield of wheat and following double-crop soybean in 2016

Treatment	Wheat yield	Double-crop soybean yield
	---------- bu/a ----------	
Tillage		
Conventional	37.8	39.0
Reduced	36.8	39.9
No-till	35.8	39.7
LSD (0.05)	1.1	NS
N Fertilization		
No-N control	9.8	40.0
Broadcast UAN†	45.5	39.4
Dribble UAN	45.1	39.7
Knife UAN	46.4	39.0
LSD (0.05)	1.4	NS

†UAN: urea-ammonium nitration solution, 28% N.

Timing of Side-Dress Applications of Nitrogen for Corn in Conventional and No-Till Systems

D.W. Sweeney and D. Shoup

Summary
Corn yields were affected by tillage and nitrogen (N) side-dress options in 2016. Corn yields were 12% greater with conventional tillage than with no-till. Side-dress applications of N at V10 resulted in greater corn yield than side-dress N applications at V6.

Introduction
Environmental conditions vary widely in the spring in southeastern Kansas. As a result, much of the N applied prior to corn planting may be lost before the time of maximum plant N uptake. Side-dress or split applications to provide N during rapid growth periods may improve N use efficiency while reducing potential losses to the environment. The objective of this study was to determine the effect of timing of side-dress N fertilization compared with preplant N applications for corn grown on a claypan soil.

Experimental Procedures
The experiment was established in spring 2015 on a Parsons silt loam soil at the Parsons unit of the Kansas State University Southeast Agricultural Research Center. The experiment was a split-plot arrangement of a randomized complete block design with four blocks (replications). Whole plot tillage treatments were conventional tillage (chisel, disk, and field cultivate) and no-till. Sub-plot nitrogen treatments were six preplant/side-dress N application combinations that include 1) a no-N control, 2) 150 lb N/a applied preplant, 3) 100 lb N/a applied preplant with 50 lb N/a applied at the V6 (six-leaf) growth stage, 4) 100 lb N/a applied preplant with 50 lb N/a applied at the V10 (ten-leaf) growth stage, 5) 150 lb N/a applied preplant with 50 lb N/a applied at the V6 growth stage, and 6) 150 lb N/a applied preplant with 50 lb N/a applied at the V10 growth stage. The N source for all treatments was liquid urea-ammonium nitrate (28% N) fertilizer. Preplant N fertilizer was applied on April 4, 2016, side-dress N at V6 on May 22, 2016, and side-dress N at V10 on June 6, 2016 to appropriate plots. Corn was planted on April 5 and harvested on August 29, 2016.

Results and Discussion
In 2016, corn yielded 12 bu/a more with conventional tillage than with no-till (Table 1). Even though yield components were not significantly affected by tillage, the combined trend for greater stand, kernel weight, and kernels/ear likely accounted for the yield response to tillage. Adding N fertilizer more than tripled yields obtained in the no-N control. Applying 100 lb N/a preplant followed by 50 lb N/a at the V6 growth state did not improve yields above that obtained with all 150 lb N/a applied preplant. However, delaying the 50 lb N/a side-dress application to the V10 stage improved yield by 8.4 bu/a compared to all N preplant. A similar increase in yield was found by delaying N side-dress to the V10 stage instead of the V6 stage when adding 50 lb N/a extra

to a 150 lb N/a preplant application. These effects of N timing on corn yield in 2016 appeared to be related to responses in kernel weight and kernels/ear.

Table 1. Tillage and N side-dress application effects on yield and yield components of corn in 2016

Treatment	Yield	Stand	Kernel weight	Ears/plant	Kernels/ear
	bu/a	#/a	mg		
Tillage (T)[1]					
Conventional	110.5	22600	231	0.99	529
No-till	98.3	21700	222	0.99	508
LSD (0.05)	6.3	NS	NS	NS	NS
Nitrogen Timing (N)[2]					
No-N control	34.4	22000	172	0.99	235
150 PP	111.2	22000	219	0.99	592
100 PP/50 V6	112.0	22200	234	0.99	553
100 PP/50 V10	119.6	22400	240	0.99	570
150 PP/50 V6	118.9	22200	240	1.00	569
150 PP/50 V10	130.3	22100	255	0.99	594
LSD (0.05)	7.0	NS	15	NS	34

[1]Conventional tillage: chisel, disk, and field cultivate.

[2] Nitrogen treatments: Control, no N fertilizer; 150 PP, 150 lb N/a applied preplant with no side-dress N; 100 PP/50 V6, 100 lb N/a applied preplant with 50 lb N/a side-dress applied at V6 (six-leaf) growth stage; 100 PP/50 V10, 100 lb N/a applied preplant with 50 lb N/a side-dress applied at V10 (ten-leaf) growth stage; 150 PP/50 V6, 150 lb N/a applied preplant with 50 lb N/a side-dress applied at V6 growth stage; and 150 PP/50 V10, 150 lb N/a applied preplant with 50 lb N/a side-dress applied at V10 growth stage.

Response of Soybean Grown on a Claypan Soil in Southeastern Kansas to the Residual of Different Plant Nutrient Sources and Tillage[1]

D.W. Sweeney, P. Barnes[2], and G. Pierzynski[3]

Summary
Soybean yields measured from 2014 through 2016 were more than 50% greater from the residual from N-based turkey litter applications during 2011 through 2013 than in the control where no nitrogen (N) or phosphorus (P) was applied. However, residual from P-based turkey litter applications or fertilizer-only did not result in soybean yield different from the no N-P control. This residual effect on yield was largely due to increased pods per plant.

Introduction
Increased fertilizer prices in recent years, especially noticeable when the cost of phosphorus spiked in 2008, have led U.S. producers to consider other alternatives, including manure sources. The use of poultry litter as an alternative to fertilizer is of particular interest in southeastern Kansas because large amounts of poultry litter are imported from nearby confined animal feeding operations in Arkansas, Oklahoma, and Missouri. Annual application of turkey litter can affect the current crop, but information is lacking concerning any residual effects from several continuous years of poultry litter applications on a following crop. This is especially true for tilled soil compared with no-till, because production of most annual cereal crops on the claypan soils of the region is often negatively affected by no-till planting. The objective of this study was to determine if the residual from fertilizer and poultry litter applications under tilled or no-till systems affects soybean yield and growth.

Experimental Procedures
A water quality experiment was conducted near Girard, KS, on the Greenbush Educational facility's grounds from spring 2011 through spring 2014. Fertilizer and turkey litter were applied prior to planting grain sorghum each spring. Individual plot size was 1 acre. The five treatments, replicated twice, were:

Control – no N or P fertilizer or turkey litter – no-till;
Fertilizer only – commercial N and P fertilizer – chisel-disk tillage;
Turkey litter, N-based – no extra N or P fertilizer – no-till;
Turkey litter, N-based – no extra N or P fertilizer – chisel-disk tillage; and
Turkey litter, P-based – supplemented with fertilizer N – chisel-disk tillage.

[1] Partially funded by U.S. Department of Agriculture Natural Resource Conservation Service Conservation Innovation Grant.

[2] Kansas State University Department of Biological and Agricultural Engineering.
[3] Kansas State University Department of Agronomy.

Starting in 2014 after the previously-mentioned study, soybean was planted in the plots with no further application of turkey litter or fertilizer. Prior to planting soybean, tillage operations were done in appropriate plots as in previous years. A subarea of 20 × 20 ft near the center of each 1-acre plot was designated for crop yield and growth measurements. Samples were taken for dry matter production at V3-V4 (approximately 3 weeks after planting), R2, R4, and R6 growth stages. Yield was determined from the center 4 rows (10 × 20 ft) of the subarea designated for plant measurements in each plot.

Results and Discussion

During 2014-2016, the residual effects of turkey litter and fertilizer amendments affected soybean yield and pods/plant (Table 1). The two treatments which had previously received a high application rate of turkey litter based on N requirements, regardless of tillage system, resulted in greater yields than from plots that had received low rates of turkey litter (P-based), commercial fertilizer, or no fertilizer N or P. Even though the average number of pods/plant was greatest where N-based turkey litter had been applied with no-till, the stand tended to be lower than where the N-based turkey litter was incorporated with tillage, but was only significant in 2015 (year interaction data not shown). Dry matter production was greatest early (V3) and late (R6) in the season where N-based turkey litter had been applied and incorporated with tillage than in the other residual treatments (Table 1).

Table 1. Residual effect of turkey litter and fertilizer amendments on following soybean yield, yield components, and dry matter production averaged across years (2014-2016)

Residual amendment†	Yield	Stand (× 1000)	Seed weight	Pods/ plant	Seeds/ pod	Dry matter V4	Dry matter R2	Dry matter R4	Dry matter R6
	bu/a	plants/a	mg			lb/a	lb/a	lb/a	lb/a
Control	32.3	112	125	28	2.3	340	1070	2700	3540
Fert-C	37.3	112	135	34	2.1	440	1720	3580	5250
TL-N	49.4	107	126	50	2.3	400	1820	4200	5980
TL-N-C	52.7	112	127	43	2.3	610	2210	4650	7310
TL-P-C	34.3	106	133	33	2.3	360	1600	3280	4710
LSD (0.05)	7.9	NS	NS	5	NS	90	480	560	1360

† Control, no turkey litter or nitrogen (N) or phosphorus (P) fertilizer with no-till; Fert-C, commercial fertilizer incorporated with conventional tillage; TL-N, N-based turkey litter application with no-till; TL-N-C, N-based turkey litter application incorporated with conventional tillage; and TL-P-C, P-based turkey litter application and supplemental N application incorporated with conventional tillage.

Crop Production Summary, Southeast Kansas – 2016

G.F. Sassenrath, L. Mengarelli, J. Lingenfelser, X. Lin, and D. Shoup

Summary
Crop production in southeast Kansas is summarized from variety trials and research plot experiments conducted at the Southeast Research and Extension Center fields in 2016.

Introduction
Crop production is dependent on many factors, most notably, environmental conditions during the growing season. Here, we present a summary of environmental conditions experienced during the 2016 growing season in comparison to previous years and the historical averages. Information on crop yields is taken from reported yields from variety trials and research plots in southeast Kansas.

Experimental Procedures
The Kansas State University Crop Performance Tests were conducted in replicated research field plots throughout the state. This report summarizes crop production for southeast Kansas. Wheat, sorghum and sunflowers were grown at the Parsons facility. Soybean varieties were grown at Columbus (upland) and Erie (river bottom). Corn was grown at Erie (full season) and Parsons (short season). Both corn variety tests were abandoned due to crop loss. Please see individual variety results at the K-State Crop Performance Test web page (http://www.agronomy.k-state.edu/services/crop-performance-tests/).

Weather information was collected from the Kansas State Mesonet site (http://mesonet.k-state.edu/weather/historical/). Historical data from the Parsons and Columbus stations were used in preparing these reports.

Results and Discussion
Weather
Rainfall
Rainfall is highly variable, both spatially and temporally. Total rainfall for 2016 was slightly above the six-year average of 39.21 inches at Columbus with 39.73 inches of rain received during the calendar year. The early spring season was dry at Columbus, but nearly average at Parsons. Columbus had a lengthy dry period (0.65 inches total rain) in June that was broken by 5 inches of rain over a two week period beginning June 30. Two additional periods of heavy rain (6.3 inches from September 8 – 16; 6.35 inches from October 4 – 12) brought the yearly total to average at Columbus. The largest single-day rain event of 2016 in Columbus was recorded on October 6 at 4.43 inches. This storm system brought 6.35 inches of rain to Parsons as well, with the single largest rain event in 2016 of 5.62 inches recorded at Parsons on October 6. Rainfall at Parsons

was very close to average throughout the winter and spring. The two-week period from June 23 until July 7 had 9.33 inches of rain. This storm increased total rainfall in Parsons to above average, where it remained for the rest of the calendar year. Rainfall at Parsons was well above the 31.15 inch average, with 44.64 inches of rain during the calendar year.

Temperature

Temperature is a critical determinant of crop growth and performance. Many studies rely on growing degree days or growing degree units to estimate crop growth and development. We have shown that crop growth is also sensitive to the number of days above 90 (corn) and 95 (soybeans). We started the year with an early warm period from mid-June to mid-July, with an above-average number of days exceeding 90°F and 95°F at both Parsons and Columbus (Figure 2). The number of days exceeding 90°F was nearly normal (57 days) at Columbus and slightly below normal (47 days) at Parsons for the remainder of the growing season. The number of days that temperatures exceeded 95°F (12 days, Columbus; 14 days, Parsons) was below normal and similar to temperatures in 2014.

Crop Production

Winter wheat yielded well in 2016 (Figure 3). Yields for the 22 hard red varieties tested ranged from 57 to 77 bu/a, with an average yield for all hard red wheat of 66 bu/a. Nineteen varieties of soft red wheat were tested, with yields ranging from 53 to 96 bu/a, and an overall average of 72 bu/a (Figure 3). These were above the 6-year averages of 52 bu/a for hard red and 62 bu/a for soft red varieties. Wheat yield and quality are particularly sensitive to high rainfall during maturation (approximately April 24 – May 14). During this period, Columbus received 3.82 inches of rain, less than the 6-year average of 4.04 inches for this time period. Parsons also received less rain (2.14 inches) than the six-year average (2.83 inches). This is significantly below the high rainfall (3.87 inches) received at Parsons during this same period in 2015, which was marked by high rates of Fusarium head blight (FHB) infection. We did have some problems with strip rust this year, which resulted in improved wheat yield with fungicide application.

Corn yields were good in 2016, though not as good as in 2014 (Figure 4). The short season corn variety test at Parsons was abandoned due to wind damage, and the full season test was abandoned due to animal damage. Corn yield results from full season corn from other studies at the research station are presented. Over the past six years, full season hybrids have averaged 183 bu/a, while short season hybrids averaged 118 bu/a for southeast Kansas. No-till corn studies showed slightly higher yields in 2016, averaging 140 bu/a, while conventional tilled corn yielded 117 bu/a at Columbus (Figure 5).

Soybean yields were also above the 6-year average, with maturity group (MG) 3-4 having an average yield of 53 bu/a, and MG 4-5 yielding 52 bu/a across all varieties and locations (Figure 5). Conventional soybeans also yielded above the 6-year average, with 35 bu/a for MG 3-4 and 44 bu/a for MG 4-5 (Figure 6).

In contrast to other crops in 2016, sorghum production (57 bu/a) was much less than average (97 bu/a) (Figure 6). Sunflowers yielded about average (Figure 7).

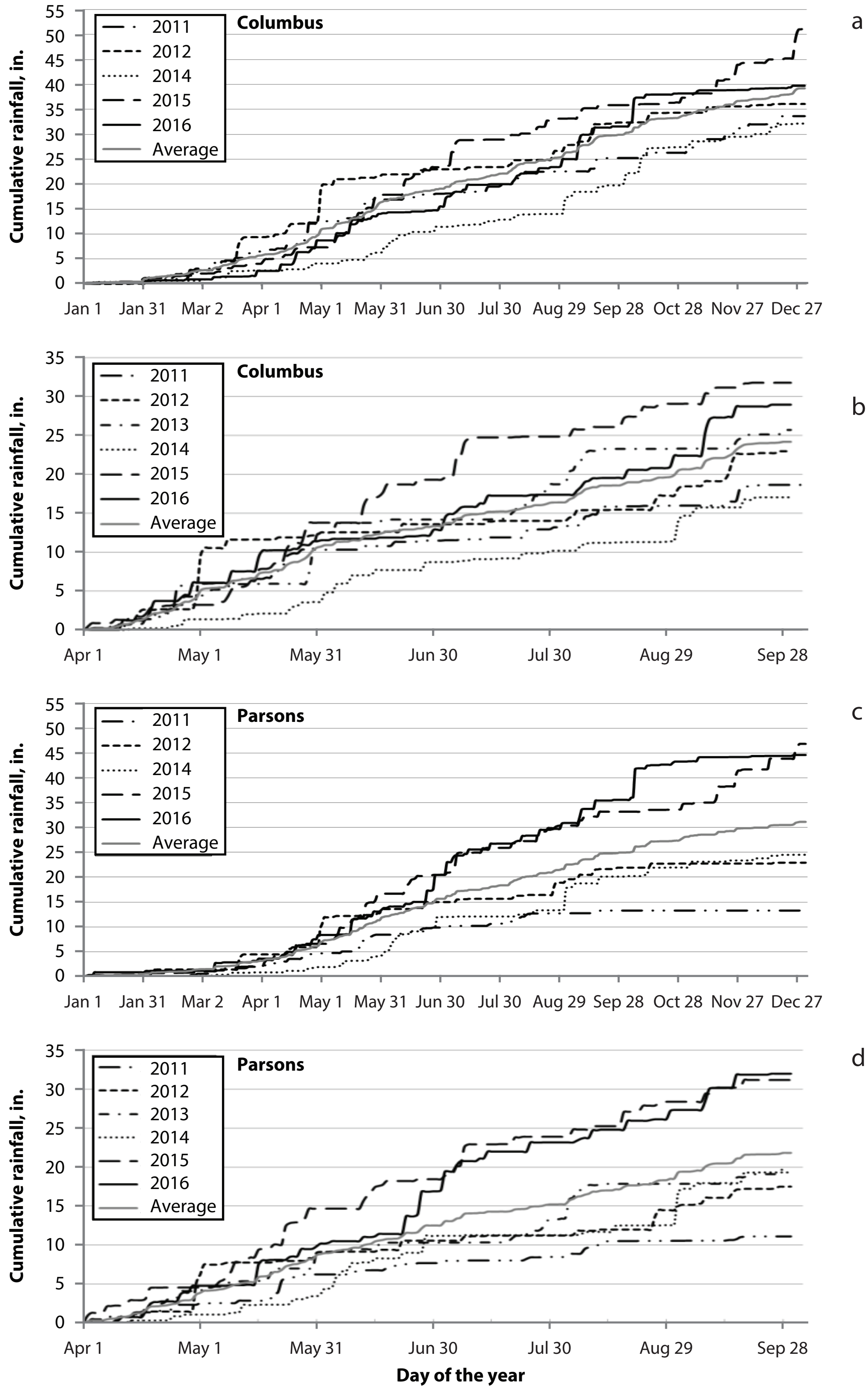

Figure 1. Cumulative rainfall during the calendar year (a and c) and the summer crop production season (b and d) at Columbus (a and b) and Parsons (c and d). Results from 2013 were omitted for clarity. Six-year average rainfall totals are included for comparison.

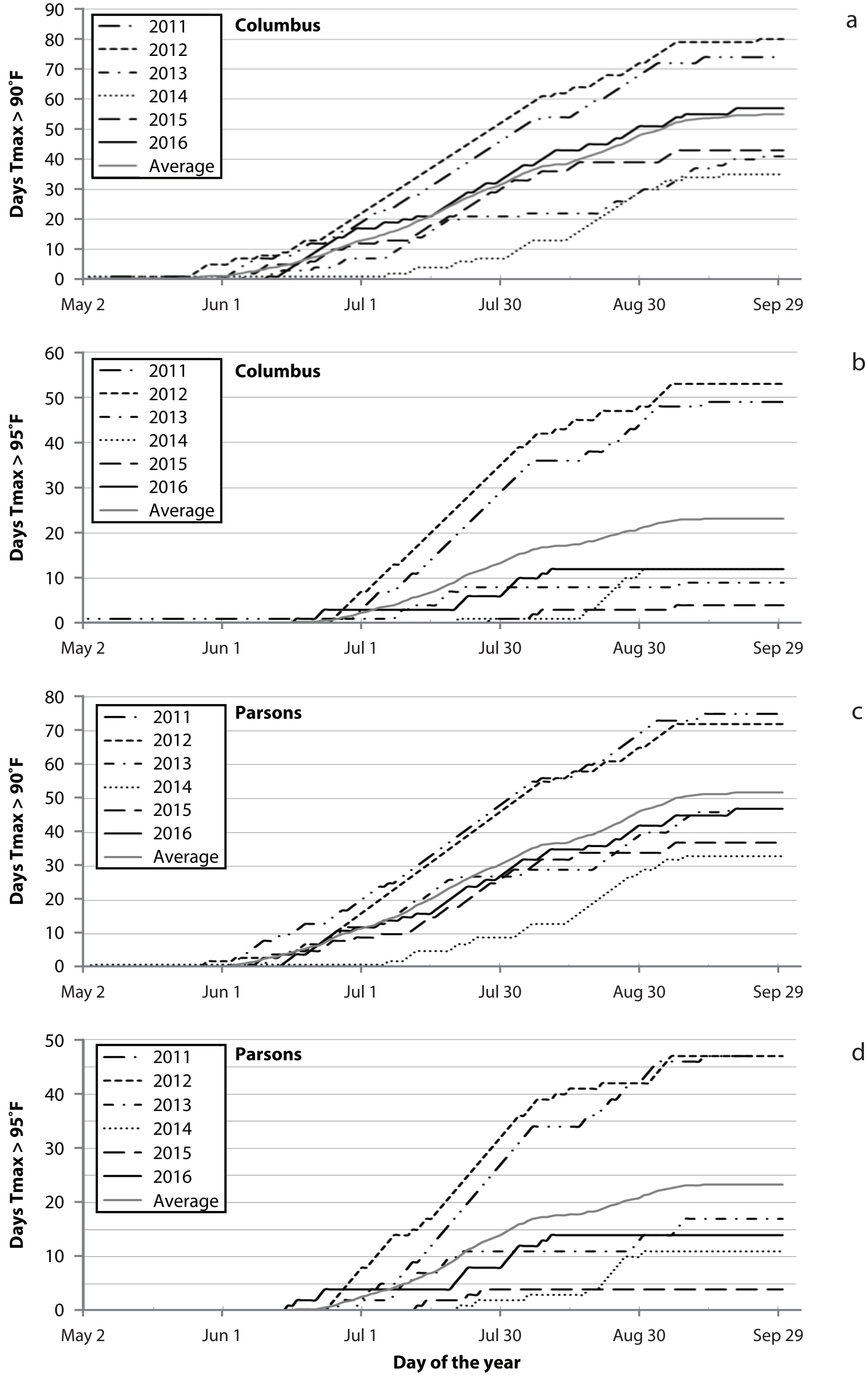

Figure 2. Temperature patterns during 2016 and preceding years for Columbus (a and b) and Parsons (c and d).

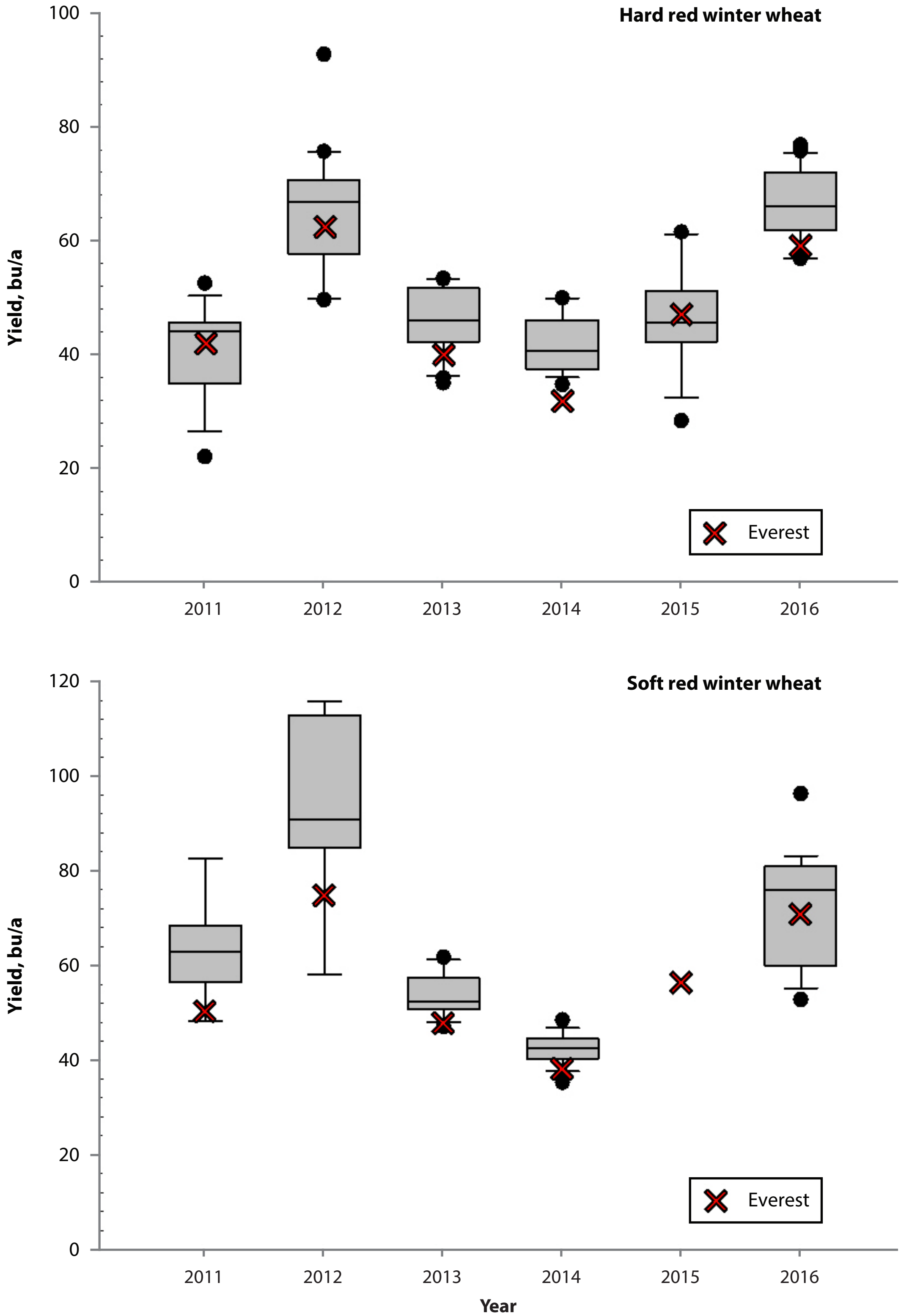

Figure 3. Winter wheat yield for hard red wheat (top) and soft wheat (bottom) from variety trials in southeast Kansas from 2011 through 2016. The line in the middle of the box plots is the median yield of all varieties. The upper and lower quartiles are given by the upper and lower edges of the boxes. The maximum and minimum values are given by the upper and lower "whiskers" extending from the box. Outliers are presented as solid circles. For comparison, average yield for Everest from the variety trial results is highlighted as an X.

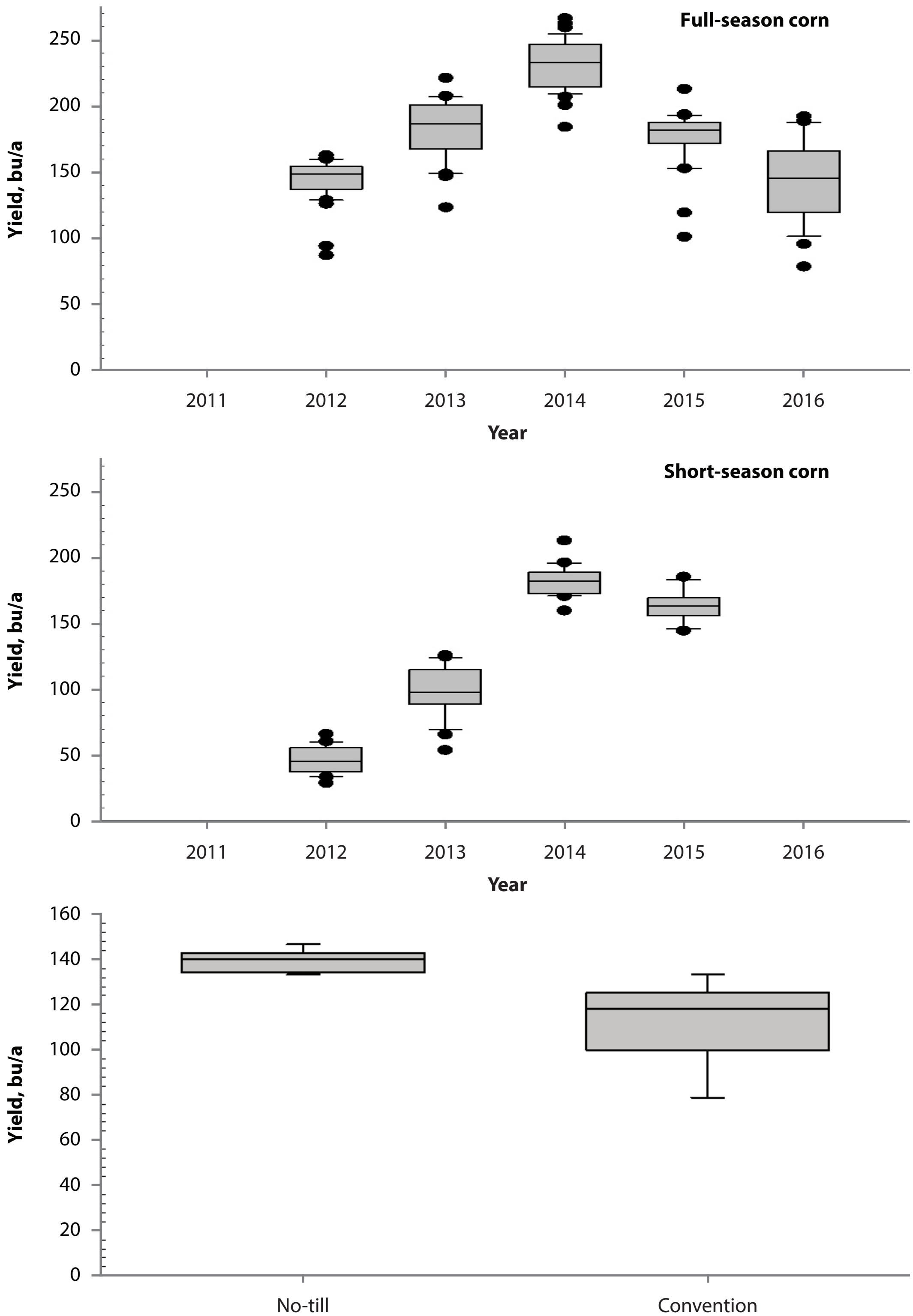

Figure 4. Full-season (top) and short-season (middle) corn yields for two environments in southeast Kansas – upland (Parsons) and river bottom (Erie). 2016 Variety trials were abandoned due to weather. Data from other research plots with full-season corn at Parsons were used for comparison. Comparison of corn yield for conventional tillage and no-till production at Columbus (bottom).

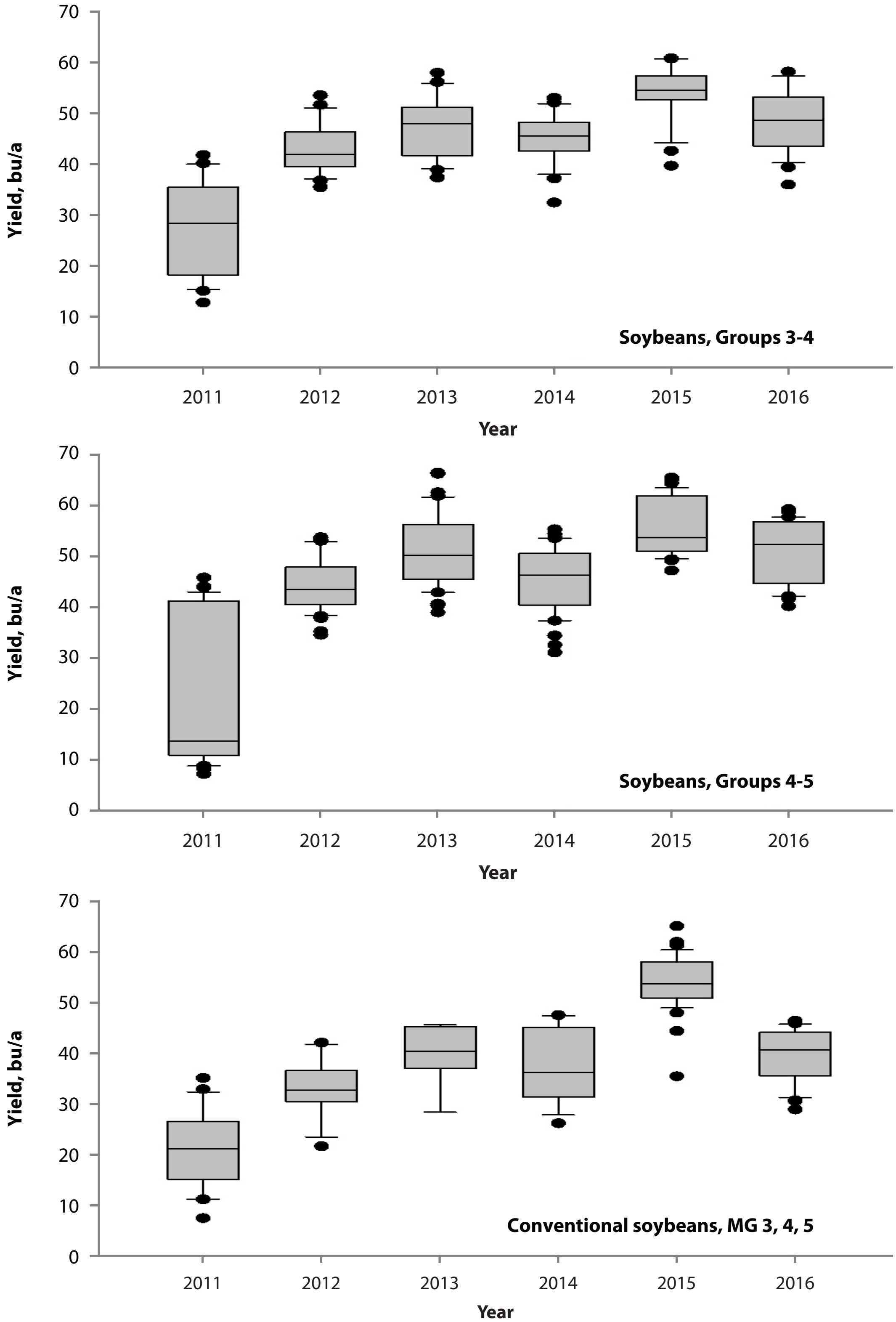

Figure 5. Soybean yields for maturity group (MG) 3-4 (top) and MG 4-5 (middle) in two growing environments: upland (Columbus) and river bottom (Erie). Yield summary for conventional varieties are summarized for MG 3, 4, and 5, for all locations (bottom).

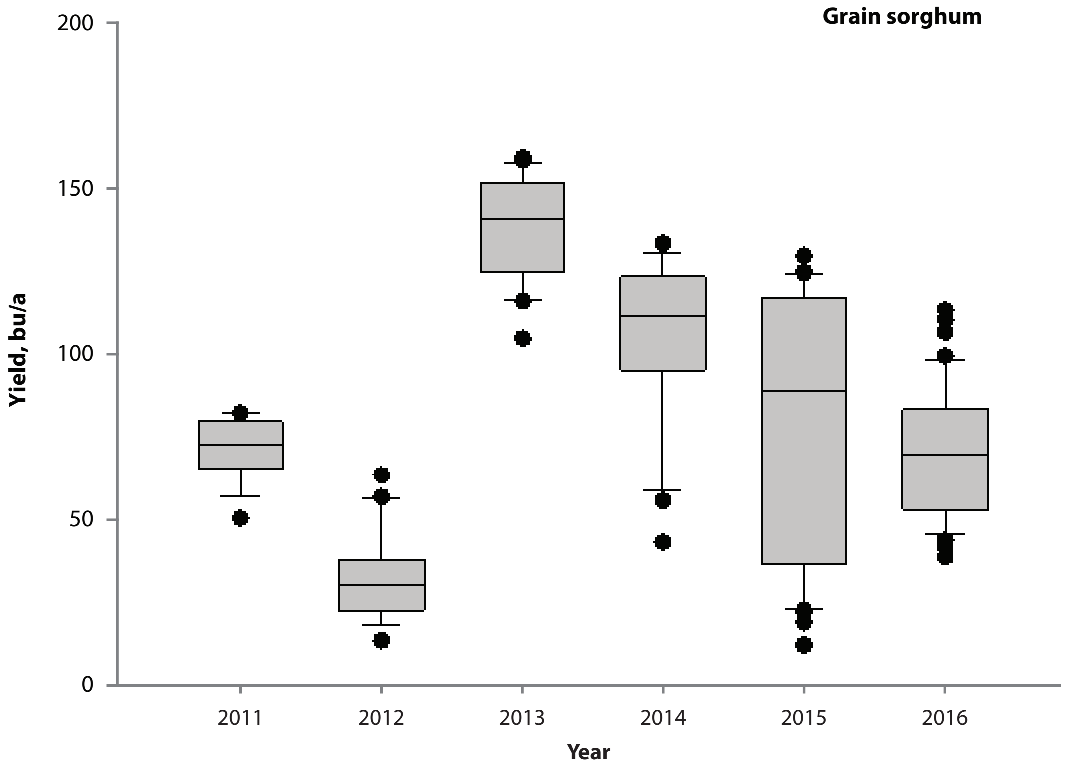

Figure 6. Grain sorghum.

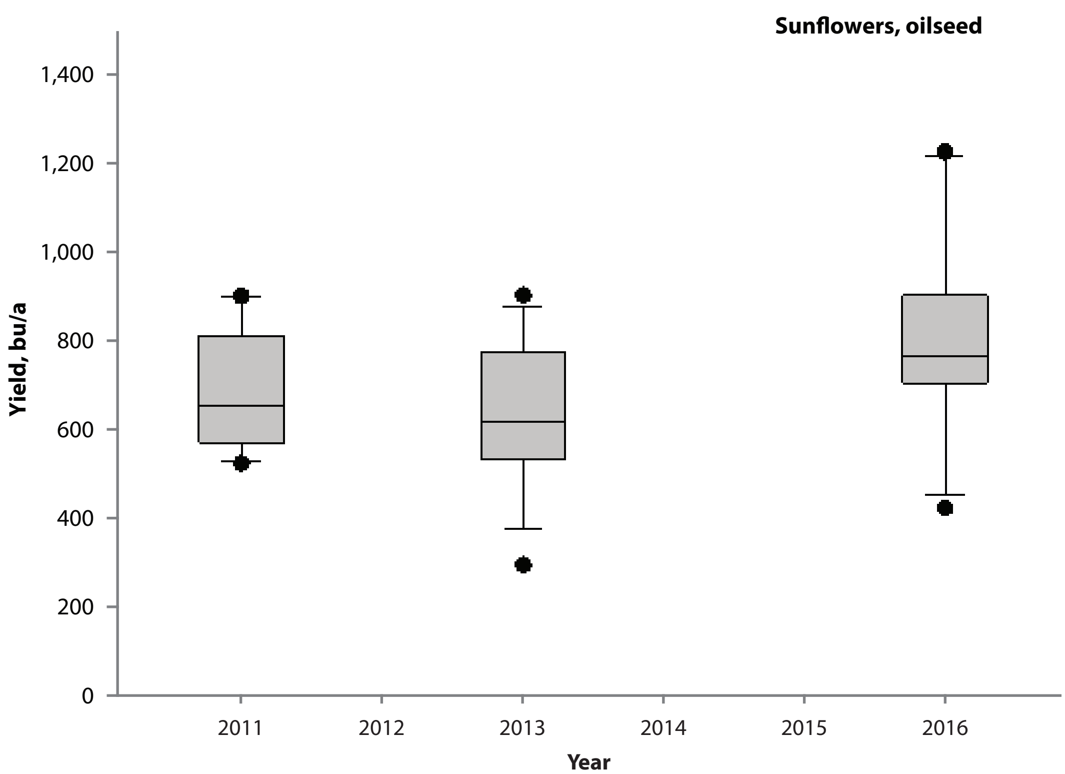

Figure 7. Oilseed sunflowers.

Cover Crop System to Control Charcoal Rot in Soybeans

G.F. Sassenrath, C. Little, C.J. Hsiao, D. Shoup, and X. Lin

Summary
This research compares methods of controlling charcoal rot in soybean cultivars from three maturity groups commonly grown in southeast Kansas. The results indicate that a mustard plant that produces high levels of glucosinolates can be used as a cover crop to reduce the charcoal rot disease in soybeans.

Introduction
Charcoal rot is a plant disease caused by the fungus *Macrophomina phaseolina* (Tassi) Goid. It limits yield and performance of soybean. The fungus is highly prevalent in crop fields in southeast Kansas. Certain plants have been shown to produce chemicals that act as biofumigants, controlling or reducing harmful soil fungi, similar to those that may cause charcoal rot. Bacterial control of diseases has been used successfully in potato (Larkin et al., 2011) and cacao production (Melnick et al., 2008). Mengistu et al. (2009) showed some suppression of charcoal rot infestation with altered tillage and use of rye as a cover crop. The research outlined here tested the ability of mustard species used as cover crops to control charcoal rot in soybean production. Incorporating a cover crop into the crop rotation may be a simple method of controlling soil-borne diseases.

Experimental Procedures
Soybean plants were grown in replicated field plots using two methods of charcoal rot control: chemical (fungal seed treatment) and biological (mustard cover crop). The control had no biological or chemical treatment. The biological treatment was a mustard plant, Mighty Mustard Pacific Gold (Johnny's Select Seed, Winslow, ME). This mustard variety produces high glucosinolate concentrations that are suggested to control soil-borne diseases. Chemical control included seed treatment with fungicide prior to planting (Acceleron, 4 oz/100 lb). The fourth treatment included both biological and chemical treatments.

The mustard seed was planted in late March, when soil temperatures were consistently above 50°F. Prior to maturity, the mustard was terminated with herbicide and disked in after the plants had died. The ground was tilled in all plots in preparation for planting. The soybean cultivars selected include two early maturity group 4s, two late group 4s, and a mid- to early-group 5.

To test the charcoal rot infestation in the soil, soil samples were collected after the mustard was terminated and disked in and prior to planting the soybeans. Additional soil samples were taken in the fall coincident with plant sampling at the R7-8 stage. The numbers of colony forming units (CFU's) of the fungi in the plant and soil samples were measured at the Department of Plant Pathology at Kansas State University. Additional samples were used to determine soil microbial activity with the phospholipid fatty acid (PLFA) assay. Final yield was measured at harvest.

Results and Discussion

Mustard plants reduced the number of colony forming units of the fungus in the soil and in the plant roots (Figure 1). Therefore, the mustard reduced the disease pressure from the charcoal rot fungus. The interaction between the mustard and the fungicide control was confounded by environmental factors, as each year showed a different response of number of CFUs in the soil to the combined control. A modest, but significant, improvement in yield was observed in 2016 for the combined chemical and biological control (Figure 2). No difference in yield was observed in 2015. Both years of the study had relatively mild summers, with little incidence of charcoal rot damage reported.

The early maturing soybean varieties showed greater infection rates, with higher number of CFUs in the plant stem and roots (Table 1). This was observed in both years. While this may indicate a greater susceptibility of the early-maturing cultivars to charcoal rot, it is more likely a function of the weather patterns in southeast Kansas. Charcoal rot is most prevalent under hot, dry conditions, usually experienced in July and August in southeast Kansas. This is also the time period during which the early maturing varieties would be flowering. The increased sensitivity to charcoal rot may thus be more dependent on the weather than on the genetics of these varieties.

Acknowledgment

This research is supported by funding from the Kansas Soybean Commission.

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Table 1. Charcoal rot infection rate as a function of soybean maturity group

Variety	Colony forming units
4.1	2.7
4.2	2.2
4.9	2.0
4.9	1.8
5.3	1.6
5.3	2.0

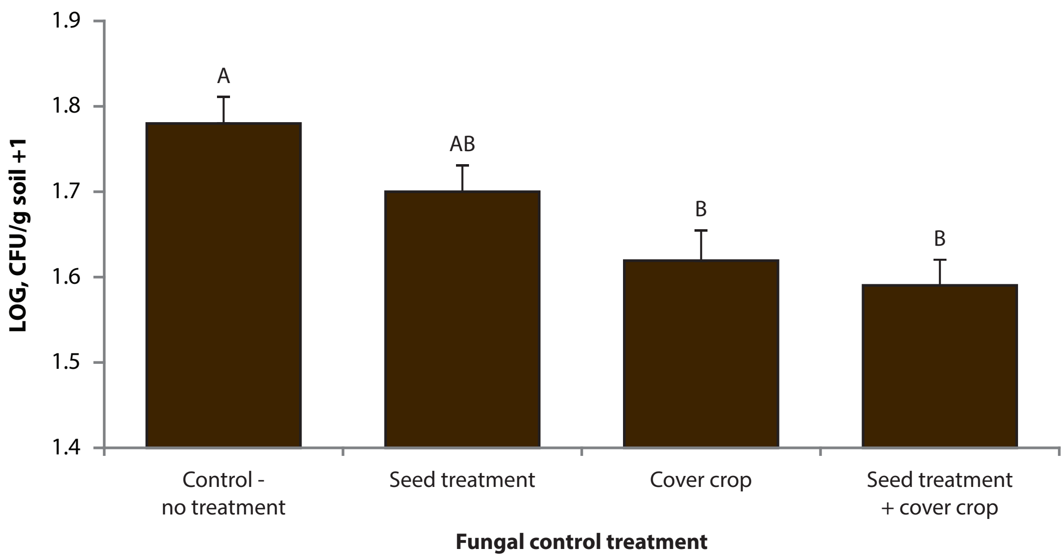

Figure 1. Number of colony forming units (CFUs) in the soil as a function of treatment. Different letters indicate statistically significant differences.

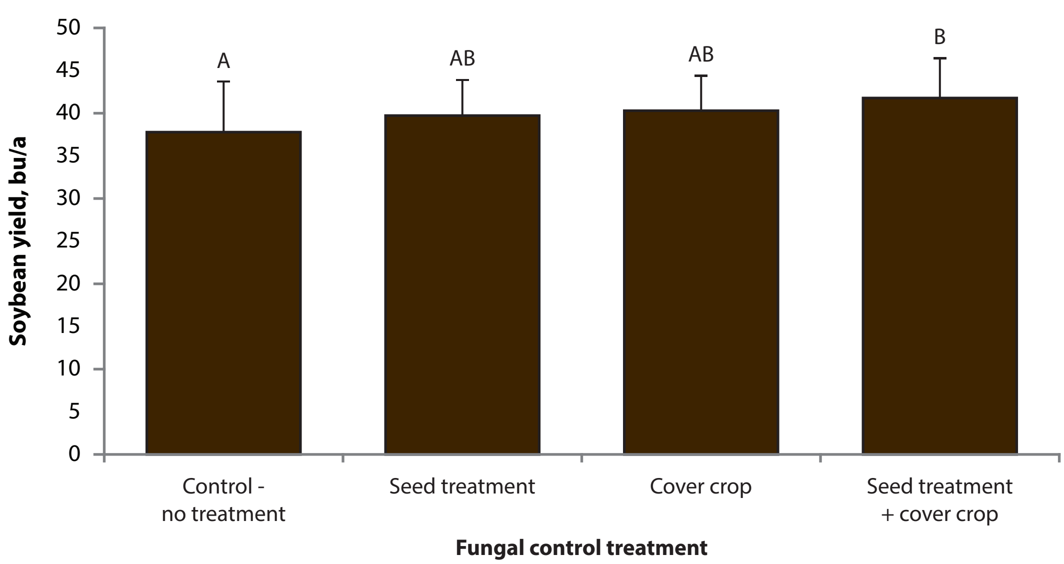

Figure 2. Impact of fungal control method on yield across all cultivars. Different letters indicate statistically significant differences.

Wheat Production

G.F. Sassenrath, D. Shoup, and R. Lollato

Summary
Wheat production in southeast Kansas is often limited due to high rainfall during the harvest. In some years, this high rainfall can exacerbate disease pressure, especially fungal infections. This study presents results from a test of fungicide applications to control Fusarium head blight (FHB) or scab in poor quality wheat.

Introduction
Fusarium head blight (FHB) or scab is most commonly observed in wheat in southeast Kansas. However, in 2015, much of eastern Kansas experienced a devastating infection level of FHB. FHB decreases wheat yield, but more importantly, reduces wheat quality due to development of mycotoxins associated with the fungal infection. High levels of vomitoxin or deoxynivalenol (DON) can render the wheat unfit for human consumption, and at very high levels, may not be suitable as a feed grain.

Experimental Procedures
The 2015 wheat harvest season experienced a long period of rain. Wheat that was harvested prior to the rain was generally good, with little fungal infection. Wheat harvested after the rain tended to have a higher rate of FHB. We obtained two groups of wheat seed (cv. Everest) that were harvested early and late from a cooperating farmer from 2015 (Figure 1). The late-harvested seed was poorer quality, and the farmer performed extra cleaning to try to improve the quality.

Seed was planted in replicated research plots at Parsons in fall 2015. Fungicide treatments included: control (no fungicide); seed treatment; in-season (flag leaf and bloom); and seed treatment + in-season. Plants were harvested at maturity in June 2016. The harvested seed was tested at the Kansas Grain Inspection Service for test weight and protein content.

Results and Discussion
Late-harvested wheat seed was of noticeably poorer quality, with many white kernels (Figure 1). The late-harvested wheat also had a lower test weight (57) than the early-harvested seed (63). Both early- and late-harvested wheat seed had levels of DON that rendered the wheat unfit for human consumption, but would allow its use as an animal feed. The late-harvested seed had a much greater number of damaged kernels (data not shown) potentially due to the additional cleaning.

The 2016 harvest season experienced a long dry period, greatly improving the harvested quality of the wheat. Disease pressure in 2016 was minor. However, each additional fungicide treatment showed an additional increase in yield (Figure 2). Seed treatment plus in-season fungicide applications showed a 20-bu/a yield improvement over the untreated control. Although there was no statistically significant difference between the early- and late-harvested seed, the consistent trend showed that the poor seed quality from late-harvested wheat seeds had reduced yields across all treatments. No consistent differences in test weight or protein content were observed between the crops harvested in 2016 based on initial seed quality.

Acknowledgment

This research is funded in part by a grant from the Kansas Crop Improvement Association.

Figure 1. Healthy ("Good", early-harvested) and infected ("Bad", late-harvested) wheat seed (cv. Everest) collected from a cooperating farmer. The "Bad" seed had been cleaned several times, but still showed bleaching associated with FHB.

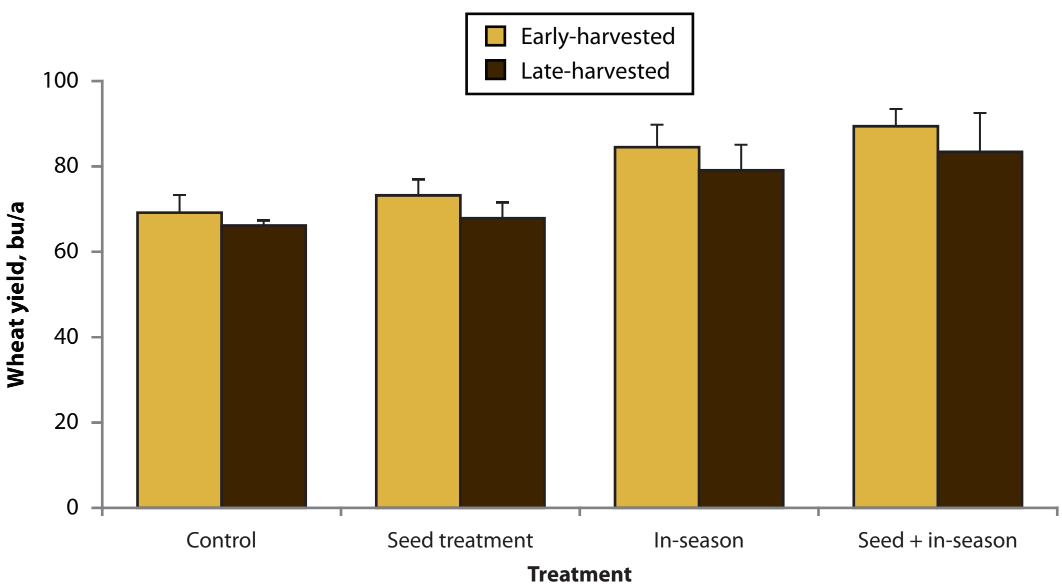

Figure 2. Impact of fungicide treatment on wheat yield for early-harvested ("good") and late-harvested ("bad") wheat seed.

Key Components of Healthy Soils and Their Role in Crop Production

C.-J. Hsiao, G.F. Sassenrath, C. Rice, L. Zeglin, and G.M. Hettiarachchi

Summary

Soil health is a confusing term that means different things to different people. To a crop producer, healthy soils are critical for good crop growth and yield. Some soil properties include soil texture, such as the relative percentage of sand, silt and clay; the water content; nutrient levels; organic carbon content; the microbial community; and microbial activity. These properties are determinants of soil health. Our research confirmed that changes in soil management affect the composition and activity of soil microorganisms in surface soils. Greater concentrations of microbial biomass and arbuscular mycorrhizal fungus (AMF) in the no-till agricultural system indicated healthier soils in this system. Our research also indicated microbial properties in subsurface soils were determined by parent materials and weathering.

Introduction

Good soil functionality improves the resiliency of the agronomic production system. Soils work in concert with weather, management practices, and genetics to determine the overall yield from a crop. Nowadays, people realize soil is a living organism, and the Natural Resources Conservation Service (NRCS) (2012) has defined soil health as: "The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans."

As described by the NRCS, some of the functions of healthy soils include providing habitat for plants, animals, and soil microorganisms; providing stability and support; providing nutrient cycling; filtering and buffering; and water relations.

Some soil characteristics are commonly measured, such as the physical makeup (clay/silt/sand content; bulk density, water content, and drainage ability) and the chemical characteristics (pH and nutrient levels, including carbon (C), nitrogen (N), phosphorus (P), potassium (K) and micronutrients). These are important determinants of soil health. The final component that is critical to the overall capacity of soil to provide a "vital living ecosystem" is the biological component. We are learning much more about the factors involved in the biology of soils and their role in soil health.

The biological components of the soil include the plant roots, bacteria, fungi, protozoa, nematodes, arthropods, earthworms, and animals. Some of these are beneficial, for example the Rhizobia bacteria that work with plants to fix nitrogen in certain nitrogen-fixing plant species such as soybeans. Arbuscular mycorrhizal fungi (AMF) are a group of beneficial fungi that form close bonds with plants, actually growing into the root cells of vascular plants and helping the plants take up nutrients. Other microorganisms are detrimental, such as the fungi *Macrophomina phaseolina* that causes charcoal rot.

We know a good bit about how to manage the physical and chemical characteristics of soils to improve their productive capacity. We are learning the importance of biological components, and their contribution to agronomic productivity. Biological soil characteristics are important for their role in integrating physical and chemical characteristics of the soil for optimal productivity.

This report presents the factors that are important for healthy soils. It also describes new research in progress on soil health.

Experimental Procedures

Soil samples were collected from a research field in Columbus, KS, under three management systems: conventional tillage row-crop production (CT); no-till row crop production (NT); and a long-term hay meadow (HM). The soil is a Parsons silt loam, nearly level. Soil samples were collected at different stages during the production cycle (preplant, after planting, at bloom, and at harvest) and separated into 7 different depth intervals (0-2, 2-6, 6-10, 10-14, 14-18, 18-22, and 22-30 inches). The soil samples were processed for microbial community composition by phospholipid fatty acid (PLFA) analysis and for microbial activity by soil enzyme activities analysis.

Results and Discussion

The soil in the field is a Parsons silt loam soil, described by the NRCS Web Soil Survey (2016) as prime farmland, with loess soil over clayey alluvium or clayey residuum weathered from clayey shale. The typical soil profile has productive silt loam soil to a depth of 14 inches, with a somewhat poorly drained silty clay layer, commonly referred to as the claypan, below about 14 inches.

In the surface soils, microbial biomass was greatest in the hay meadow, followed by no-till, and then conventional-till production systems (Figure 1). Subsoils from the HM had the greatest microbial concentration at every depth interval. Soil enzyme activities also followed a similar pattern. Microbial activity was greatest in the surface soils of the HM, followed by NT and CT agricultural systems.

Land management practices impacted microbial community composition (Figure 2). The fungal fraction was greatest in the soils from the HM, as indicated by the greater ratio of fungi to bacteria. No significant differences in total fungi content were measured between NT and CT soils. However, in contrast to the total fungal populations, the AMF fraction showed a greater concentration in the NT system than in the CT system.

The results also demonstrate a stratified response of soil microbial properties with depth in the soil profile. The land management practices influenced soil biological activity in the upper 6 in. of the soil profile (Table 1). The soil microbial properties in the lower soil profile (below approximately 14 in.) were dependent on the parent material and weathering. The intermediate depths in the soil profile could be influenced by both parent materials and management practices.

These results demonstrate the impact of management practices on soil microbial activity. Because AMF are important in nutrient cycling and nutrient uptake by plants, their increased populations in NT systems improves the productive capacity of the soil. Changes in management practices can have profound impacts on the health of the soil, and hence on its productive capacity.

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U.S. Department of Agriculture Natural Resources Conservation Service. Web Soil Survey. 2016. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

U.S. Department of Agriculture Natural Resources Conservation Service. Soil Health. 2012. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/

Table 1. Significant factors controlling biological activity in claypan soils

Soil depth	Tillage	Clay %	Carbon %	Nitrogen %	Phosphorus (ppm)	Potassium (ppm)
0-6 in.	X	-	X	X	-	X
6-14 in.	-	X	-	-	-	X
14-30 in.	-	X	X	X	-	X

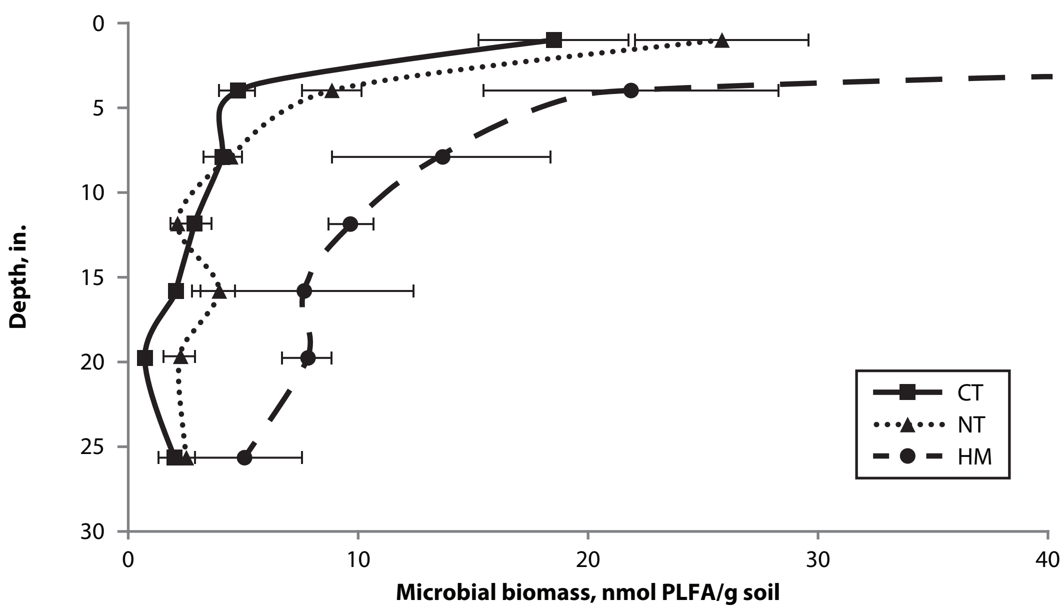

Figure 1. Change in microbial biomass with depth for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. The results are the average of all replications with standard error.

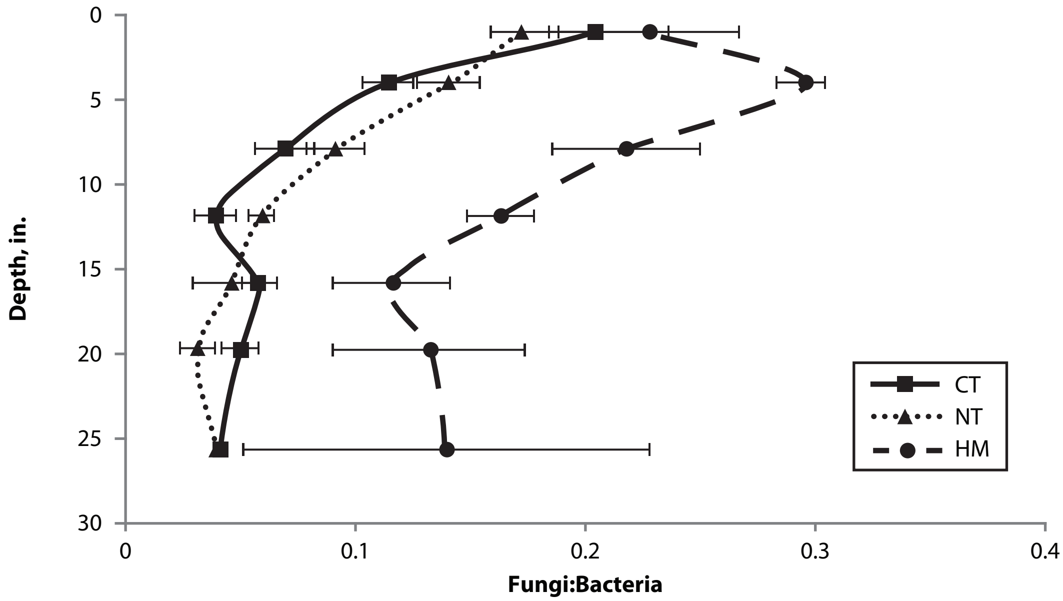

Figure 2. Change in the ratio of fungi to bacteria with depth in the soil profile for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. The results are the average of all replications with standard error.

Measuring Soil Electrical Conductivity to Delineate Zones of Variability in Production Fields

G.F. Sassenrath and S. Kulesza

Summary

Production fields in southeast Kansas are highly variable. Differences in elevation and changes in soil texture contribute to unevenness in plant-available moisture and nutrients, resulting in significant inconsistencies in crop production and yield within a field. These variabilities complicate management and impact the return on investments from different areas of the field. Identification of the regions of variability is possible through several methods, including visual inspection, remote imagery, and yield maps. An additional method of assessing soil variability is by measuring the electrical conductivity of the soil. Measuring apparent electrical conductivity gives a map of the spatial distribution of soil properties, which can be used to identify potential limitations to production and develop site-specific management. Delineation of within-field variability can be used to target production inputs to better match potential crop yield with inputs to maximize return on investment.

Introduction

The productive capacity of soil is one of the key components determining yield and quality of crops. While some soil factors can be altered through management, other characteristics cannot be modified and instead must be managed. Soils of southeast Kansas are potentially productive silt loam underlain with an impermeable clay layer. The soils within a field can be highly variable, in part due to fluctuating depths of the silt loam topsoil. Other factors, including topographic position in the landscape, such as whether the area is at the top of a hill or at a low point in the field, alter the productivity of the soil through modification of drainage.

Precision agriculture is a management strategy that seeks to optimize return on investment by matching the production potential of a region within a field with the needed inputs for that level of productivity. The production potential, or productive capacity, is the capacity of the soils to produce at a given level (yield per acre). In precision agriculture, prescribed rates of inputs are developed to apply reduced inputs on areas within a field that have limited production potential, while highly productive areas are given more inputs to support that high level of productivity. This strategy improves net return by putting resources where they are most likely to give the highest return, and reducing application of costly inputs on poorly-performing regions within a field. Precision agriculture is a powerful technology, but requires accurate mapping of within-field spatial variability and knowledge of factors contributing to that variability.

Soil variability is a key component of the spatial variability of plant production and yield observed in production fields. The change in soil characteristics across a field are modified by the growing environment (temperature and rainfall) and management practices (tillage, fertility, etc.). Delineating zones of soil productivity allows development of prescriptions to match management practices and inputs to the productive capacity of each distinct production zone within a field. Changes in soil characteristics can often be visually detected using changes in soil color. Publically available imagery allows examination of entire fields from aerial images at different times during the production year. Grid or zone sampling measures details of soil characteristics, including texture (sand, silt, and clay content), organic matter, and nutrient content. Soil sampling has its limitations, due to the expense of analysis, and limited coverage.

Electrical conductivity is a measure of how well a material, in this case soil, conducts electricity. The soil's ability to conduct electricity changes as a function of the soil texture (clay, silt, and sand content), organic matter, cation exchange capacity, water content, and the salinity. Soil electrical conductivity varies as a function of several key factors important in crop production. It is also relatively stable, changing very little over the course of a year or for different management practices. Thus, it is a useful tool in defining productivity zones within a crop field. Moreover, it can be used to map the entire field relatively quickly, giving a good measure of the spatial variability of soils over the entire field. These maps can then be used to identify zones of variability to direct soil sampling, or develop prescription maps for site-specific applications.

Experimental Procedures

Crop production fields were selected in collaboration with farmer-cooperators. Yield and plant growth information was collected at harvest. Yields were recorded with commercial yield monitors on production-scale combines, and mapped in SMS Advanced (AgLeader, Ames, IA). Profit maps were developed based on K-State Research and Extension Cost-Return Budgets for corn, soybeans, and wheat grown in southeast Kansas (Ibendahl et al., MF992, MF993, and MF994). A Veris 3100 system (Veris Technologies, Salina, KS) was used to measure soil electrical conductivity. Soil samples were taken at discrete locations throughout the fields and tested at the Kansas State University Soil Testing Lab in Manhattan, KS, for determination of soil texture and nutrient content.

Historical images of the crop production fields were downloaded from Google Earth. Digital elevation maps (DEMs) were downloaded from the Kansas Data Access and Support Center (http://www.kansasgis.org/resources/lidar.cfm), and were used for terrain analysis of the production fields using ArcGIS 10.1 (Esri, Redlands, CA).

Results and Discussion

Visual inspection of fields gives immediate information on potential regions of variability. Publicly available imagery is also available from Google Earth and other providers (http://nationalmap.gov). By selecting previous years, historical information on field conditions can be examined in Google Earth. This visual imagery can be used to identify potential low-lying areas that may hold water (darker soils), or potential zones of high runoff (lighter soils; Figure 1A). The production field shows a region in the center of the field with wetter (darker) soils, as well as along the terraces. Terraces are seen to drain into the grassed waterway in the west-central southern portion of the field. A region of very light soil is seen in the southeast corner.

Information on specific soil types in the field is available from the Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm). Three predominant soils are identified in the field: Dennis silt loam, Parsons silt loam, and Kenoma silt loam (Figure 1B). The complete description, available from the Web Soil Survey, describes the Dennis silt loam as a silty and clayey residuum weathered from shale, with a typical profile of silt loam from 0 – 10 inches, with silty clay loam from 10-15 inches and silty clay below 15 inches. Dennis silt loam is in hydrological class C, indicating a layer in the lower soil profile that impedes downward water movement. The Parsons and Kenoma soils have silt loam extending from 0 to 13 inches, with silty clay beginning at 13 inches. Both Parsons and Kenoma are classified in hydrologic soil group D, indicating a very low rate of water infiltration due to a claypan or clay layer near the surface. The Kenoma is weathered from limestone and shale. The restrictive layer begins at about 80 inches in all three soil types. Soils throughout the field are classified as prime farmland.

A Veris 3100 system was used to map apparent electrical conductivity (EC_a) across the entire field (Figure 2). The Veris system measures EC_a through the soil using two arrays of electrodes on coulters. The arrays measure EC_a at two depths in the field: 0-10 inches and 0-30 inches. In our measurements, clay content was the largest determinant of soil EC_a. High EC_a measurements are indicative of soil with high clay content. This is seen to coincide with the region of lighter soil in the southeast corner of the field, and also in the soils to the north of the grassed waterway in the center of the field (Figure 3A). The soils with the lowest EC_a are observed in the center of the field.

Corn yield corresponds closely with EC_a, as the lowest yields were measured in the southeast corner, which had the highest EC_a (Figure 3B). The best yields corresponded with the regions of soil with the lowest measured EC_a, in the center of the field. Using yield maps from one complete crop rotation (corn/winter wheat/soybeans) over 2 years, and the K-State Cost-Return budgets, we can develop a profitability map of the field (Figure 4). The southeast corner of the field and the area just to the north of the grassed waterways had the lowest profitability. The center of the field had the greatest return. The area to the north of the field had intermediate return.

The measurements demonstrate the extent of soil variability within a production field, and methods of identifying potential sources of that variability. Clay content is one factor contributing to the observed variability in crop production. The EC_a measurements of soil gives a spatial map of the variability in soil characteristics throughout the field. We can use this to develop a zone sampling strategy to further delineate sources of soil variability. Other factors contributing to variability in crop production may include topographic position and soil moisture content, which are correlated, as soils at higher elevation will tend to dry out more quickly while low-lying areas will stay wetter. The knowledge can be used to develop site-specific management practices for the field. Implementing precision management practices could improve net return by reducing inputs on regions with low productive capacity.

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Gregg Ibendahl, Daniel M. O'Brien, and Douglas Shoup, Corn Cost-Return Budget in Southeast Kansas, Kansas State University, April 2015. MF993. https://www.bookstore.ksre.ksu.edu/pubs/MF993.pdf

Gregg Ibendahl, Daniel M. O'Brien, and Douglas Shoup, Soybean Cost-Return Budget in Southeast Kansas, Kansas State University, April 2015. MF994. https://www.bookstore.ksre.ksu.edu/pubs/MF994.pdf

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Figure 1. A. Visual images of crop production fields are an easy way to identify regions of variability. This bare-soil image was downloaded from Google Earth (https://www.google.com/earth/). Darker regions of the fields are most likely caused by low-lying areas that are holding moisture. B. Description of the soils in the fields from the Web Soil Survey add additional information about the potential variability. For this field, three predominant soil types are identified in the field, 8679 Dennis silt loam, 1 to 3% slope, 8863 Parsons silt loam, 0 to 1% slope, and 8775 Kenoma silt loam, 1 to 3% slope. (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

Figure 2. A Veris 3100 system was used to measure apparent soil electrical conductivity across the entire field.

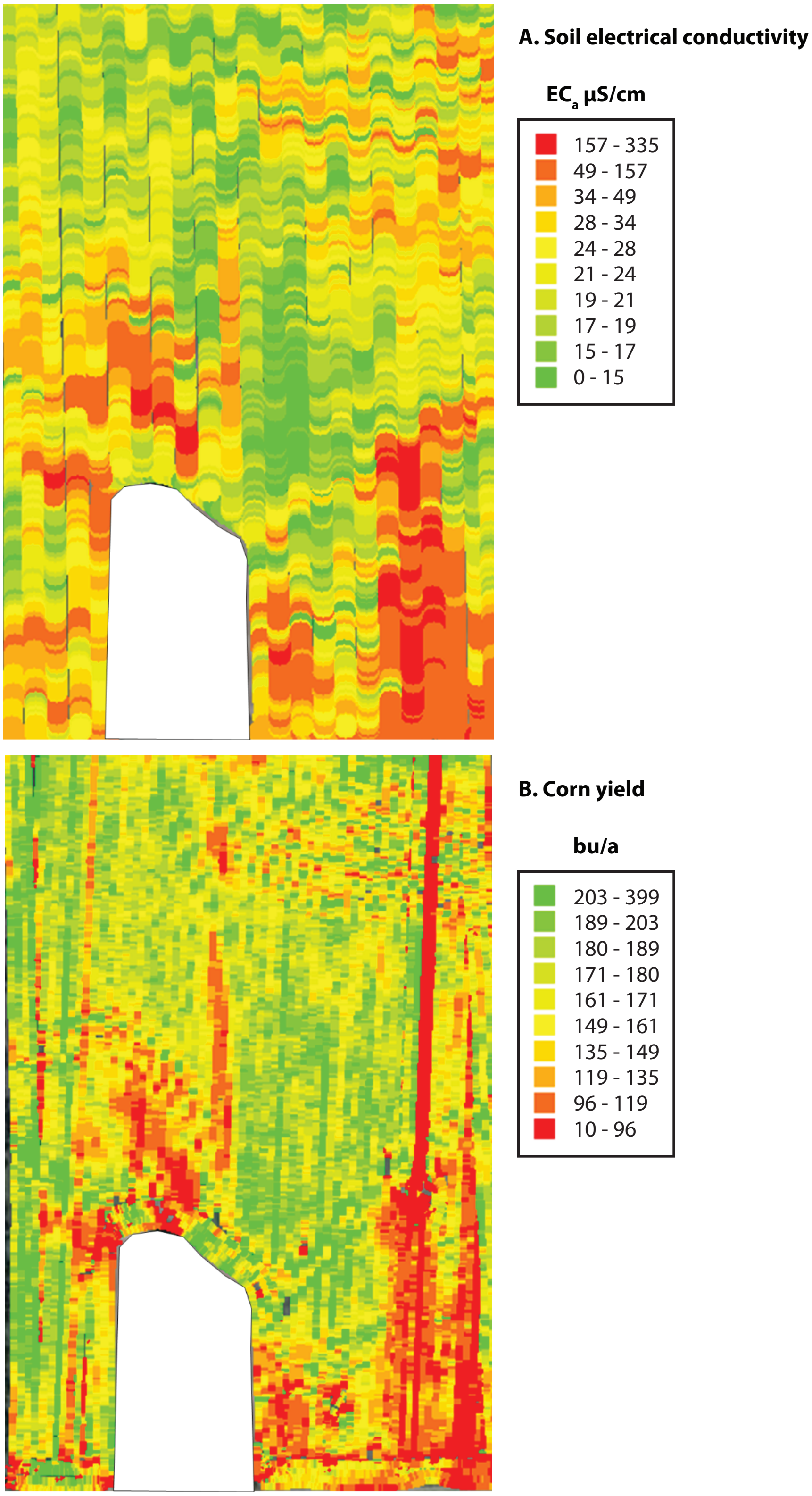


Figure 3. A. Soil apparent electrical conductivity, EC_a, measured in a production field with a Veris 3100 System. B. Corn yield measured with a yield monitor.

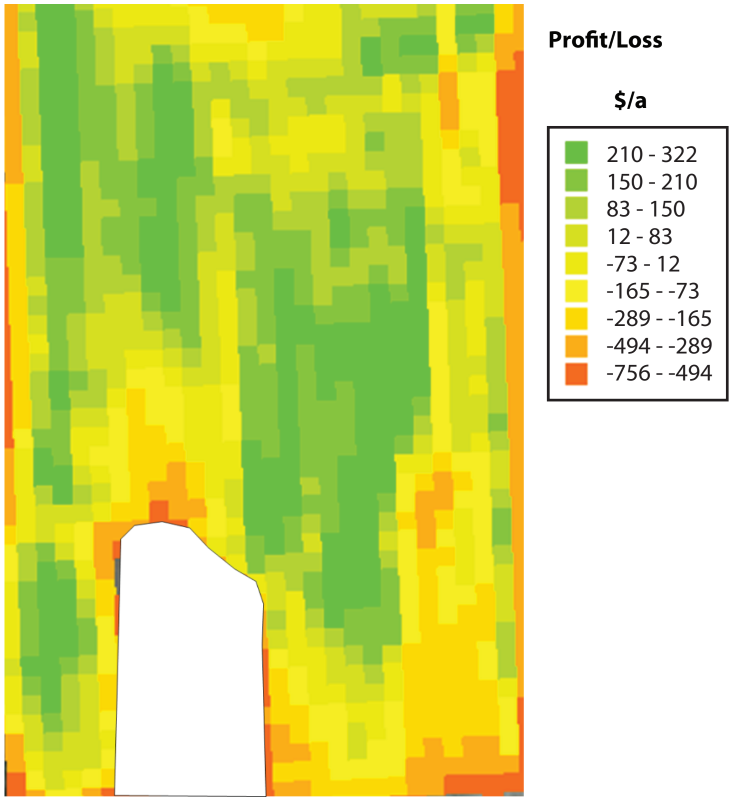
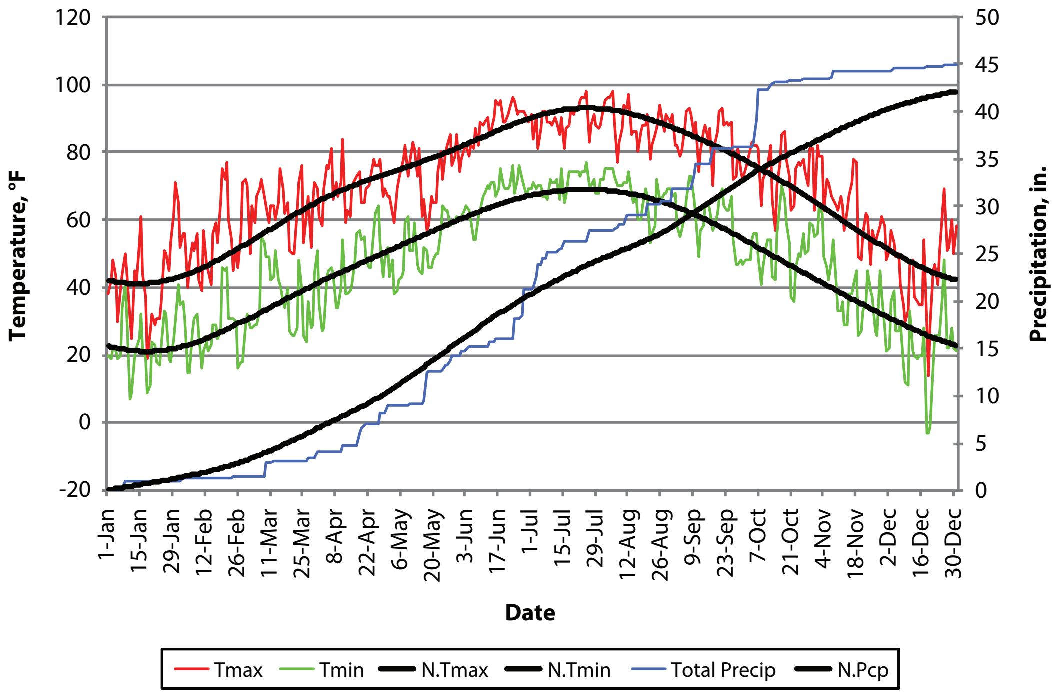


Figure 4. Crop profitability map. The spatial distribution of return on investment was calculated for a complete crop rotation (corn/winter wheat/soybeans) for two years based on measured crop yields and cost-return budgets (see resource list).

Annual Summary of Weather Data for Parsons



2016 Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Avg. max	42.5	55.0	63.4	70.1	72.9	88.4	89.4	88.8	83.6	74.9	63.8	45.0	69.8
Avg. min	22.8	27.7	37.0	45.8	51.7	67.3	70.8	67.8	60.2	51.8	39.7	22.3	47.1
Avg. mean	32.6	41.4	50.2	58.0	62.3	77.8	80.1	78.3	71.9	63.4	51.8	33.7	58.5
Precip	1.01	0.45	2.72	4.8	5.28	7.02	6.16	4.32	4.47	7.20	0.86	0.53	44.86
Snow	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Heat DD*	1003	686	460	227	143	0	0	0	23	109	413	971	4033
Cool DD*	0	0	0	17	59	385	469	413	230	59	16	0	1646
Rain days	5	2	10	7	12	11	9	8	6	9	5	5	89
Min < 10	3	0	0	0	0	0	0	0	0	0	0	3	6
Min < 32	25	23	12	2	0	0	0	0	0	0	7	26	95
Max > 90	0	0	0	0	0	11	12	13	5	0	0	0	41

Normal values (1981-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Avg. max	42.0	47.6	57.1	67.1	75.7	84.4	90.0	90.3	81.3	69.6	56.6	44.2	67.2
Avg. min	21.8	26.0	35.0	44.5	55.0	64.1	68.5	66.6	57.6	45.5	35.3	24.6	45.5
Avg. mean	31.9	36.8	46.1	55.8	65.3	74.2	79.3	78.5	69.4	57.6	46.0	34.4	56.4
Precip	1.41	1.77	3.19	4.38	5.93	5.53	3.92	3.29	4.69	3.86	2.94	2.06	42.97
Snow	2.8	1.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.7	8.7
Heat DD	1026	790	590	299	85	8	1	1	52	260	574	948	4632
Cool DD	0	0	2	23	96	285	442	418	186	29	2	0	1483

Departure from normal

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. max	0.5	7.4	6.3	3.0	-2.8	4.0	-0.6	-1.5	2.3	5.3	7.2	0.8	2.7
Avg. min	1.0	1.7	2.0	1.3	-3.3	3.2	2.3	1.2	2.6	6.3	4.4	-2.3	1.7
Avg. mean	0.7	4.6	4.1	2.2	-3.0	3.6	0.8	-0.2	2.5	5.8	5.8	-0.7	2.2
Precip	-0.4	-1.32	-0.47	0.46	-0.65	1.49	2.24	1.03	-0.22	3.34	-2.08	-1.53	1.89
Snow	-1.8	-1.7	-1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-2.7	-7.7
Heat DD	-23	-105	-131	-72	58	-8	-1	-1	-30	-151	-161	23	-601
Cool DD	0	0	-2	-7	-38	100	27	-6	44	30	14	0	163

* Daily values were computed from mean temperatures. Each degree that a day's mean is below (or above) 65°F is counted for one heating (or cooling) degree day.

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Commercial Bank
Community National Bank & Trust
CONICYT, Chile
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DeLange Seed Co., Girard, KS
DLF International, Halsey, OR
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