Southeast Research and Extension Center Agricultural Research 2020

K·STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

JAYMELYNN K. FARNEY
Beef Systems Specialist, Associate Professor

B.S., Animal Science and Industry, Kansas State University
M.S., Animal Science and Industry - Ruminant Nutrition, Oklahoma State University
Ph.D., Animal Science and Industry - Ruminant Nutrition, Kansas State University

Jaymelynn joined the staff in 2012. Her research and extension efforts have focused on cow-calf and stocker management. Specific areas include forage utilization by livestock of annual forages within integrated production systems, mineral and feed supplementation for production, and fescue management for production and cattle utilization.

LYLE LOMAS
Animal Scientist, Professor

B.S., M.S., Animal Husbandry, University of Missouri
Ph.D., Animal Husbandry, Michigan State University

Lyle directs beef cattle research at the Kansas State University Research and Extension Center. He joined the staff in 1979 as Animal Scientist and served as Research Center Head from 1986 to 2018. His research interests are beef cattle nutrition and forage utilization by grazing beef cattle.

J.D. McNUTT
Professor and Southeast Research and Extension Center Department Head

B.S. Oklahoma State University, Agricultural Education
M. Ed. East Central University, Secondary Education/Natural Sciences
Ed.D. Oklahoma State University, Higher Education Administration

Dr. McNutt provides administrative and research leadership to the faculty and staff at the SEREC, as well as being the Director of Extension for the Southeast extension region. His research efforts were in the field of community/rural development.

GRETCHEN F. SASSENRATH
Cropping Systems Agronomist, Professor

B.A., Oberlin College
M.S., Biophysics, University of Illinois
Ph.D., Plant Physiology, University of Illinois

Gretchen joined the staff in 2013. Her research focuses on crop production; physiological, edaphic, biotic, and abiotic stressors in cropping systems; and integrated production systems.

DAN SWEENEY
Soil and Water Management Agronomist, Professor

B.S., Chemistry, Kentucky Wesleyan College
M.S., Agronomy, Purdue University
Ph.D., Soil Science, University of Florida

Dan joined the staff in 1983. His research focuses on soil fertility, tillage and compaction, water quality, and irrigation.

SEREC
Agricultural Research
2020

Contents

Beef Cattle Research

Soil and Water Management Research

Cropping Systems Research

Evaluation of Supplemental Energy Source for Grazing Stocker Cattle

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

Summary

A total of 216 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, 2016, 2017, 2018, and 2019. Supplementation treatments evaluated were: no supplement, a supplement with starch as the primary source of energy, and a supplement with fat as the primary energy source. 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 six years. In 2014, 2016, 2017, 2018, and 2019, 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. In 2016, steers fed the starch-based or fat-based supplement had greater ($P < 0.05$) hot carcass weight and higher ($P < 0.05$) marbling scores than those fed no supplement. Supplementation had no effect ($P > 0.05$) on finishing gains. In 2017, steers fed the starch-based supplement had greater ($P < 0.05$) finishing gain and lower ($P < 0.05$) feed:gain than those fed no supplement and steers that were supplemented while grazing had greater ($P < 0.05$) hot carcass weight than those that received no supplement. In 2018, steers fed the starch-based or fat-based supplement had greater ($P < 0.05$) hot carcass weight and higher ($P < 0.05$) marbling scores than those fed no supplement. Supplementation treatment had no effect ($P > 0.05$) on finishing gains.

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

Thirty-six steer calves 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); April 6, 2016 (444 lb); March 21, 2017 (437 lb); March 27, 2018 (443 lb); and April 9, 2019 (468 lb). Three pastures of steers were randomly assigned to one of three supplementation treatments (3 replicates per treatment) and were grazed for 181, 224, 223, 238, 224, and 189 days in 2014, 2015, 2016, 2017, 2018, and 2019, 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, 2017, 2018, and 2019, 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, 2017, 2018, and 2019) and energy (3.3 lb of TDN in 2014 and 2015 and 3.4 lb of TDN in 2016, 2017, 2018, and 2019) per head daily. Pastures were fertilized with 100 lb/a of nitrogen (N) on February 24, 2014; February 12, 2015; February 11, 2016; February 10, 2017; February 13, 2018; and March 18, 2019. Pastures were stocked with 0.8 steers/a and grazed continuously until October 7, 2014 (181 days); November 10, 2015 (224 days); November 15, 2016 (223 days); November 14, 2017 (238 days); November 6, 2018 (224 days), and October 15, 2019 (189 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 in 2014, 2015, 2016, and 2017 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, 97, 98, 91, and 112 days in 2014, 2015, 2016, 2017, and 2018, 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 2019 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 smooth bromegrass pastures are presented by supplementation treatment for 2014, 2015, 2016, 2017, and 2018 in Tables 1, 2, 3, 4, and 5, respectively. Grazing performance only is presented for 2019 in Table 6. Supplementation treatment had no effect ($P > 0.05$) on the quantity of forage available for grazing in any of the years that it was measured. 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 forage consumption was not affected.

Supplemented steers had greater ($P < 0.05$) weight gain, daily gain, and steer gain/a than those that received no supplement in all six years. In 2014, 2016, 2017, 2018, and 2019, 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 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, 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 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.

In 2016, 2017, and 2018, steers that were supplemented during the grazing phase maintained their weight advantage from grazing and were heavier ($P < 0.05$) at the end of the finishing phase, had greater ($P < 0.05$) hot carcass weight, and greater ($P < 0.05$) overall gain than those that received no supplement. Final finishing weight and hot carcass weight were similar ($P > 0.05$) for steers supplemented with starch or fat during the grazing phase.

In 2016, dry matter intake was lower ($P < 0.05$) for steers that received no supplement while grazing than for those supplemented with fat, which may be due at least in part to the unsupplemented steers being lighter weight. Supplementation treatment during the grazing phase had no effect ($P > 0.05$) on backfat thickness, ribeye area, or percentage grading USDA Choice. Steers supplemented with starch during the grazing phase had lower ($P < 0.05$) numerical yield grades than those supplemented with fat. Steers supplemented with starch or fat during the grazing phase had higher ($P < 0.05$) marbling scores than those that received no supplement. Marbling scores and overall gains were similar ($P > 0.05$) between those supplemented with starch or fat.

In 2017, steers fed the starch-based supplement had greater ($P < 0.05$) finishing gain and lower ($P < 0.05$) feed:gain than those fed no supplement. Final finishing weight, hot carcass weight, and overall gain were similar ($P > 0.05$) for steers supplemented with starch or fat during the grazing phase. Supplementation treatment during the grazing phase had no effect ($P > 0.05$) on backfat thickness, ribeye area, yield grade, marbling score, or percentage grading USDA Choice.

In 2018, steers fed the starch-based supplement had higher ($P < 0.05$) marbling scores than those that received no supplement while grazing. Supplementation treatment during the grazing phase had no effect ($P > 0.05$) on finishing gain, feed:gain, backfat thickness, ribeye area, yield grade, or percentage grading USDA Choice. Marbling scores and overall gains were similar ($P > 0.05$) between those supplemented with starch or fat.

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 little effect on carcass quality.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Effect of supplemental energy source on grazing and subsequent finishing performance of steers grazing smooth bromegrass pastures, Kansas State University Southeast Research and Extension 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, lb	---	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, Kansas State University Southeast Research and Extension 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, lb	---	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 and subsequent finishing performance of steers grazing smooth bromegrass pastures, Kansas State University Southeast Research and Extension 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, lb	---	8.2	9.2
Average available forage dry matter, lb/a	7,403	7,402	7,309
Finishing phase (98 days)			
Beginning weight, lb	754a	871b	856b
Ending weight, lb	1167a	1274b	1280b
Gain, lb	412	403	424
Daily gain, lb	4.21	4.11	4.33
Daily dry matter intake, lb	26.7a	27.7ab	28.5b
Feed:gain	6.36	6.75	6.58
Hot carcass weight, lb	723a	790b	794b
Backfat, in.	0.43	0.44	0.45
Ribeye area, sq. in.	11.9	12.4	12.1
Yield grade	2.4ab	2.3a	2.8b
Marbling score[1]	632a	684b	710b
Percentage USDA grade Choice	100	100	100
Overall performance (grazing plus finishing; 321 days)			
Gain, lb	722a	829a	836b
Daily gain, lb	2.25a	2.58b	2.60b

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

Table 4. Effect of supplemental energy source on grazing and subsequent finishing performance of steers grazing smooth bromegrass pastures, Kansas State University Southeast Research and Extension Center, 2017

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (238 days)			
Number of head	12	12	12
Initial weight, lb	431	437	443
Final weight, lb	807a	912b	942b
Gain, lb	376a	475b	499b
Daily gain, lb	1.58a	2.00b	2.10b
Gain/a, lb	301a	380b	399b
Supplement consumption, lb/head per day	0	4.25	4.25
Supplement, lb/additional gain, lb	---	10.1	8.2
Average available forage dry matter, lb/a	6,371	6,369	6,293
Finishing phase (91 days)			
Beginning weight, lb	807a	912b	842b
Ending weight, lb	1104a	1304b	1301b
Gain, lb	297a	392b	359ab
Daily gain, lb	3.26a	4.31b	3.95ab
Daily dry matter intake, lb	26.4	28.0	27.0
Feed:gain	8.26a	6.49b	6.87ab
Hot carcass weight, lb	662a	783b	780b
Backfat, in.	0.39	0.45	0.50
Ribeye area, sq. in.	11.6	12.8	12.4
Yield grade	2.4	2.4	2.8
Marbling score[1]	650	646	692
Percentage USDA grade Choice	92	92	100
Overall performance (grazing plus finishing; 329 days)			
Gain, lb	673a	868b	858b
Daily gain, lb	2.04a	2.64b	2.61b

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

Table 5. Effect of supplemental energy source on grazing and subsequent finishing performance of steers grazing smooth bromegrass pastures, Kansas State University Southeast Research and Extension Center, 2018

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (224 days)			
Number of head	12	12	12
Initial weight, lb	443	443	443
Final weight, lb	742a	864b	880b
Gain, lb	299a	421b	437b
Daily gain, lb	1.33a	1.88b	1.95b
Gain/a, lb	239a	336b	350b
Supplement consumption, lb/head per day	0	4.25	4.25
Supplement, lb/additional gain, lb	---	7.7	6.9
Finishing phase (112 days)			
Beginning weight, lb	742a	864b	880b
Ending weight, lb	1177a	1321b	1302b
Gain, lb	435	457	421
Daily gain, lb	3.88	4.08	3.76
Daily dry matter intake, lb	27.7	28.8	28.0
Feed:gain	7.14	7.08	7.47
Hot carcass weight, lb	706a	793b	781b
Backfat, in.	0.49	0.52	0.57
Ribeye area, sq. in.	11.5	12.1	12.0
Yield grade	2.7	2.9	2.9
Marbling score[1]	706a	768b	713ab
Percentage USDA grade Choice	100	100	100
Overall performance (grazing plus finishing; 336 days)			
Gain, lb	733a	878b	858b
Daily gain, lb	2.18a	2.61b	2.55b

[1]700 = moderate, 800 = slightly abundant.

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

Table 6. Effect of supplemental energy source on grazing performance of steers grazing smooth bromegrass pastures, Kansas State University Southeast Research and Extension Center, 2019

	Supplemental energy source		
Item	None	Starch	Fat
Grazing phase (189 days)			
Number of head	12	12	12
Initial weight, lb	468	468	468
Final weight, lb	684a	803b	793b
Gain, lb	215a	335b	325b
Daily gain, lb	1.14a	1.77b	1.72b
Gain/a, lb	172a	268b	260b
Supplement consumption, lb/head per day	0	4.25	4.25
Supplement, lb/additional gain, lb	---	6.7	7.3

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

Including Legumes in Bermudagrass Pastures

J.L. Moyer and L.W. Lomas

Summary
Use of legumes in wheat-bermudagrass pastures did not affect summer cow gains in 2019, but did reduce the quantity of nitrogen fertilizer required.

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 a 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 Kansas State University Southeast Research and Extension Center (Parsons silt-loam soil) were assigned to Legume or Nitrogen treatments in a completely randomized design with four replications. All pastures were interseeded with 100 lb/a of 'Everest' wheat on September 25, 2018. Legume pastures that had been previously interseeded with 'Will' ladino clover were interseeded with 21 lb/a of crimson clover using a no-till drill on September 25, 2018. Nitrogen pastures were fertilized with 50 lb/a of nitrogen on January 30 and May 7, 2019, and all pastures received 50-30-30 of N-P_2O_5-K_2O on July 13, 2019.

Thirty-two pregnant fall-calving cows of predominantly Angus breeding were weighed on consecutive days and assigned randomly by weight to pastures on March 29, 2019. Final cow weights were taken on consecutive days before removal from the pastures on August 15, 2019 (139 days).

Results and Discussion
Cow performance data are presented in Table 1. Cow gains and gain/a for the Nitrogen and Legume treatments were similar ($P > 0.05$).

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Performance of cows grazing wheat-bermudagrass pastures interseeded with wheat and fertilized with nitrogen or interseeded with legumes, Mound Valley Unit, Kansas State University Southeast Research and Extension Center, 2019

	Management system	
Item	Nitrogen	Legumes
Number of cows	16	16
Number of days	139	139
Stocking rate, cows/a	0.8	0.8
Cow initial weight, lb	1223	1224
Cow final weight, lb	1576	1524
Cow gain, lb	353	300
Cow daily gain, lb	2.54	2.16
Cow gain, lb/a	283	240

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

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

L.W. Lomas and J.L. Moyer

Summary

Two hundred fifty-six yearling steers grazing tall fescue pastures were used to evaluate the effects of fescue cultivar and interseeding ladino clover on available forage, grazing gains and subsequent finishing performance in 2016, 2017, 2018, and 2019. Fescue cultivars evaluated were high-endophyte 'Kentucky 31,' low-endophyte Kentucky 31 'HM4,' and 'MaxQ.' In 2016, 2018, and 2019, 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 ($P > 0.05$). In 2017, steer gains were similar ($P > 0.05$) among all cultivars. High-endophyte Kentucky 31 pastures had more ($P < 0.05$) available forage than low-endophyte Kentucky 31, HM4, or MaxQ pastures during both 2016 and 2017. Steer gains and gain/a were similar ($P > 0.05$) between pastures fertilized with nitrogen in the spring and those interseeded with ladino clover during all four years. Fescue cultivar or legume treatment had little effect on finishing performance or carcass characteristics of steers grazed in 2016, 2017, or 2018. Steers that grazed high-endophyte Kentucky 31 in 2016 or 2018 had lower ($P < 0.05$) final finishing weight and lower ($P < 0.05$) carcass weight than those that grazed low-endophyte Kentucky 31, HM4, or MaxQ. In 2017, steers that grazed pastures interseeded with ladino clover had lower ($P < 0.05$) finishing gains and greater ($P < 0.05$) feed:gain than those that grazed pastures with no legume.

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

Sixty-four mixed black yearling steers were weighed 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) on March 30, 2016 (535 lb); March 28, 2017 (597 lb); April 3, 2018 (581 lb); and April 2, 2019 (563 lb). 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, February 16, 2017, January 31, 2018, and March 6, 2019. All pastures were fertilized with 40 lb/a N and P_2O_5 and K_2O (as recommended via results of soil test) on September 13, 2016, September 11, 2017, September 25, 2018, and August 29, 2019.

Pasture was the experimental unit and weight gain was the primary measurement. No implants or feed additives were used. Cattle were weighed every 28 days. Forage availability was measured at the same time in 2016 and 2017 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. Four steers were removed from the study in 2016 for reasons unrelated to experimental treatment and replaced with grazers to maintain equal stocking rates. Pastures were grazed continuously until November 29, 2016 (244 days); December 6, 2017 (253 days); November 7, 2018 (218 days); and November 14, 2019 (226 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) to determine the effect of grazing treatment on subsequent finishing performance. Cattle that grazed in 2016, 2017, and 2018 were fed a finishing diet for 98 days, 98 days, and 112 days, respectively. Cattle were then slaughtered in a commercial facility, and carcass data were collected on each individual steer. Cattle that were grazed during 2019 were being finished for slaughter at the time this report was written.

Results and Discussion

Grazing and finishing performance is pooled across legume treatment and presented by tall fescue cultivar for 2016, 2017, and 2018 in Table 1, Table 3, and Table 5, respectively, and pooled across fescue cultivar and presented by legume treatment for 2016, 2017, and 2018 in Table 2, Table 4, and Table 6, respectively. Grazing performance for 2019 is presented by tall fescue cultivar and legume treatment in Table 7 and Table 8, respectively. There were significant interactions ($P < 0.05$) between fescue cultivar and legume treatment for average available forage DM in 2016 and average daily dry matter intake during the finishing phase in 2017. In 2016, 2018, and 2019, 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 that grazed 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. In 2016, 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. In 2017, average available forage DM of low-endophyte Kentucky 31, HM4, or MaxQ pastures were similar ($P > 0.05$). Steer gains were similar ($P > 0.05$) between pastures fertilized with an additional 80 lb/a N and those interseeded with ladino clover in all four years. 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 ($P > 0.05$).

In 2016, fescue cultivar had no effect ($P > 0.05$) on finishing gain, dry matter intake, or feed:gain ratio. However, steers that had previously grazed high-endophyte Kentucky 31 had lower ($P < 0.05$) weight at the end of the finishing phase and lower ($P < 0.05$) hot carcass weight than those that had previously grazed low-endophyte Kentucky 31, HM4, or MaxQ. The weight differential between cattle that grazed high-endophyte Kentucky 31 and those that grazed low-endophyte Kentucky 31, HM4, or MaxQ was similar at the end of the grazing phase (156 lb) and the end of the finishing phase (155 lb). Therefore, the weight advantage of cattle that grazed low-endophyte Kentucky 31, HM4, or MaxQ occurred during the grazing phase and was maintained during the finishing phase. Cattle that grazed high-endophyte Kentucky 31 did not exhibit any compensatory gain during the finishing phase. Backfat thickness of steers that grazed high-endophyte Kentucky 31 or HM4 were similar ($P > 0.05$) and lower ($P < 0.05$) than that of steers that grazed low-endophyte Kentucky 31 or MaxQ. Yield grade of steers that grazed high-endophyte Kentucky 31 was numerically lower ($P < 0.05$) than that of steers that grazed low-endophyte Kentucky 31 or MaxQ and similar ($P > 0.05$) to that of steers that grazed HM4. Fescue cultivar had no effect ($P > 0.05$) on ribeye area, marbling score, or percent of carcasses that graded USDA Choice. Overall gain of steers that grazed high-endophyte Kentucky 31 was lower ($P < 0.05$) than that of steers that grazed low-endophyte Kentucky 31, HM4, or MaxQ, and overall gain of steers that grazed low-endophyte Kentucky 31, HM4, or MaxQ were similar ($P > 0.05$). Legume treatment had no effect ($P > 0.05$) on finishing performance or carcass traits.

In 2017, fescue cultivar had no effect ($P > 0.05$) on finishing performance or overall performance. Steers that grazed pastures interseeded with ladino clover had lower ($P < 0.05$) finishing gains and greater ($P < 0.05$) feed:gain than those that grazed pastures with no legume.

In 2018, fescue cultivar had no effect ($P > 0.05$) on finishing gain. However, steers that had previously grazed low-endophyte Kentucky 31, HM4, or MaxQ maintained their weight advantage from the grazing phase, were heavier ($P < 0.05$) at the end of the finishing phase, had greater ($P < 0.05$) hot carcass weight, and greater overall gains than those that had grazed high-endophyte Kentucky 31. Legume treatment had little effect on grazing performance. Steers that grazed pastures interseeded with ladino clover had lower ($P < 0.05$) feed:gain than those that grazed pastures without clover that were fertilized with additional nitrogen.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Effects of cultivar on grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2016

	Tall fescue cultivar			
Item	High-endophyte Kentucky 31	Low-endophyte Kentucky 31	HM4	MaxQ
Grazing phase (244 days)				
Number of head	13	16	16	15
Initial weight, lb	533	535	535	537
Ending weight, lb	770a	920b	931b	924b
Gain, lb	238a	385b	396b	387b
Daily gain, lb	0.97a	1.58b	1.62b	1.59b
Gain/a, lb	190a	308b	310b	310b
Average available forage dry matter, lb/a*	7,365a	5,944b	6,139bc	6,300c
Finishing phase (98 days)				
Beginning weight, lb	770a	920b	931b	924b
Ending weight, lb	1219a	1374b	1366b	1386b
Gain, lb	449	454	435	462
Daily gain, lb	4.58	4.63	4.44	4.71
Daily dry matter intake, lb	26.2	27.4	28.3	28.3
Feed:gain	5.74	5.91	6.41	6.05
Hot carcass weight, lb	756a	852b	847b	859b
Backfat, in.	0.47a	0.60b	0.55a	0.60b
Ribeye area, sq. in.	12.7	12.8	12.7	12.9
Yield grade	2.3a	3.0b	2.9ab	3.0b
Marbling score[1]	627	669	623	616
Percentage USDA grade Choice	100	100	100	100
Overall performance (grazing plus finishing; 342 days)				
Gain, lb	687a	839b	831b	849b
Daily gain, lb	2.01a	2.45b	2.43b	2.48b

[1]600 = modest, 700 = moderate.

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 grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2016

	Legume treatment	
Item	No legume	Ladino clover
Grazing phase (244 days)		
Number of head	30	30
Initial weight, lb	534	536
Ending weight, lb	868	905
Gain, lb	334	369
Daily gain, lb	1.37	1.51
Gain/a, lb	267	295
Average available forage dry matter, lb/a*	6,888a	5,986b
Finishing phase (98 days)		
Beginning weight, lb	868	905
Ending weight, lb	1320	1353
Gain, lb	453	448
Daily gain, lb	4.62	4.57
Daily dry matter intake, lb	27.4	27.6
Feed:gain	5.97	6.09
Hot carcass weight, lb	819	839
Backfat, in	0.55	0.56
Ribeye area, sq. in.	12.8	12.8
Yield grade	2.8	2.8
Marbling score[1]	619	649
Percentage USDA grade Choice	100	100
Overall performance (grazing plus finishing; 342 days)		
Gain, lb	786	817
Daily gain, lb	2.30	2.39

[1]600 = modest, 700 = moderate.
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 3. Effects of cultivar on grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2017

	Tall fescue cultivar			
Item	High-endophyte Kentucky 31	Low-endophyte Kentucky 31	HM4	MaxQ
Grazing phase (253 days)				
Number of head	16	16	16	16
Initial weight, lb	597	597	597	597
Ending weight, lb	901	1029	986	1007
Gain, lb	304	432	389	411
Daily gain, lb	1.20	1.71	1.54	1.62
Gain/a, lb	244	346	311	328
Average available forage dry matter, lb/a	5,179a	4,728b	4,812b	4,808b
Finishing phase (98 days)				
Beginning weight, lb	901	1029	986	1007
Ending weight, lb	1311	1422	1374	1400
Gain, lb	410	393	389	393
Daily gain, lb	4.18	4.01	3.97	4.01
Daily dry matter intake, lb*	28.5	28.4	28.7	27.6
Feed:gain	6.82	7.13	7.25	7.01
Hot carcass weight, lb	813	882	852	868
Backfat, in.	0.46	0.58	0.58	0.52
Ribeye area, sq. in.	13.1	13.3	13.1	13.1
Yield grade	2.4	2.8	2.8	2.7
Marbling score[1]	659	694	754	701
Percentage USDA grade Choice	94	100	100	100
Overall performance (grazing plus finishing; 351 days)				
Gain, lb	715	826	778	803
Daily gain, lb	2.04	2.35	2.22	2.29

[1]600 = modest, 700 = moderate, 800 = slightly abundant.
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 4. Effects of interseeding ladino clover on grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2017

	Legume treatment	
Item	No legume	Ladino clover
Grazing phase (253 days)		
Number of head	32	32
Initial weight, lb	597	597
Ending weight, lb	951	1011
Gain, lb	354	414
Daily gain, lb	1.40	1.64
Gain/a, lb	283	331
Average available forage dry matter, lb/a	5,215a	4,548b
Finishing phase (98 days)		
Beginning weight, lb	951	1011
Ending weight, lb	1363	1391
Gain, lb	412a	380b
Daily gain, lb	4.20a	3.88b
Daily dry matter intake, lb*	28.0	28.6
Feed:gain	6.68a	7.42b
Hot carcass weight, lb	845	862
Backfat, in	0.51	0.56
Ribeye area, sq. in.	13.0	13.3
Yield grade	2.7	2.7
Marbling score[1]	693	711
Percentage USDA grade Choice	97	100
Overall performance (grazing plus finishing; 351 days)		
Gain, lb	766	794
Daily gain, lb	2.18	2.26

[1]600 = modest, 700 = moderate, 800 = slightly abundant.
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 5. Effects of cultivar on grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2018

	Tall fescue cultivar			
Item	High-endophyte Kentucky 31	Low-endophyte Kentucky 31	HM4	MaxQ
Grazing phase (218 days)				
Number of head	16	16	16	16
Initial weight, lb	581	581	581	581
Ending weight, lb	815a	954b	940b	953b
Gain, lb	234a	372b	359b	372b
Daily gain, lb	1.07a	1.71b	1.65b	1.70b
Gain/a, lb	187a	298b	287b	297b
Finishing phase (112 days)				
Beginning weight, lb	815a	954b	940b	953b
Ending weight, lb	1225a	1381b	1341b	1371b
Gain, lb	410	427	401	418
Daily gain, lb	3.66	3.81	3.58	3.73
Daily dry matter intake, lb	26.2	28.6	28.2	26.5
Feed:gain	7.16a	7.50ab	7.92b	7.12a
Hot carcass weight, lb	760a	856b	831b	850b
Backfat, in.	0.51	0.55	0.55	0.56
Ribeye area, sq. in.	12.7	13.1	12.9	13.2
Yield grade	2.7	2.8	2.8	2.8
Marbling score[1]	740ab	759a	671c	694bc
Percentage USDA grade Choice	100	100	100	100
Overall performance (grazing plus finishing; 330 days)				
Gain, lb	644a	799b	760b	789b
Daily gain, lb	1.95a	2.42b	2.30b	2.39b

[1]600 = modest, 700 = moderate, 800 = slightly abundant.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 6. Effects of interseeding ladino clover on grazing and subsequent finishing performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2018

	Legume treatment	
Item	No legume	Ladino clover
Grazing phase (218 days)		
Number of head	32	32
Initial weight, lb	581	581
Ending weight, lb	914	917
Gain, lb	332	336
Daily gain, lb	1.52	1.54
Gain/a, lb	266	269
Finishing phase (112 days)		
Beginning weight, lb	914	917
Ending weight, lb	1322	1337
Gain, lb	408	420
Daily gain, lb	3.64	3.75
Daily dry matter intake, lb	28.1	26.6
Feed:gain	7.73a	7.12b
Hot carcass weight, lb	820	829
Backfat, in	0.55	0.54
Ribeye area, sq. in.	12.8	13.1
Yield grade	2.8	2.8
Marbling score[1]	711	721
Percentage USDA grade Choice	100	100
Overall performance (grazing plus finishing; 330 days)		
Gain, lb	741	756
Daily gain, lb	2.24	2.29

[1]700 = moderate, 800 = slightly abundant.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 7. Effects of cultivar on performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2019

	Tall fescue cultivar			
Item	High-endophyte Kentucky 31	Low-endophyte Kentucky 31	HM4	MaxQ
Grazing phase (226 days)				
Number of head	16	16	16	16
Initial weight, lb	563	563	563	563
Ending weight, lb	840a	915b	895b	915b
Gain, lb	278a	352b	332b	352b
Daily gain, lb	1.23a	1.56b	1.47b	1.56b
Gain/a, lb	222a	281b	266b	281b

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

Table 8. Effects of interseeding ladino clover on performance of steers grazing tall fescue pastures, Kansas State University Southeast Research and Extension Center, 2019

	Legume treatment	
Item	No legume	Ladino clover
Grazing phase (226 days)		
Number of head	32	32
Initial weight, lb	563	563
Ending weight, lb	891	892
Gain, lb	328	329
Daily gain, lb	1.45	1.45
Gain/a, lb	262	263

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

Effects of Various Grazing Systems on Grazing and Subsequent Finishing Performance

L.W. Lomas and J.L. Moyer

Summary
A total of 400 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, 2016, 2017, 2018, and 2019. Daily gains of steers that grazed MaxQ fescue, wheat-bermudagrass, or wheat-crabgrass were similar ($P > 0.05$) in 2010, 2016, 2017, and 2018. Daily gains of steers that grazed wheat-bermudagrass or wheat-crabgrass were greater ($P > 0.05$) than those that grazed MaxQ fescue in 2011, 2012, and 2019. 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, 2014, 2016, and 2018. 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. In 2017, finishing gains of steers that grazed wheat-crabgrass were greater ($P < 0.05$) than those that grazed MaxQ fescue.

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 Kansas State University Southeast Research and Extension 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 2010–2019, 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); March 30, 2016 (600 lb); March 28, 2017 (669 lb); April 3, 2018 (655 lb); and April 2, 2019 (651 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, 100 lb/a, 100 lb/a, 88 lb/a, and 82 lb/a of 'Everest' hard red winter wheat on September 27, 2011, September 25, 2012, September 23, 2013, September 29, 2014, September 22, 2015, October 4, 2016, September 29, 2017, and September 24, 2018, 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; February 11, 2016; February 13, 2017; January 31, 2018; and March 5, 2019. 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; May 23, 2016; June 13, 2017; June 8, 2018; and July 26, 2019. 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; September 7, 2016; September 22, 2017; August 29, 2018; and August 28, 2019. An additional 5 lb/a, 4 lb/a, 4 lb/a, 4 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, April 12, 2016, February 21, 2017, April 24, 2018, and June 11, 2019, 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 in 2010–2017 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); September 15, 2016 (169 days); September 12, 2017 (168 days); September 11, 2018 (161 days); and September 17, 2019 (168 days). 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); November 15, 2016 (230 days); November 14, 2017 (231 days); November 6, 2018 (217 days); and November 13, 2019 (225 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; 99 days (wheat-bermudagrass and wheat-crabgrass) or 97 days (fescue) in 2015; 99 days (wheat-bermudagrass and wheat-crabgrass) or 98 days (fescue) in 2016; 99 days (wheat-bermudagrass and wheat-crabgrass) or 91 days (fescue) in 2017; and 112 days in 2018. All steers were slaughtered in a commercial facility, and carcass data were collected.

Cattle that grazed these pastures in 2019 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, 6, 7, 8, and 9 for 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018, respectively. Grazing performance only for 2019 is presented in Table 10. 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 gains with 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 gains with 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. Grazing treatment had no effect ($P > 0.05$) on finishing gain or feed:gain; however, final finishing weight and hot carcass weight of steers that grazed MaxQ fescue were greater ($P < 0.05$) than those that grazed wheat-bermudagrass or wheat-crabgrass. Overall gain of steers that grazed MaxQ tall fescue was greater ($P < 0.05$) and overall daily gain was lower ($P < 0.05$) than that of those that grazed wheat-bermudagrass or wheat-crabgrass. This was due to steers that grazed wheat-bermudagrass or wheat-crabgrass spending a greater percentage of time in the finishing phase than those that grazed MaxQ tall fescue.

In 2017, 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 63 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 411, 312, and 332 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. Finishing gains of steers that grazed wheat-crabgrass were greater ($P < 0.05$) than those that had grazed MaxQ tall fescue and similar ($P > 0.05$) to those of steers that had grazed wheat-bermudagrass. Steers that had grazed MaxQ tall fescue had higher ($P < 0.05$) feed:gain and higher ($P < 0.05$) marbling scores than those that grazed wheat-bermudagrass or wheat-crabgrass.

In 2018, 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 56 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 403, 305, and 302 lb/a, respectively. Steers that grazed MaxQ pastures maintained their weight advantage from grazing through the finishing phase and were heavier ($P < 0.05$) at the end of the finishing phase, had greater ($P < 0.05$) hot carcass weight, greater ($P < 0.05$) ribeye area, and greater ($P < 0.05$) overall gain than those that grazed wheat-bermudagrass or wheat-crabgrass pastures.

In 2019, daily gains were greater ($P < 0.05$) for steers that grazed a wheat-bermudagrass double-crop system or a wheat-crabgrass double-crop system than for those that grazed MaxQ tall fescue. However, MaxQ tall fescue pastures were grazed 57 days longer and as a result produced similar ($P > 0.05$) steer grazing gain, similar ($P > 0.05$) steer ending weight, and similar ($P > 0.05$) gain per acre as wheat-bermudagrass and wheat-crabgrass pastures. Gain/a for MaxQ fescue, wheat-bermudagrass, and wheat-crabgrass were 259, 245, and 271 lb/a, respectively.

Hotter and 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 other years.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Effects of forage system on grazing and subsequent performance of stocker steers, Kansas State University Southeast Research and Extension 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 grade Choice	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, Kansas State University Southeast Research and Extension 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 grade Choice	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, Kansas State University Southeast Research and Extension 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 grade Choice	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, Kansas State University Southeast Research and Extension 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 grade Choice	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, Kansas State University Southeast Research and Extension 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 grade Choice	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, Kansas State University Southeast Research and Extension 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 grade Choice	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 and subsequent finishing performance of stocker steers, Kansas State University Southeast Research and Extension 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
Finishing phase			
Number of days	98	99	99
Beginning weight, lb	968a	880b	887b
Ending weight, lb	1412a	1322b	1328b
Gain, lb	444	442	441
Daily gain, lb	4.53	4.47	4.46
Daily dry matter intake, lb	28.8	28.7	28.5
Feed:gain	6.38	6.43	6.39
Hot carcass weight, lb	875a	820b	823b
Backfat, in.	0.50	0.53	0.47
Ribeye area, sq. in.	13.2a	12.2b	12.5ab
Yield grade	2.7ab	2.9a	2.6b
Marbling score[1]	645	620	607
Percentage USDA grade Choice	100	100	100
Overall performance (grazing plus finishing)			
Number of days	328	268	268
Gain, lb	812a	723b	728b
Daily gain, lb	2.48a	2.70b	2.72b

[1]600 = modest, 700 = moderate.

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

Table 8. Effects of forage system on grazing and subsequent finishing performance of stocker steers, Kansas State University Southeast Research and Extension Center, 2017

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	231	168	168
Number of head	16	12	12
Initial weight, lb	669	669	669
Ending weight, lb	1080a	981b	1002b
Gain, lb	411a	312b	332b
Daily gain, lb	1.78	1.86	1.98
Gain/a, lb	411a	312b	332b
Average available forage dry matter, lb/a	7183a	5191b	4719c
Finishing phase			
Number of days	91	99	99
Beginning weight, lb	1080a	981b	1002b
Ending weight, lb	1390	1371	1411
Gain, lb	310a	390b	410b
Daily gain, lb	3.41a	3.94ab	4.14b
Daily dry matter intake, lb	29.4	28.3	29.9
Feed:gain	8.65a	7.21b	7.22b
Hot carcass weight, lb	862	850	875
Backfat, in.	0.52	0.46	0.51
Ribeye area, sq. in.	13.4	13.4	13.1
Yield grade	2.6	2.4	2.6
Marbling score[1]	724a	597b	634b
Percentage USDA grade Choice	100	100	92
Overall performance (grazing plus finishing)			
Number of days	322	267	267
Gain, lb	721	702	742
Daily gain, lb	2.24a	2.63b	2.78b

[1]500 = small, 600 = modest, 700 = moderate, 800 = slightly abundant.
Means within a row followed by the same letter do not differ ($P < 0.05$).

Table 9. Effects of forage system on grazing and subsequent finishing performance of stocker steers, Kansas State University Southeast Research and Extension Center, 2018

	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	655	655	654
Ending weight, lb	1058a	959b	956b
Gain, lb	403a	305b	302b
Daily gain, lb	1.86	1.89	1.87
Gain/a, lb	403a	305b	302b
Finishing phase			
Number of days	112	112	112
Beginning weight, lb	1058a	959b	956b
Ending weight, lb	1450a	1343b	1345b
Gain, lb	392	384	389
Daily gain, lb	3.50	3.43	3.47
Daily dry matter intake, lb	27.4	27.5	27.8
Feed:gain	7.92	8.03	8.05
Hot carcass weight, lb	899a	833b	834b
Backfat, in.	0.58	0.54	0.53
Ribeye area, sq. in.	13.7a	13.2b	13.0b
Yield grade	2.7	2.7	2.8
Marbling score[1]	672	691	656
Percentage USDA grade Choice	94	100	100
Overall performance (grazing plus finishing)			
Number of days	329	273	273
Gain, lb	795a	688b	691b
Daily gain, lb	2.42	2.52	2.53

[1]600 = modest, 700 = moderate.

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

Table 10. Effects of forage system on grazing performance of stocker steers, Kansas State University Southeast Research and Extension Center, 2019

	Forage system		
Item	MaxQ fescue	Wheat-bermudagrass	Wheat-crabgrass
Grazing phase			
Number of days	225	168	168
Number of head	16	12	12
Initial weight, lb	651	651	651
Ending weight, lb	910	897	922
Gain, lb	259	245	271
Daily gain, lb	1.15a	1.46b	1.61b
Gain/a, lb	259	245	271

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

Spices Fed to Growing Heifers on Bromegrass Result in Increased Gains with Some Effects on Tick Populations

J.K. Farney

Summary

Alternative methods to antibiotics/chemical usage in cattle production have been of interest in recent years and essential oils/spices have been promoted to fill this niche. The purpose of this research was to evaluate effect of feeding spices on heifer gains and as a control method for ticks. Eight bromegrass pastures were stocked (March to November) with four heifers per pasture to compare control mineral (CON) to mineral containing spices (SPICE; garlic + proprietary blend of 4 spices). Mineral (4 oz/hd/d) was blended in dried distillers grains (DDGs) and total blend was supplemented daily at 0.5% of heifer body weight. Heifers were weighed on two consecutive days at the start and end of the study and every 28 d. Weekly (first 10 weeks), ticks were counted and removed from every heifer. Average daily gain was increased by 0.15 lb/d with the SPICE mineral, and heifers on SPICE gained 33 lb more over the entire grazing period than heifers on CON. The gain advantage for SPICE was observed within the first four months on supplement and continued through the end of the study. Overall, these heifers had a low tick population (137 total ticks collected). Even so, there was a tendency for SPICE heifers to have more ticks/heifer than CON heifers when measured on weeks 2 and 3, yet at weeks 8 and 10 SPICE heifers tended to have fewer ticks/heifer than CON. SPICE in a mineral blended with DDGs increased heifer gains and appeared, after a minimum of 4 weeks of consumption, to show some repellent effects to ticks.

Introduction

The major driver for the economics of cattle production is still the increase in pounds of beef. Tools to improve gains are important options for producers. Essential oils have been promoted as a "natural method" to increase cattle gains and a method to control ticks and flies. Work completed mainly in feedlots located in South America showed that feeding spices (aka essential oils) increased calf gain more than no additive feeding. Additionally, some research has found that feeding spices/essential oils has resulted in similar gains in feedlot cattle as feeding the ionophore monensin.

Ticks are ectoparasites that reduce profits and preventing/controlling ticks is important in many types of cattle operations. Controlling ticks is especially important for anaplasmosis management. Essential oils from garlic and oregano have been shown to have the potential to kill ticks. Spraying a garlic extract with distilled water on cattle removed all ticks within 2 days of spraying and kept the ticks off the cattle for 7 days. Additionally, in a grazing dairy cow study, feeding garlic for 3 days reduced ticks on cattle, even when measuring 11 days after feeding ended. Most studies that have shown effectiveness in controlling ticks have included methods of spraying cattle with essential oils.

A limited number of studies evaluated growing calf gains on grass with essential oils, and a limited number of studies evaluated tick management while feeding essential oils, especially on beef species. Therefore, the purpose of this study was to evaluate heifer gains on bromegrass while feeding spices and to evaluate the ability of spices to control ticks.

Experimental Procedures

Eight pastures (5 acres each) of smooth bromegrass were stocked with 4 heifers per pasture beginning April 9, 2019. All heifers were fed dried distillers grains daily at 0.5% of body weight on a dry matter basis. This was adjusted every 28 days based on weights. The two treatments consisted of complete mineral mixed into the DDGs. The two minerals (Table 1) were a control mineral with 25% of magnesium, copper, manganese, and zinc coming from a chelated source or that same base mineral with garlic (3 pounds/ton) and Solus (18 pounds/ton; SPICE). Animals were fed four ounces of the mineral type for their group, mixed with the DDGs and offered daily. We hand-fed the mixture for a more accurate consumption base measurement and to know that all heifers ate the mineral every day. There were four pastures of each treatment type. Heifers were individually weighed every 28 days.

Beginning one week after heifers were placed on brome pastures each heifer was run through the chute and the number of ticks were counted and then removed from the heifer. The tick type, sex, and engorgement were recorded. Ticks were counted and collected weekly until May 22, when infestation level was drastically reduced. Ticks were counted and removed again on June 6 and June 20 when only 4 heifers had ticks. Generally, at this location there were no ticks on the cattle after the first month of grazing.

Results and Discussion

Heifer Gains

Average daily gain was increased by 0.15 lb/d with the SPICE mineral, and heifers on SPICE gained 33 lb more over the entire grazing period than heifers on CON (Table 2). By ~4 months on supplement, the SPICE heifers had gained more than the CON heifers (Figure 1) and they continued this advantage through end of study.

Tick Control

Overall, there were more ticks on the SPICE heifers than those on the CON mineral (73 total ticks over the study versus 64 total ticks). However, there fewer overall number of ticks on the SPICE heifers that were engorged (7 ticks engorged for SPICE and 14 engorged for CON). Engorgement means ticks had been attached for a long enough period that they increased in size. Potentially the SPICE cattle had a less desirable blood flavor that did not attract these ticks to stay on the animal for longer period of time. The greatest number of ticks was observed 1 month after grazing started (Figure 2). It took a month or more for the SPICE to have an effect on the ticks that attached to the heifers. By week 5 there were fewer ticks on heifers receiving the SPICE mineral, and a beginning of a trend for fewer heifers to have ticks (Figure 2). This might indicate a time to "build up" tick resistance with the levels of spices fed.

Table 1. Mineral composition

Item (on dry matter basis)	Control mineral	Spice mineral[1]
Crude protein (%)	5.69	5.50
Calcium (%)	16.67	16.17
Phosphorus (%)	3.33	3.44
Salt (%)	22.54	22.53
Magnesium[2] (%)	2.51	2.48
Potassium (%)	0.89	0.88
Iron (ppm)	5546	5529
Copper[3] (ppm)	1153	1153
Zinc[3] (ppm)	3471	3471
Manganese[3] (ppm)	1817	1818
Selenium (ppm)	22	22
Iodine (ppm)	333	333
Cobalt (ppm)	13	13
Vitamin A (IU)	141,667	141,667
Vitamin D (IU)	14,167	14,167
Vitamin E (IU)	172	172

[1]Spice mineral similar base as control mineral with addition of 3 pounds per ton garlic oil and 18 pounds per ton of Solace (Wildcat Feeds Inc., Topeka, KS) that replaced dried distillers grains and limestone in control mineral.
[2]Nuplex Mg/K, Nutech Biosciences Inc. (Oneida, NY) contributed 25% of the magnesium in the minerals.
[3]Nuplex 3-chelate blend, Nutech Biosciences Inc. (Oneida, NY) contributed 25% of the copper, zinc, and manganese of the total trace mineral supplied in the minerals.

Table 2. Gain differences based on treatment

Item	Control	Spice	*P*-value
Initial weight, lb	438.7	438.8	0.99
Final weight, lb	773.7	806.0	0.13
Average daily gain, lb/d	1.72	1.88	0.04

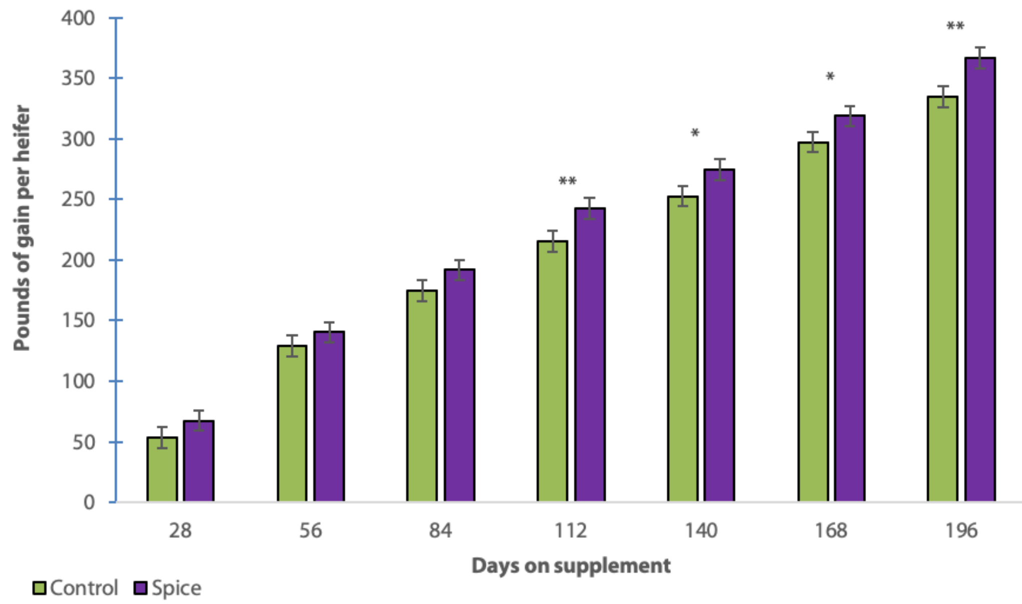


Figure 1. Average weight gain (pounds/heifer) while grazing bromegrass and fed with dried distillers grains with mineral daily.

Control mineral is in green bars, spice mineral in purple bars.

*Indicates gains tended to be different between treatments at $0.05 < P < 0.10$.

**Indicates gains tended to be different between treatments at $P < 0.05$.

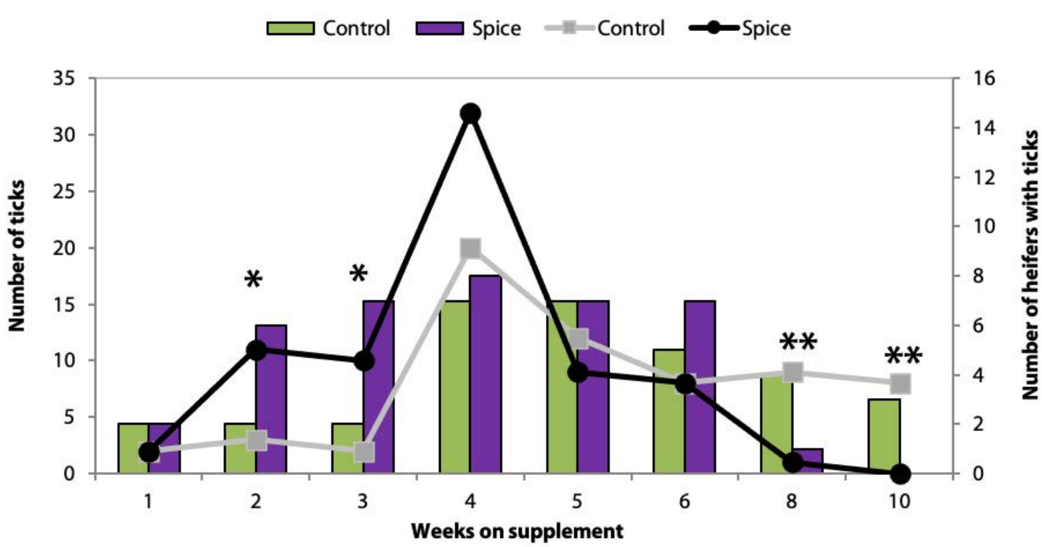


Figure 2. Weekly number of ticks and heifers with ticks by treatment.

Black line is the number of ticks collected off of heifers each week that were fed SPICE mineral. Grey line is the number of ticks collected off of heifers each week that were fed CON mineral. Green bars are the number of heifers with ticks that were fed the CON mineral. Purple bars are the number of heifers with ticks that were fed the SPICE mineral. No effect $P > 0.10$ on number of heifers with ticks. Treatment × week ($P = 0.02$) was different for tick numbers.

*Indicates gains tended to be different between treatments at $0.05 < P < 0.10$.

**Indicates gains tended to be different between treatments at $P < 0.05$.

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

D.W. Sweeney and D. Ruiz-Diaz[1]

Summary
Corn yield and yield components were affected by tillage and nitrogen (N) side-dress application options in 2019. Average corn yields were 15% greater with conventional tillage than with no-till. Yields were improved by either splitting N rate between pre-plant and side-dress at the V10 growth stage or adding additional side-dress N as compared with applying 150 lb/a pre-plant.

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 pre-plant 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 tillage. Sub-plot nitrogen treatments were six pre-plant/side-dress N application combinations that include:

1. A no-N control;
2. 150 lb N/a applied pre-plant;
3. 100 lb N/a applied pre-plant with 50 lb N/a applied at the V6 (six-leaf) growth stage;
4. 100 lb N/a applied pre-plant with 50 lb N/a applied at the V10 (ten-leaf) growth stage;
5. 150 lb N/a applied pre-plant with 50 lb N/a applied at the V6 growth stage; and
6. 150 lb N/a applied pre-plant 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. Pre-plant N fertilizer was applied on March 13, 2019, side-dress N at V6 on June 3, 2019, and side-dress N at V10 on June 13, 2019, to appropriate plots. All N was broadcast applied with 7-stream pattern fertilizer nozzles. Corn was planted on April 11 and harvested on September 5, 2019.

1 Department of Agronomy, Kansas State University, Manhattan, KS.

Results and Discussion

In 2019, average corn yielded 22 bu/a more with conventional tillage than with no-tillage, partially due to having a 9% greater established stand (Table 1). Adding N fertilizer more than tripled yields obtained in the no-N control. Splitting the N fertilizer to apply 100 lb N/a preplant followed by 50 lb N/a at the V10 growth stage improved yields by 15 bu/a more than all N applied pre-plant. Adding 50 lb N/a extra at the V6 or V10 growth stages to a 150 lb N/a preplant application did not improve yields more than that obtained with 150 lb N/a applied split pre-plant and side-dress at V10. These effects of N application timing on corn yield in 2019 appeared to be related to the combined responses in kernel weight, ears/plant, and kernels/ear.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project KS00-0104-HA.

Table 1. Tillage and nitrogen (N) side-dress application effects on yield and yield components of corn in 2019

Treatment	Yield	Stand	Kernel weight	Ears/plant	Kernels/ear
	bu/a	plants/a	mg		
Tillage					
Conventional[1]	167	22,300	271	0.95	709
No-till	145	20,400	258	0.97	689
LSD (0.10)	15	800	NS	NS	NS
N timing[2]					
No-N control	54	21,900	205	0.84	371
150 PP	164	21,600	260	0.99	752
100 PP/50 V6	166	21,600	273	0.99	724
100 PP/50 V10	179	22,200	273	0.98	768
150 PP/50 V6	187	21,000	287	0.99	801
150 PP/50 V10	186	21,000	289	1.00	778
LSD (0.05)	9	NS	15	0.05	52

[1]Conventional tillage: chisel, disk, and field cultivate.
[2]Nitrogen treatments:
Control = no N fertilizer.
150 PP = 150 lb N/a applied pre-plant with no side-dress N.
100 PP/50 V6 = 100 lb N/a applied pre-plant with 50 lb N/a side-dress applied at V6 (six-leaf) growth stage.
100 PP/50 V10 = 100 lb N/a applied pre-plant with 50 lb N/a side-dress applied at V10 (ten-leaf) growth stage.
150 PP/50 V6 = 150 lb N/a applied pre-plant with 50 lb N/a side-dress applied at V6 growth stage.
150 PP/50 V10 = 150 lb N/a applied pre-plant with 50 lb N/a side-dress applied at V10 growth stage.

Pre-Plant Nitrogen Rate and Application Method and Side-Dress Nitrogen Rate Effects on No-Till Corn Grown on a Claypan Soil

D.W. Sweeney and D. Ruiz-Diaz[1]

Summary
Average corn yield in 2019 was increased by 14 bu/a with knife application of pre-plant nitrogen (N) fertilizer compared with broadcast application. Applying N more than doubled yield of corn grown without N. In general, applying side-dress N increased yields compared to yields obtained with only pre-plant applications.

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. Pre-plant N application method, pre-plant N rate, and side-dress N rate selections create opportunities to provide N during rapid growth periods and 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 pre-plant and side-dress N fertilization options on corn grown no-till on a claypan soil.

Experimental Procedures
The experiment was established in spring 2018 on a Parsons silt loam soil at the Parsons Unit of the Kansas State University Southeast Research and Extension Center that had been in continuous no-till for more than 10 years. The experiment was a factorial arrangement of a randomized complete block design with four blocks (replications). The two factors were pre-plant N fertilizer placement of broadcast and knife (subsurface band at 4 inches deep) and pre-plant/side-dress N rates of 0-0, 0-150, 100-0, 100-50, 100-100, 150-0, 150-50, 150-100, and 200-0 lb/a. Side-dress applications were broadcast at the V10 growth stage using 7-stream pattern, fertilizer nozzles dropped to less than a foot above the soil surface. The N source for all treatments was liquid urea-ammonium nitrate (UAN; 28% N) fertilizer. Pre-plant N fertilizer was applied on March 19, 2019, and side-dress N was applied at V10 on June 20, 2019, to appropriate plots. Corn was planted on April 11 and harvested on September 4, 2019.

Results and Discussion
Knife application of the N applied pre-plant resulted in 14 bu/a greater yields than when the pre-plant N was broadcast applied (Table 1). This was partially because of approximately 7% greater number of ears per plant with knifing than with broadcasting. The other yield components were not affected by pre-plant application method ($P = 0.05$). Applying N at any rate and time more than doubled corn yield in 2019 compared to the 84 bu/a yield with the no-N control. In general, applying side-dress N

1 Department of Agronomy, Kansas State University, Manhattan, KS.

increased yields compared to yields obtained with only pre-plant applications; however, the increase from side-dress appeared greater when the pre-plant N was 100 lb N/a than when the pre-plant N was 150 lb N/a. Increasing total N rate to greater than 100 lb N/a resulted in increased yield regardless of individual rates of pre-plant/side-dress N applications, with few differences in combinations where total N was 150 lb/a or greater. Stand was not affected by pre-plant/side-dress N rates, but fertilizing with N increased kernel weight, the number of ears/plant, and the number of kernels/ear compared with corn grown in the no-N control.

Acknowledgment
This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project KS00-0104-HA.

Table 1. Pre-plant application method and pre-plant/side-dress nitrogen (N) rates effects on yield and yield components of corn planted no-till on a claypan soil in 2019

Treatment	Yield	Stand	Kernel weight	Ears/plant	Kernels/ear
	bu/a	plants/a	mg		
Pre-plant N method					
Broadcast	176	21,700	257	1.17	675
Knife[1]	190	21,400	261	1.25	691
LSD (0.10)	6	NS	NS	0.05	NS
Pre-plant/side-dress[2]					
N rates (lb/a)					
0-0 (No-N control)	84	21,000	220	0.91	510
0-150	188	21,300	277	1.11	730
100-0	174	21,900	262	1.15	674
100-50	197	22,200	262	1.20	721
100-100	201	21,100	271	1.34	677
150-0	195	21,800	264	1.26	692
150-50	205	21,700	272	1.29	691
150-100	208	21,800	240	1.33	772
200-0	194	21,200	266	1.29	681
LSD (0.05)	13	NS	20	0.10	67

[1]Knife: subsurface band at 4 inch depth.
[2]Side-dress applications were made at the V10 growth stage.

Nitrogen Fertilizer Timing and Phosphorus and Potassium Fertilization Rates for Established Endophyte-Free Tall Fescue

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

Summary
Tall fescue production was measured during the second year of a study with locations started in fall of 2016 and fall of 2017. In the second year at both sites, phosphorus (P) fertilization rate did not affect harvest yields. Applying nitrogen (N) in late fall or late winter resulted in greater spring yields than applying N in spring or not applying N. However, fall harvest yields at Site 1 in 2018 were greater without N, but were greater with spring N application at Site 2 in 2019. In both site-years, the second-year tall fescue total yield rank as affected by N fertilizer timing was late fall=late winter>spring>no N, even though overall yields were greater in 2019 at Site 2.

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. The objective of this study was to determine the effect of N fertilizer timing and P and potassium (K) fertilization rates on tall fescue yields.

Experimental Procedures
The experiment was conducted on two adjacent sites of established endophyte-free tall fescue beginning in the fall of 2016 (Site 1) and 2017 (Site 2) at the Parsons Unit of the Kansas State University Southeast Research and Extension Center. The soil at both sites was a Parsons silt loam. The experimental design was a split-plot arrangement of a randomized complete block. The six whole plots received combinations of P_2O_5 and K_2O fertilizer rates allowing for two separate analyses: 1) four rates 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) a 2 × 2 factorial combination of two rates of P_2O_5 (0 and 50 lb/a) and two levels of K_2O (0 and 40 lb/a). Subplots were four application timings of N fertilization consisting of none, late fall, late winter, and spring (E2 growth stage). Phosphorus and K fertilizers were broadcast applied in the fall as 0-46-0 (triple superphosphate) and 0-0-60 (potassium chloride). Nitrogen, as 46-0-0 (urea) solid at 120 lb N/a, was broadcast applied to appropriate plots on December 1, 2017, March 2, 2018, and April 27, 2018, at Site 1. Nitrogen was applied on December 4, 2018, March 18, 2019, and April 25, 2019, at Site 2. Second-year harvest dates from each site were as follows: (1) spring yield was measured at R4 (half bloom) on May 17, 2018, at Site 1 and on May 17, 2019, at Site 2; (2) fall harvest was taken on September 12, 2018, at Site 1 and on September 10, 2019, at Site 2.

Results and Discussion

Dry conditions in 2018 resulted in low, second-year tall fescue yields at Site 1 (Table 1). In the second year of the study at Site 1, spring harvest, fall harvest, or total yield of tall fescue was unaffected by P fertilization. Spring harvest yield was greatest when N was applied either in late fall or late winter. Even though applying N fertilizer at the E2 growth stage in spring resulted in greater yield compared with no N, delaying N application resulted in more than a 40% reduction in spring yield compared with the more traditional timings of either late fall or late winter. However, at the fall harvest, tall fescue yield was less with N application than without. Average annual total tall fescue yield was increased by applying N. Late fall and late winter application resulted in similar total yields which were 35% to 67% greater than with spring (E2) fertilization or no N, respectively.

Second-year tall fescue spring harvest, fall harvest, or total yields in 2019 at Site 2 were unaffected by P fertilization (Table 2). Spring tall fescue yield was similar with late fall and late winter N fertilization. However, as for the second year at Site 1 (Table 1), both late fall and late winter N fertilization in the first year at Site 2 resulted in greater spring yield than with no N or N applied at the E2 growth stage in spring (Table 2). In contrast to results from Site 1 (Table 1), spring N application did result in greater fall yield than with no N or N applied in late fall or late winter (Table 2). At Site 2, as with Site 1 (Table 1), the second-year tall fescue total yield rank as affected by N fertilizer timing was late fall=late winter>spring>no N (Table 2).

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project KS00-0104-HA.

Table 1. Second-year yield of established tall fescue in the spring (R4-half bloom) and fall 2018 as affected by P_2O_5 fertilization rates and nitrogen (N) application timing at Site 1

Treatment	Spring harvest	Fall harvest	Total harvest (R4 + Fall)
P_2O_5 (lb/a)	-------------------------- ton/a, 12% moisture --------------------------		
0	0.82	1.02	1.83
25	1.03	0.99	2.02
50	1.06	1.01	2.07
100[1]	1.08	1.00	2.08
LSD (0.05)	NS	NS	NS
N application timing			
None	0.31	1.13	1.44
Late fall	1.43	0.96	2.39
Late winter	1.45	0.95	2.41
Spring	0.80	0.96	1.76
LSD (0.05)	0.17	0.15	0.20

[1]The 100 lb P_2O_5/a rate was only applied at the beginning of the study (Fall 2016).

Table 2. First-year yield of established tall fescue in the spring (R4-half bloom) and fall 2019 as affected by P_2O_5 fertilization rates and nitrogen (N) application timing at Site 2

Treatment	Spring harvest	Fall harvest	Total harvest (R4 + Fall)
P_2O_5 (lb/a)	-------------------------- ton/a, 12% moisture --------------------------		
0	1.84	1.41	3.25
25	1.92	1.34	3.26
50	2.12	1.35	3.47
100[1]	2.00	1.28	3.28
LSD (0.05)	NS	NS	NS
N application timing			
None	0.62	1.17	1.79
Late fall	2.96	1.20	4.16
Late winter	2.81	1.31	4.12
Spring	1.49	1.70	3.19
LSD (0.05)	0.19	0.16	0.28

[1]The 100 lb P_2O_5/a rate was only applied at the beginning of the study (Fall 2017).

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

D.W. Sweeney, P. Barnes,[1] and G. Pierzynski[2]

Summary
The residual from previous high-rate turkey litter applications, which were based on nitrogen (N) requirements of the previous grain sorghum crop, increased 2019 soybean yield more than that obtained from the residual of phosphorus (P)-based turkey litter applications (low rate) or the control. Even though early soybean growth was unaffected by residual treatments, the dry matter production at the R6 growth stage was greater with N-based litter application than with P-based applications or the control.

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
Previous to this study, a water quality experiment was conducted near Girard, KS, on the Greenbush Educational facility's grounds from spring 2011 through spring 2014. Those treatments, listed below, were fertilizer and turkey litter applications based on 120 lb N/a and 50 lb P_2O_5/a rates applied prior to planting grain sorghum each spring. Individual plot size was 1 acre. The five treatments, replicated twice, were:

1. Control: no N or P fertilizer or turkey litter—no tillage;
2. Fert-C: commercial N and P fertilizer only—chisel-disk tillage;
3. TL-N: N-based turkey litter, no extra N or P fertilizer—no tillage;
4. TL-N-C: N-based turkey litter, no extra N or P fertilizer—chisel-disk tillage; and
5. TL-P-C: P-based turkey litter, supplemented with fertilizer N—chisel-disk tillage.

Starting in 2014 after the previously-mentioned study, soybean was planted with no further application of turkey litter or fertilizer. Prior to planting soybean, tillage opera-

1 Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS.
2 Department of Agronomy, Kansas State University, Manhattan, KS.

tions were done in appropriate plots as in previous years. A sub-area 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 sub-area designated for plant measurements in each plot. Soybean was planted on June 7, 2019, and harvested on October 28, 2019. Whole plant samples were taken on June 28 (V4), July 24 (R2), August 19 (R4), and September 23 (R6), 2019.

Results and Discussion

In 2019, the residual from previous high rate turkey litter applications, which were based on N requirements of the previous grain sorghum crops grown from 2011 through 2013, increased 2019 soybean yield compared to that obtained from the residual of P-based turkey litter applications (low rate) or the control (Table 1). The soybean yields with the Fert-C treatment were less than TL-N, but were not statistically different than TL-N-C. The number of pods/plant were greater where N-based turkey litter had been applied in no-till than where a low rate of turkey litter or no fertilizer or litter had been applied. The effect of residual treatments on soybean dry matter production was non-significant through most of the growing season. However, by R6, dry matter production was greater where turkey litter had previously been applied on an N-basis (high rate) than on a P-basis (low rate) or the no-N/no-P control, with dry matter from the Fert-C treatment being intermediate.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project KS00-0104-HA; and partially funded by a U.S. Department of Agriculture Natural Resource Conservation Service Conservation Innovation Grant.

Table 1. Residual effect of turkey litter and fertilizer amendments on soybean yield, yield components, and dry matter production during 2019

Residual amendment[1]	Yield	Stand (×1000)	Seed weight	Pods/ plant	Seeds/ pod	Dry matter V3	R2	R4	R6
	bu/a	plants/a	mg			lb/a			
Control	31.3	87.0	151	50	2.2	100	970	2280	5460
Fert-C	46.7	89.1	143	77	2.2	70	710	2780	8090
TL-N	59.3	88.9	155	76	2.1	90	1030	4610	9120
TL-N-C	56.9	86.6	152	91	2.1	80	690	3340	9440
TL-P-C	41.1	86.5	151	62	2.1	100	860	3280	5500
LSD (0.10)	10.3	NS	NS	21	NS	NS	NS	NS	2650

[1]Control = no turkey litter or N and P fertilizer with no tillage.
Fert-C = commercial fertilizer incorporated with conventional tillage.
TL-N = N-based turkey litter application with no tillage.
TL-N-C = N-based turkey litter application incorporated with conventional tillage.
TL-P-C = P-based turkey litter application and supplemental N application incorporated with conventional tillage.

Effect of Burning and Tillage Options on Yields in a Continuous Wheat-Double-Crop Soybean Rotation

D.W. Sweeney

Summary

Double-crop soybean yields during the first two years of this study have not been affected by management of previous wheat straw practices by burning or tillage done before planting. However, by the second year of the study, subsequent wheat yields were 41% greater where the wheat residue had been burned the previous year.

Introduction

Double-cropping of soybeans after wheat is practiced by many producers in southeastern Kansas. Several options exist for dealing with wheat straw residue from the previous crop before planting soybeans. However, the method of managing the residue may affect not only the double-crop soybeans but also the following wheat crop. The objective of this study was to determine the effect of burning or no burning with three tillage options (reduced-till, strip-till, and no-till) on double-crop soybean and subsequent wheat yields.

Experimental Procedures

Six wheat residue management systems for double-crop soybean and the subsequent wheat crop were established in spring 2017. The experiment was a split-plot arrangement of a randomized complete block with three replications. The whole plots were burn and no-burn and the subplots were tillage options of reduced-till, strip-till, and no-till prior to planting the double-crop soybeans. In each year after the soybean harvest, the entire area was disked, field cultivated, fertilized, and planted to wheat. Thus, treatment effects on wheat yield was due to the residual from the residue management treatments for the double-crop soybeans.

Results and Discussion

In both 2017 and 2018, burning or not of wheat straw, or tillage prior to planting, did not affect double-crop soybean yields. In 2018, after one year of a continuous wheat-double-crop soybean rotation, subsequent wheat yields were unaffected by the residual of burn or tillage treatments. However, in 2019 wheat yields were 41% greater where the wheat residue had been burned in 2018, even though wheat yields were unaffected by using reduced-, strip-, or no-tillage to plant the previous double-crop soybeans.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project KS00-0104-HA.

Table 1. Effect of residue management on double-crop soybean and subsequent wheat yields

	Double-crop soybean yields		Wheat yields	
Residue management[1]	2017	2018	2018	2019
	---------- bu/a ----------			
Burn				
Yes	36.4	33.5	55.4	48.5
No	38.2	38.0	55.4	34.3
LSD (0.05)	NS	NS	NS	10.1
Tillage				
Reduced-till	38.3	33.5	55.2	42.4
Strip-till	36.1	36.6	56.9	40.6
No-till	37.4	37.2	54.2	41.2
LSD (0.05)	NS	NS	NS	NS

[1]Residue management effects on wheat yields are the residual following those treatments for the double-crop soybeans in the previous year.

Southeast Kansas Crop Production Summary - 2019

G.F. Sassenrath, L. Mengarelli, J. Lingenfelser, X. Lin, and E. Adee

Summary
This is a summary of the crop production conditions in southeast Kansas in 2019, and the results of the variety testing for corn, soybean, sorghum, sunflower, and wheat.

Introduction
Crop production is dependent on many factors including cultivar selection, environmental conditions, soil, and management practices. This report summarizes the environmental conditions during the 2019 growing season in comparison to previous years and the historical averages. In 2019, full-season corn varieties were flooded out at the river bottom location at Erie. Thirty full-season corn varieties were compared at Ottawa; 9 short-season corn varieties were tested at Parsons and Ottawa. Both hard and soft wheat variety plots were abandoned at both locations due to excessive rain and poor stand establishment. There were 29 sorghum varieties tested and seven sunflower varieties at Parsons. Soybeans tested included 31 varieties of MG3-4 and 37 varieties of MG4-5 at both upland and river bottom locations at Parsons and Erie.

Growing degree day information is now available on the Kansas Mesonet website (http://mesonet.k-state.edu/agriculture/degreedays/) (Lin et al., 2019).

Experimental Procedures
The Kansas State University Crop Performance Tests were conducted in replicated research fields throughout the state. This report summarizes crop production for southeast Kansas, focusing on crops grown at Parsons, Erie, and Columbus, KS. Due to crop loss from flooding, results from variety testing at the Ottawa station in Franklin County are reported for comparison. Crop varieties were tested in river bottom fields (Lanton silt loam soil type) near Erie, KS; upland fields (Parsons silt loam soil) at the Southeast Research and Extension Center in Parsons; and the research fields outside of Columbus, KS (Parsons silt loam soil). The river bottom land near Erie, KS, was flooded and the corn crop was abandoned. Poor stand establishment from excessive rain led to abandonment of wheat plots at all testing locations. All crop variety trials are managed with conventional tillage. Individual variety results are available at the K-State Crop Performance Test webpage (http://www.agronomy.k-state.edu/services/crop-performance-tests/).

Soybeans were planted in 30-in. rows on June 26, 2019, in Columbus and Erie, and harvested November 18, 2019. Fertilizer was broadcast at 18-46-60 lb/a N-P-K diammonium phosphate (DAP) and potash in Columbus; no fertilizer was applied at Erie. Weeds were controlled with Gramoxone (2 pt/a), Dual II Magnum (2 pt/a), metribuzin (1.5 lb/a), and Authority XL (6 oz/a).

Sorghum was planted on June 19, 2019, at a seeding rate of 87,120 seeds/a in Parsons and harvested October 3, 2019. Fertilizer was applied at a rate of 150-46-60 lb/a N-P-K. Weeds were controlled with atrazine (2 qt/a), Dual II (S-metolachlor, 2 pt/a), and 2,4-D Amine (2 qt/a).

Sunflowers were planted July 11, 2019, at a rate of 23,800 seed/a in 30-in. rows at Parsons. Plots were fertilized at a rate of 80-46-60 lb/a N-P-K. Weed control was Gramoxone (1 qt/a), Dual Magnum (1 pt/a), and Spartan (6 oz/a). Plots were harvested on November 12, 2019.

Weather information was downloaded from the Kansas Mesonet site (http://mesonet.k-state.edu/weather/historical/). Historical data from the Parsons and Columbus stations were used in preparing these reports. Rainfall is reported on a water year (WY) basis, that begins October 1 and ends September 30 of the next year. Cumulative rainfall during the summer growing season was also calculated. Growing degree days were calculated using a base temperature of 50°F.

Results and Discussion

Rainfall

Rainfall during the 2018-19 water year was near record highs (Figure 1A). Initial rainfall in the fall was slightly higher than average. However, beginning with a 3.7 in. rainfall on April 30, the next 8 months received 47.5 in. of rain. There were several periods of very high rainfall totals, such as the 4.4 in. rain received on August 1. While high single-day rain events are not uncommon in southeast Kansas, the continuous high rain events made for a very wet year, well above the 9-year average of 40.4 in. Water-year rainfall totals ranged from a low of 21.9 in. in WY2012 to 69.9 in. in WY2019. Total rainfall during the summer growing season (March-October, 60.7 in.; Figure 1B) greatly exceeded the 9-year average of 33.1 in. Summer rainfall can be quite variable, ranging from a low of 12.7 in. in 2011 to a high of 60.7 in. in 2017.

Temperature

Temperatures in 2019 were slightly cooler than average throughout the summer growing season (Figure 2A), especially later in the summer. Extreme values of cumulative GDD50 were experienced in 2012 and 2019, which also had the greatest and the least number of days, respectively, with maximum temperatures exceeding 90°F (Figure 2B). Higher temperatures reduce the yield of corn and soybeans. High temperatures days during 2019 were much lower than average (Figure 2B).

Crop Production

Winter wheat was planted on 6.9 million acres throughout Kansas. Wheat was particularly hard-pressed from the excessive rain. Wheat variety trials at many locations in the state were abandoned in 2019 due to poor stands. State-wide, wheat yields were slightly above average in 2019 at 52 bu/a (Figure 3).

Corn was planted in 6.4 million acres in Kansas in 2019, an increase from last year. Full-season corn varieties were tested in river bottom ground at Erie. Flooding eliminated the crop and the crop variety test at Erie was abandoned. Thirty full-season corn varieties were tested at Ottawa, with an average yield of 154.8 bu/a and a range from 110.7 to

196.6 bu/a (Figure 4A). Nine short-season corn varieties were tested on upland ground at Parsons, with an average yield of 143.5 bu/a, and a range of 121.3 to 158.7 bu/a (Figure 4B). This was greater than the state average yield for 2019 of 133 bu/a and the 10-year state average yield of 128.5 bu/a.

Soybeans were planted on 4.55 million acres in Kansas in 2019, with 1.19 million acres in southeast Kansas. Thirty-one cultivars of soybeans from maturity groups (MG) 3-4 were tested, with an average yield of 51.7 bu/a and a range of 40.4 to 61.7 bu/a, which was greater than the state average yield of 41.5 bu/a (Figure 5A). This was also greater than the state 10-year average of 36.4 bu/a. Thirty-seven cultivars of soybeans from MG 4-5 were tested, with an average yield of 51.6 bu/a and a range from 41.9 to 58.6 bu/a (Figure 5B).

Grain sorghum was planted on 2.6 million acres in Kansas in 2019. Grain sorghum yields were lower in 2019 for the twenty-eight cultivars tested, with an average yield of 91 bu/a and a range from 53.5 to 113.4 bu/a (Figure 6). This is higher than state average yield for 2019 of 85 bu/a and the 10-year average state yield of 73.6 bu/a.

Sunflowers were planted on 45,000 acres in Kansas in 2019. Six cultivars of oilseed sunflowers were grown in 2019, with an average yield of 2142 lb/a and a range from 1957 to 2377 lb/a (Figure 7). This was much higher than the 10-year state average yield of 1404 lb/a and the state average yield of 1372 lb/a.

Conclusions

2019 was a challenging year for crop production due to excessive rainfall. Mild temperatures reduced heat stress for summer crop production. State average crop yields for corn, sorghum, soybeans, and wheat were above the 10-year average; sunflower yields were slightly below the 10-year average.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1003478.

References

Lin, X., Z. Zambreski, M. Knapp, R. Aiken, G. Sassenrath. 2019. Learn about the new monthly Kansas Ag-Climate Update. Agronomy eUpdate. Iss 731, Feb. 8, 2019. https://webapp.agron.ksu.edu/agr_social/m_eu_article.throck?article_id=2098

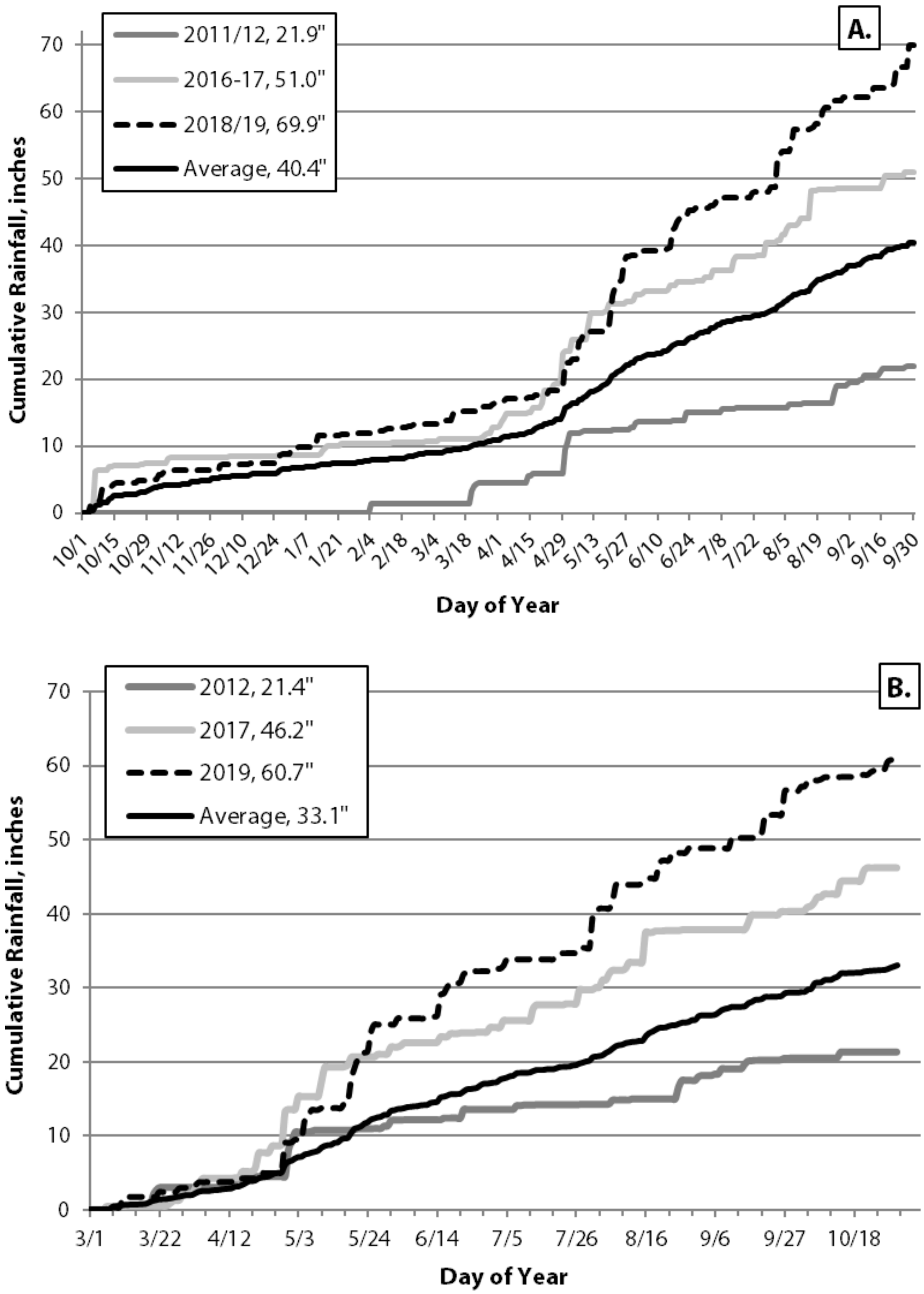


Figure 1. Cumulative rainfall (A) during the water year from October 1 through September 30 and (B) during the summer crop production season. Nine-year average included for comparison. Rainfall total in inches given after each year in legend.

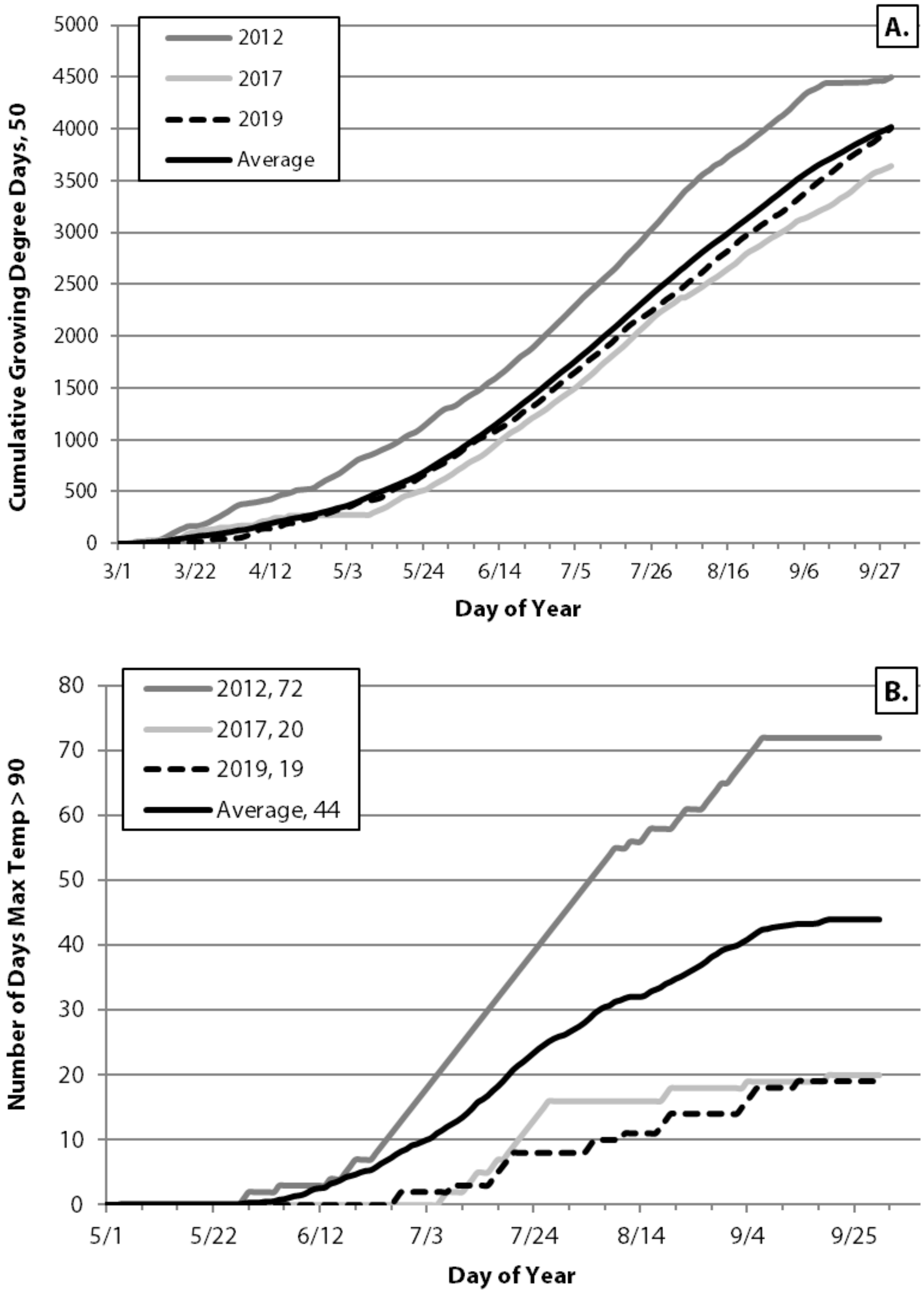
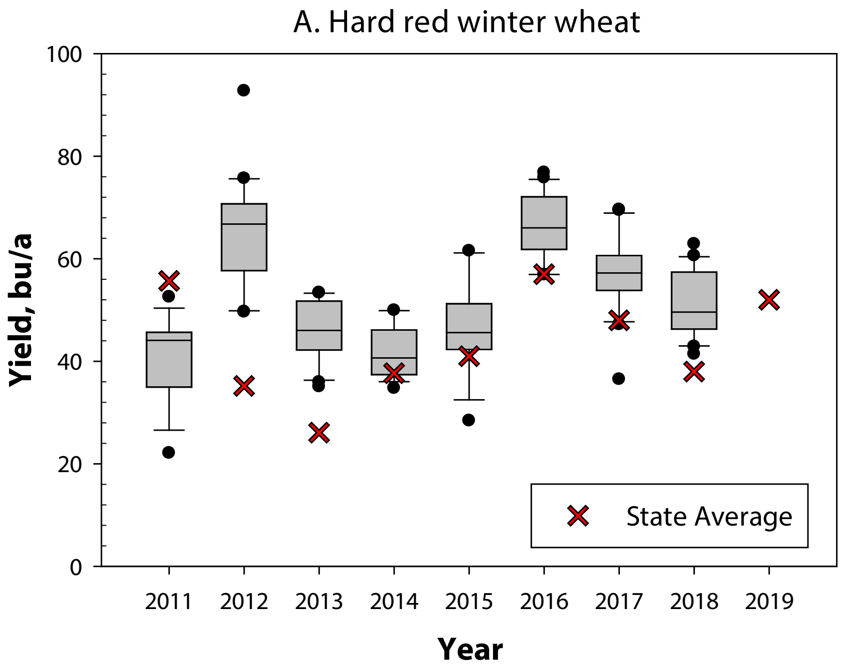


Figure 2. Temperature patterns and extremes during 2018 and preceding years. (A) Cumulative growing degree days calculated with a base temperature of 50°F during the summer growing season. (B) Number of days the maximum temperature was greater than 90°F. Nine-year average included for comparison.



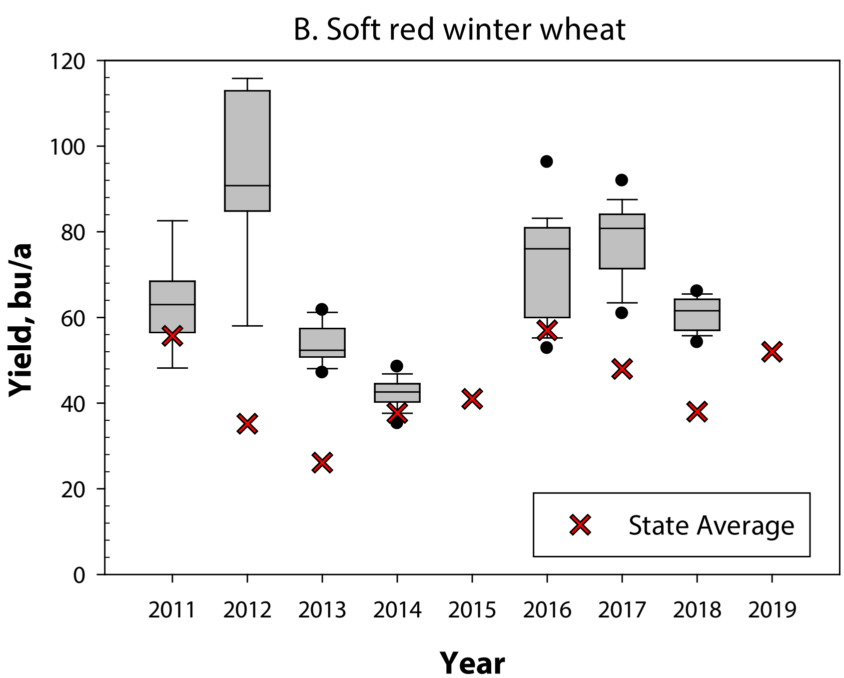


Figure 3. Winter wheat yield for (A) hard red wheat and (B) soft red wheat from variety trials in southeast and eastern Kansas from 2011 through 2018. Variety testing at Ottawa and Parsons were abandoned due to flooding and poor stands. The line in the middle of the box plots is the median yield of all 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 given as solid circles. Note the difference in scale between the hard red and soft red variety results. For comparison, average reported yields from Kansas are highlighted as a red X.

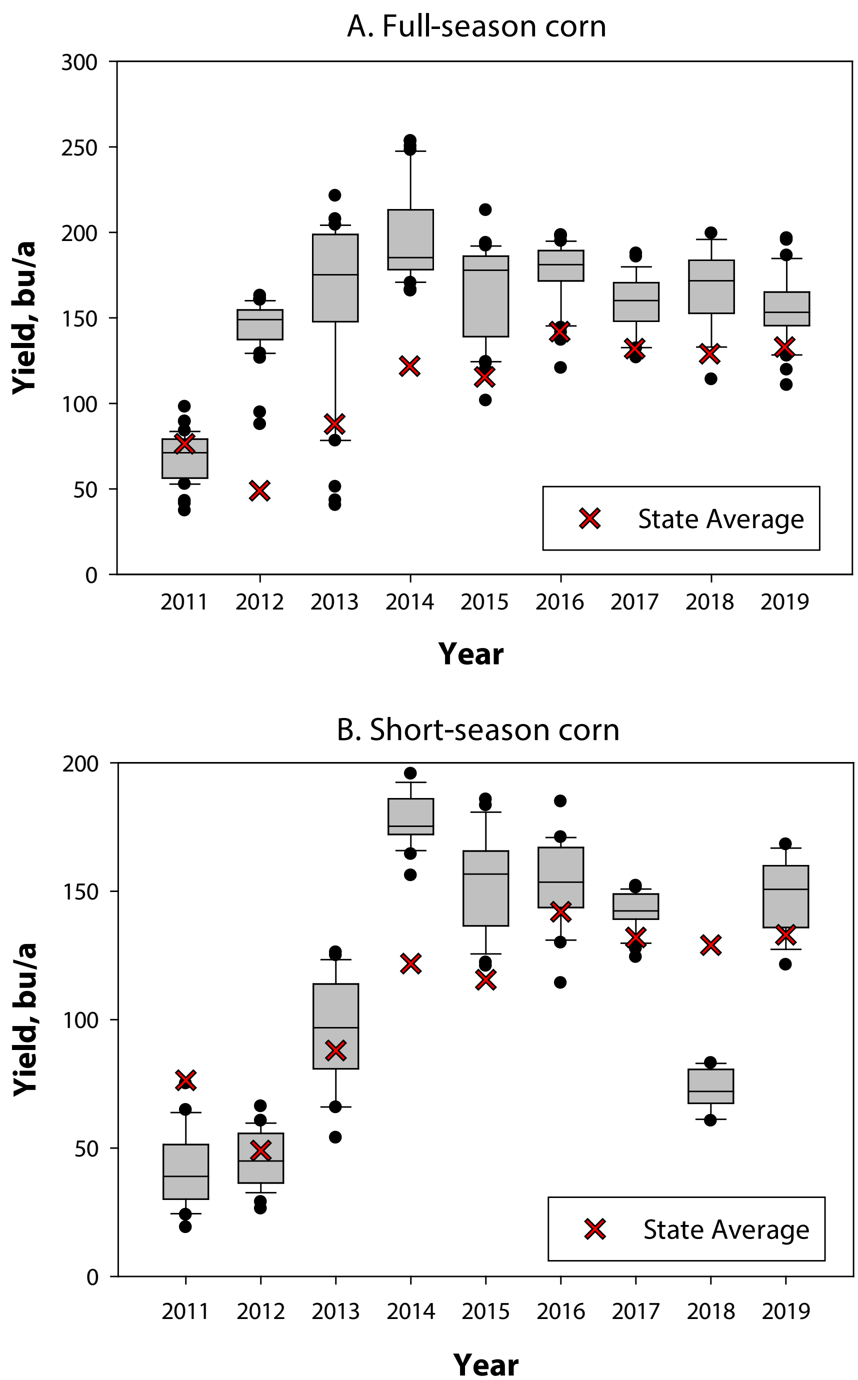


Figure 4. (A) Full-season corn at Ottawa and (B) and short-season corn at Parsons and Ottawa, KS, from variety trials grown from 2011 through 2019. For comparison, reported state average yields are highlighted as a red X.

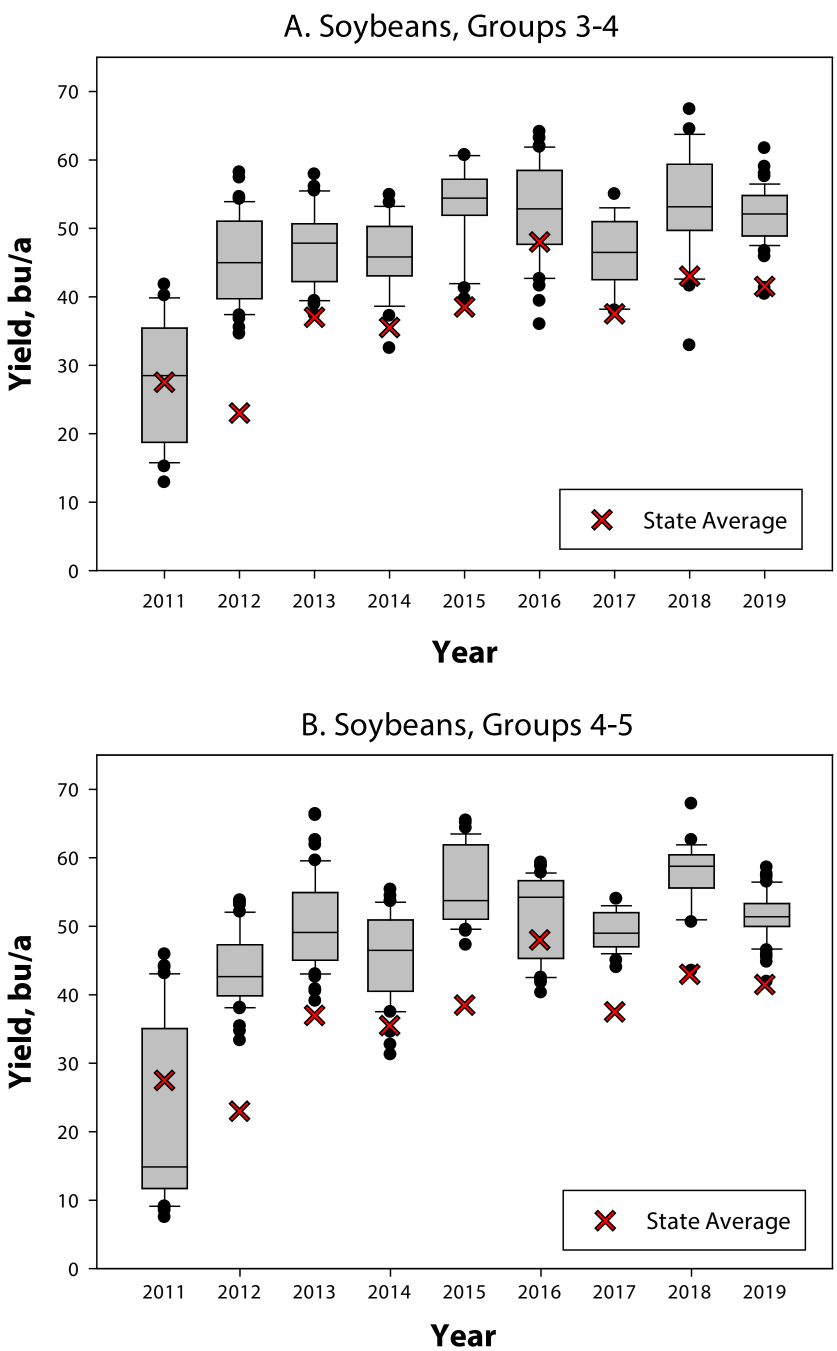


Figure 5. Soybeans from (A) MG3-4 and (B) MG4-5 from variety trials grown at Columbus, Erie, and Parsons, KS, from 2011 through 2019. For comparison, average reported yields from Kansas are highlighted as a red X.

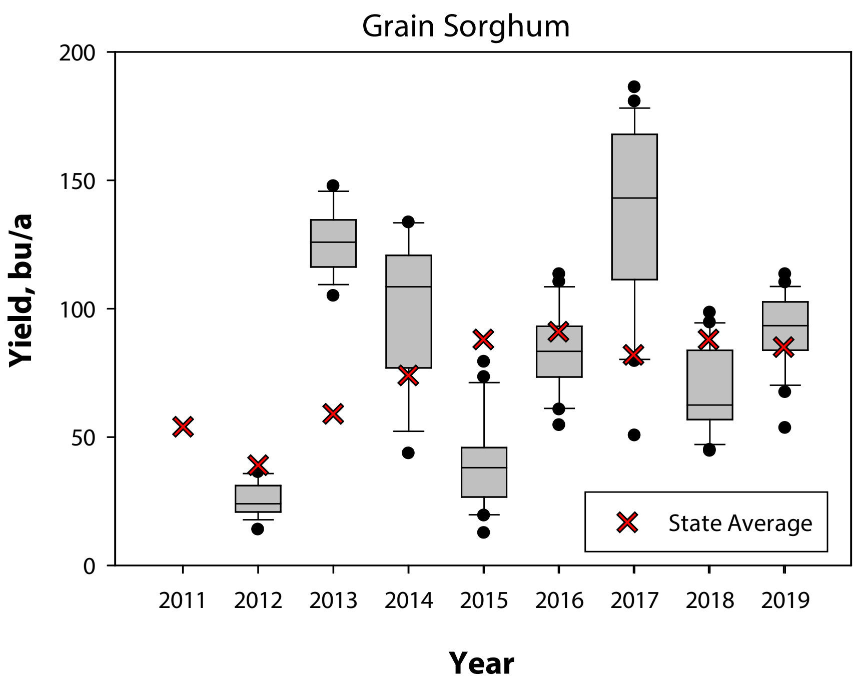


Figure 6. Grain sorghum from variety trials grown at Parsons, KS, from 2011 through 2019. Yield was not available for the variety trials in 2011. For comparison, average reported yields from Kansas are highlighted as a red X.

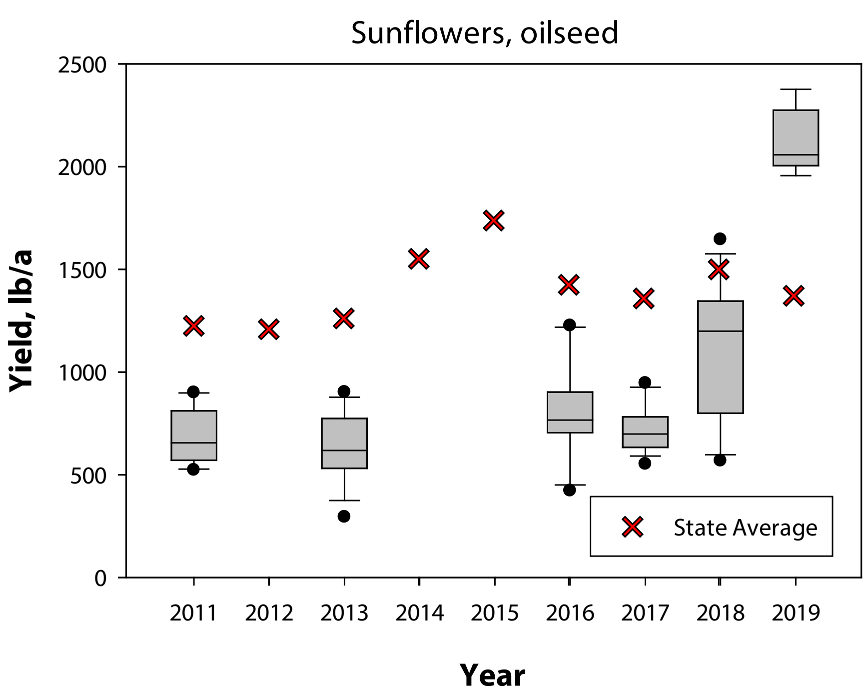


Figure 7. Oilseed sunflowers from variety trials grown at Parsons, KS, from 2011 through 2019. Yield data were not available from the variety plots in 2012, 2014, or 2015. For comparison, average reported Kansas state yields are highlighted as a red X.

The Cost of Tillage

G.F. Sassenrath

Summary
Tillage has been a common event in farming for centuries. New information and management practices are demonstrating better ways of managing the soil to reduce erosion and improve productivity and profitability. Tillage destroys the soil structure, actually increasing the weeds and reducing the water holding capacity of the soil. Highly erodible areas of a field can lose more than 5 tons of soil per year with conventional tillage. Converting to no-till management can reduce production costs more than $30 per acre per year, saving topsoil and reducing management time in the field.

Introduction
Tillage has been used for centuries. The common thought is that it is required to loosen the soil to prepare a good seed bed and can be used to control weeds. However, tillage damages the soil structure and increases erosion. In addition, over the long term, tillage increases compaction of the soil because of poor soil structure.

This research explores the real cost of tillage from a broader standpoint. Impacts of tillage on soil erosion, crop productivity, equipment and fuel costs, nutrients, water, and time requirements are presented. Long-term productivity and profitability are determined for a silt-loam soil in southeast Kansas.

Experimental Procedures
Three crop production fields in southeast Kansas were used to estimate costs of tillage. The soil types in the fields included Verdigris silt loam and Kenoma silt loam. One field was in long-term conventional tillage. One field had been in conventional tillage and was converted to no-till 5 years prior. The third field had been in no-till for more than 20 years.

Conventional tilled and no-till production systems were compared for a corn/soybean rotation system using the SoilCalculator from Agren, Inc. For the simulation, field size was set to 80 acres with a silt-loam soil in Labette County, KS. Specific management practices for the conventional tillage included chisel and cultivate prior to corn and soybean planting. No-till management had no tillage operations. Fertilizer, herbicide, fungicide, planting, and harvesting operations were the same for both conventional and no-till production. Grain yield for corn was estimated to be 170 bu/a with 3136 lb/a crop residue, and 40 bu/a for soybeans with 866 lb/a crop residue.

Cost-Return Budgets for southeast Kansas from the Kansas State University Department of Agricultural Economics were used to estimate production costs. Economic and productivity impacts for 1, 2, 5, 10, and 20 years were calculated with the Agren SoilCalculator based on the cost-return budgets for southeast Kansas. Crop water use was modeled using a modified evapotranspiration model based on the Penman-Monteith.

Soil samples were collected to a depth of 6 in. in each of the three fields in late June 2018. The soil was weighed, dried, and reweighed to determine total water content.

Results and Discussion

Conventional tillage increased the per-acre cost of production by $28.19 (Table 1). The one-year average soil loss across the entire field was calculated to be much greater in the tilled field than in the no-till field (2.9 tons for the tilled field vs. 0.5 tons for the no-till field; Table 2). Not all areas within a field will have the same rate of soil loss. For the areas of the fields with highest rates of erosion, the soil loss estimates were calculated as 5.7 tons from the tilled field versus 0.9 tons for the no-till field. Over a 10-year time period, this would result in a 0.19 in. of soil loss in a tilled field versus only a 0.03 in. soil loss in no-till. Similarly, the most erodible portion of the field would lose an estimated 0.39 in. of soil under tillage, with only a 0.06 in. of soil loss with no-till.

Soil loss decreases the productive capacity of the soil, reducing the crop yield. Nutrients are lost with the soil particles during erosion. Moreover, loss of soil reduces the water and nutrient holding capacity of the soil. These losses are additive. The Agren SoilCalculator estimated the average yield loss arising because of the calculated soil loss (Table 3 and 4). Soil erosion would result in $0.23 loss per acre in crop yield under conventional tillage in comparison to $0.04 lost with no-till. Similarly, nutrient loss was estimated at $15.07 per acre under conventional tillage compared to $2.69 per acre under no-till. Over the entire 80-acre field, this yearly lost productivity and nutrient loss would result in a cumulative erosion cost of $2,074.98 for the conventional tillage. Soil erosion still occurs under no-till production. However, the total cumulative cost of erosion is much less for no-till production, estimated at $370.52 per acre. These losses accumulate for each year the field is in production.

Soil is an important component of the water cycle. Healthy soil is able to hold more water and make that water available to the growing crop. It has been estimated (Bryant, 2015) that for every 1% increase in organic matter, soil available water increases by more than 20,000 gallons per acre. During the hottest time of the growing season, corn uses nearly 0.5 inch of water every day (Figure 1). The water in the soil was nearly double for the long-term no-till field than for the conventionally tilled field (Figure 2). This would provide much greater water available for the growing crop in the no-tilled field.

Tillage has often been reported to improve soil tilth. Some evidence suggests that tillage improves yields. However, new evidence is showing that the yield-drag from no-till is much smaller than originally thought and may even be non-existent. Tillage is expensive to implement. The cost of equipment and fuel averages about $14 per tillage pass per acre. That value is not per tillage event, it is per tillage pass. If multiple passes are made across a field, for example for field cultivation, each pass is costing about $14. Additionally, approximately 0.12 hours (7 minutes) are being spent on each acre of ground tilled. Moreover, nutrient and production losses cost about $15.23/acre. Tillage also reduces the water-holding capacity of the field, reducing water available to the growing crop. Most significantly, the loss of soil from a tilled field is not replaced. The loss of soil is nearly permanent, as it takes about 500 years to make an inch of soil. The lost soil is a permanent reduction in the productive capacity of the field.

No-till crop production is a viable alternative for southeast Kansas. While there is concern that no-till fields remain too wet in the spring, the fact is that the no-till fields have better soil structure. This improved soil structure allows access to no-till fields earlier than for tilled fields. No-till requires careful management to control weed populations. However, the increase in herbicide-resistant weeds makes weed control important in any production system. Moreover, it has been shown that tillage can actually increase the weed population (Chism et al. 2019). While the weed population was reduced immediately after a tillage event, the weeds were not controlled and additional measures were required to reduce weed pressure. The productivity and profitability of crop production can be improved by implementing no-till production methods.

Acknowledgments

We are grateful to Tom Buman for providing the Agren SoilCalculator results. This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1003478.

References

Bryant, L. 2015. Organic matter can improve your soil's water holding capacity. NRDC. https://www.nrdc.org/experts/lara-bryant/organic-matter-can-improve-your-soils-water-holding-capacity

Chism, L.I., Dille, J.A., Sassenrath, G.F. 2019. Using cover crops as an effective weed control method in Southeast Kansas. *Kansas Agricultural Experiment Station Research Reports*: Vol. 5: Iss. 2. https://doi.org/10.4148/2378-5977.7743

Table 1. Production costs – conventional and no-tillage corn/soybean rotation

Tillage operation	Conventional tillage	No-tillage
	---------------------------------- $/acre ----------------------------------	
Fall – chisel	$15.91	
Spring – cultivator	$12.28	
Total yearly costs	$28.19	$0.00

Costs estimated from the Kansas State University Cost-Return Budgets for southeast Kansas.

Table 2. Soil loss estimation – conventional and no-tillage corn/soybean rotation

Tillage operation	Conventional tillage	No-tillage
1-year soil loss (tons/acre)		
Field average	2.9 tons	0.5 tons
Top 20% most erodible average	5.7 tons	0.9 tons
10-year soil loss (inches)		
Field average	0.19 inches	0.03 inches
Top 20% most erodible average	0.39 inches	0.06 inches

Calculations modeled with the Agren SoilCalculator.

Table 3. Yield and nutrient loss estimation – conventional tillage

Year	Cumulative yield loss/acre	Cumulative nutrient loss/acre	Total yield and nutrient loss/acre	Total cumulative erosion cost
1	$0.23	$15.07	$15.30	$2,074.98
3	$1.37	$45.22	$46.59	$6,318.05
5	$3.43	$75.36	$78.79	$10,685.25
10	$12.59	$150.72	$163.31	$22,146.33
20	$48.06	$301.45	$349.50	$47,396.02

Calculations modeled with the Agren SoilCalculator.

Table 4. Yield and nutrient loss estimation – no-tillage

Year	Cumulative yield loss/acre	Cumulative nutrient loss/acre	Total yield and nutrient loss/acre	Total cumulative erosion cost
1	$0.04	$2.69	$2.73	$370.52
3	$0.25	$8.07	$8.32	$1,128.20
5	$0.61	$13.46	$14.07	$1,908.04
10	$2.25	$26.91	$29.16	$3,954.61
20	$8.58	$53.83	$62.41	$8,463.38

Calculations modeled with the Agren SoilCalculator.

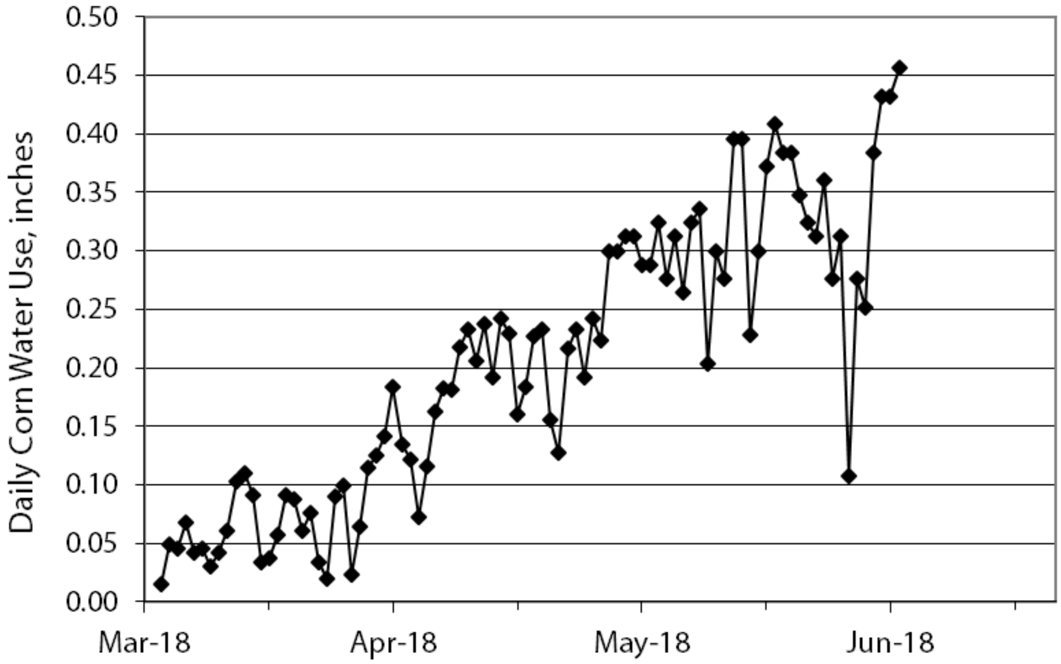


Figure 1. Corn water use for a Kenoma silt loam soil in Labette, KS. Daily water use was calculated using a modified Penman-Monteith equation for the corn growing season of 2018.

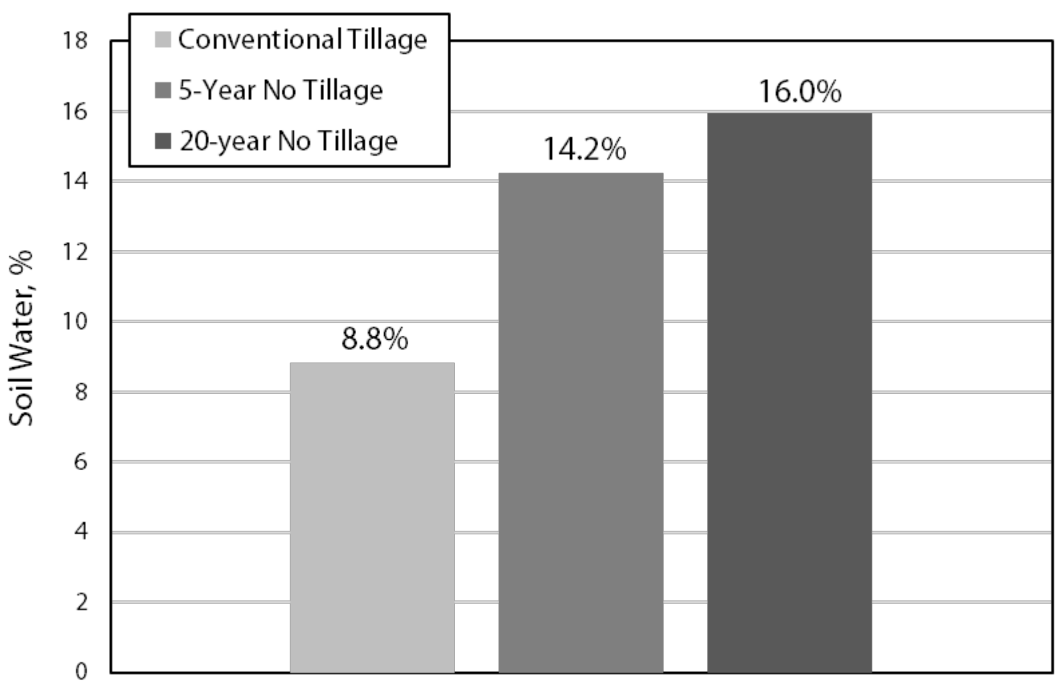


Figure 2. Soil water content of top 6 inches of soil from a conventional-tilled field, and fields that have been in no-till production for 5 years, and more than 20 years.

Corn Date of Planting and Depth

G.F. Sassenrath, L. Mengarelli, and X. Lin

Summary
The exceptionally wet weather in 2019 impacted corn yield. Excessive rainfall reduced corn emergence and plant stand. Many production fields were replanted due to poor stand from flooding. In this study, corn that was planted too shallow (1 inch) or too deep (3 inches) had less yield than that planted at 2-inch depth. The best yield was observed in the corn planted on April 16, 2019. The results from this record wet year were different from previous years, when early planted corn had higher yields.

Introduction
Temperature and rainfall are important for crop growth and development. Growing degree days (GDD) for corn production are calculated by subtracting a base or threshold temperature of 50°F from the average daily temperature. The calculated GDD50 are available on the Kansas Mesonet website (http://mesonet.k-state.edu/agriculture/degreedays/). The cumulative GDD is a useful tool to estimate crop development and predict crop stage for management inputs, and is calculated by adding GDD from a date, such as day of planting, to the current day. On average, it takes 90–120 GDD for corn to emerge (https://www.rawlins.k-state.edu/agronomy/cornmaturity.html). Corn will silk at about 1500 GDD. Physiological maturity, or black layer, requires approximately 2670 GDD for a 110-day hybrid.

Early season soil temperatures are important for corn germination and growth. High temperatures later in the season can limit grain filling. The timing and amount of rainfall are important for crop development. Because corn only flowers once, it is very sensitive to drought during the flowering period (tasseling and silking). Insufficient rainfall can reduce the fertilization of ovules, resulting in unfertilized ovules and reduced yield. Conversely, excess rainfall during pollination can disrupt fertilization and reduce yield. Inadequate rainfall or temperatures that are too high or low may abort ovules and reduce yield. Climatic conditions cannot be managed. However, management practices can be implemented that make the best use of the environmental conditions. Corn planting in southeast Kansas begins in mid-March after soil temperatures are above 50°F. The later the corn is planted, the warmer the soil temperatures will be. However, previous research has demonstrated the need to time the flowering of corn to coincide with periods of adequate moisture in rainfed environments. Since our highest rainfall period occurs in late May, corn pollination ideally should be timed to occur prior to July 4.

This study was undertaken to explore the impact of planting date and planting depth on corn yield. Soil temperature and moisture change with depth in the soil profile. Planting at deeper depths may allow the corn roots to access more moisture. Conversely, shallower depths may have warmer temperatures and allow more rapid crop growth early in the season.

Experimental Procedures

Corn was planted in replicated plots at the Kansas State University Southeast Research and Extension Center fields in Parsons, KS, in 30 in. rows at a rate of 23,100 seeds per acre with a Monosem planter. The field was managed with conventional tillage: chisel disk, fertilized with 180-46-60 N-P-K as urea, diammonium phosphate (DAP) and potash, and field cultivated. Weeds were controlled with a pre-emerge mix of glyphosate (2 qt/a), atrazine (1.5 lb/a), and 2,4-D (1 qt/a); and a post-emerge mix of Roundup (1 qt/a), atrazine (1 lb), and 2,4-D (1 qt/a). Roundup was sprayed as needed around V6.

Treatments included four cultivars of varying maturity: 96 day (P9697); 105 day (P0589); 115 day (P1151); and 118 day (P1862). Corn was planted on three planting dates: early (March 28, 2019); mid (April 16, 2019); and late (May 16, 2019); at planting depths of 1, 2, and 3 in. Early- and mid-planted plots were harvested on September 9, 2019. Late-planted plots were harvested on October 14, 2019.

Weather data were downloaded from the Kansas Mesonet website at Parsons, KS. Growing degree days were calculated from date of planting for each of the planting dates, using a base temperature of 50°F. Daily GDD were summed to determined cumulative GDD50 for each planting date. Similarly, daily rainfall data were summed for each planting date to determine total rainfall for each planting date.

Results and Discussion

2019 was a record-setting year for rainfall in Kansas. The rain hampered field operations. It also impacted corn emergence. The early-planted corn had a reasonably dry spell immediately after planting, but cooler soil temperatures delayed emergence until approximately 18 days after planting (DAP; Figure 2). The mid-planted corn emerged at 12 DAP, while the late-planted corn emerged at 8 DAP. However, the mid-planted corn experienced a 10-day period of rain totaling 8.5 inches shortly after emergence. Similarly, the late-planted corn received 11.26 inches of rain over a 10-day period just after planting.

Corn emergence is usually delayed for early planting dates due to lower soil temperatures. This occurred in 2019 as well, with no corn emergence until after 14 days after planting for the early planting date (Figure 2). Emergence was also delayed at lower planting depths (3 inches). Emergence was more rapid in the mid-planted corn. Emergence was still delayed, however, possibly due to the heavy rainfall. Surprisingly, emergence was very delayed in the late-planted corn. This was again due to the heavy rain, as the seeds had received enough GDD for emergence. The rain also reduced the plant stand, as the best rate of emergence was less than 80%. Emergence was particularly suppressed at lower planting depths, again due to the wet soil conditions.

Accumulation of heat units was almost parallel during the growing season for all three planting dates, with an expected delay with later planting (Figure 1). Physiological maturity was similarly delayed, with the latest planting date not achieving black layer until August 29. This delayed harvest.

Yield was surprisingly consistent between planting dates, but was strongly dependent on planting depth (Figure 3). The best yield was measured at 2-inch planting depth. Either shallower or deeper planted corn had reduced yield, irrespective of planting date. Slight improvement in yield was observed at the mid-planting date. This is in contrast to previous years' data at this site, when the early-planted corn had higher yields than mid- or late-planted corn.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1003478.

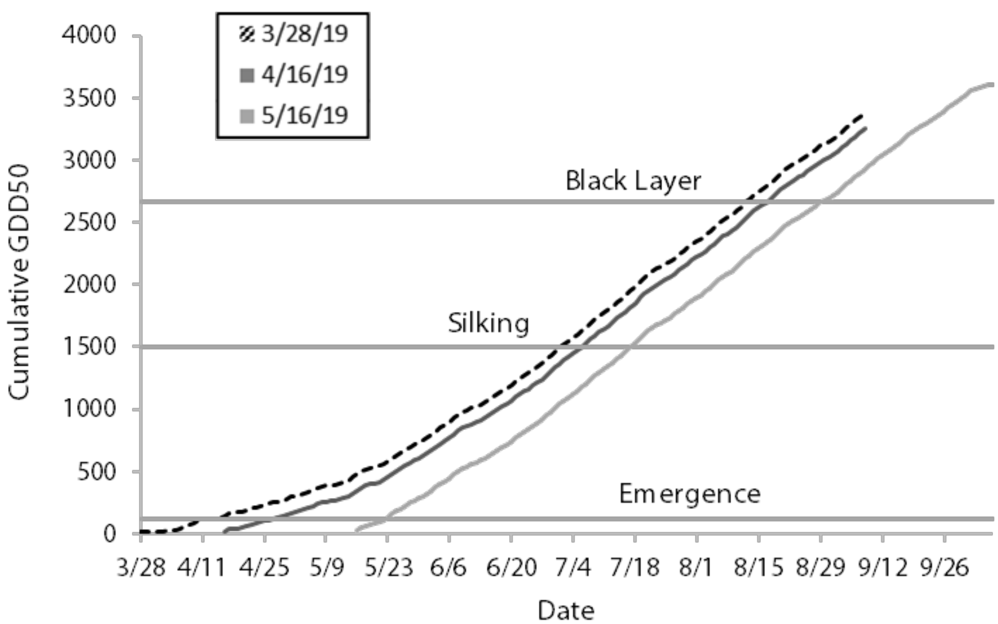


Figure 1. Cumulative growing degree days from day of planting for corn at three planting times. Estimated growing degree days for emergence (120 GDD), silking (1500 GDD) and physiological maturity (black layer, 2670 GDD) are shown.

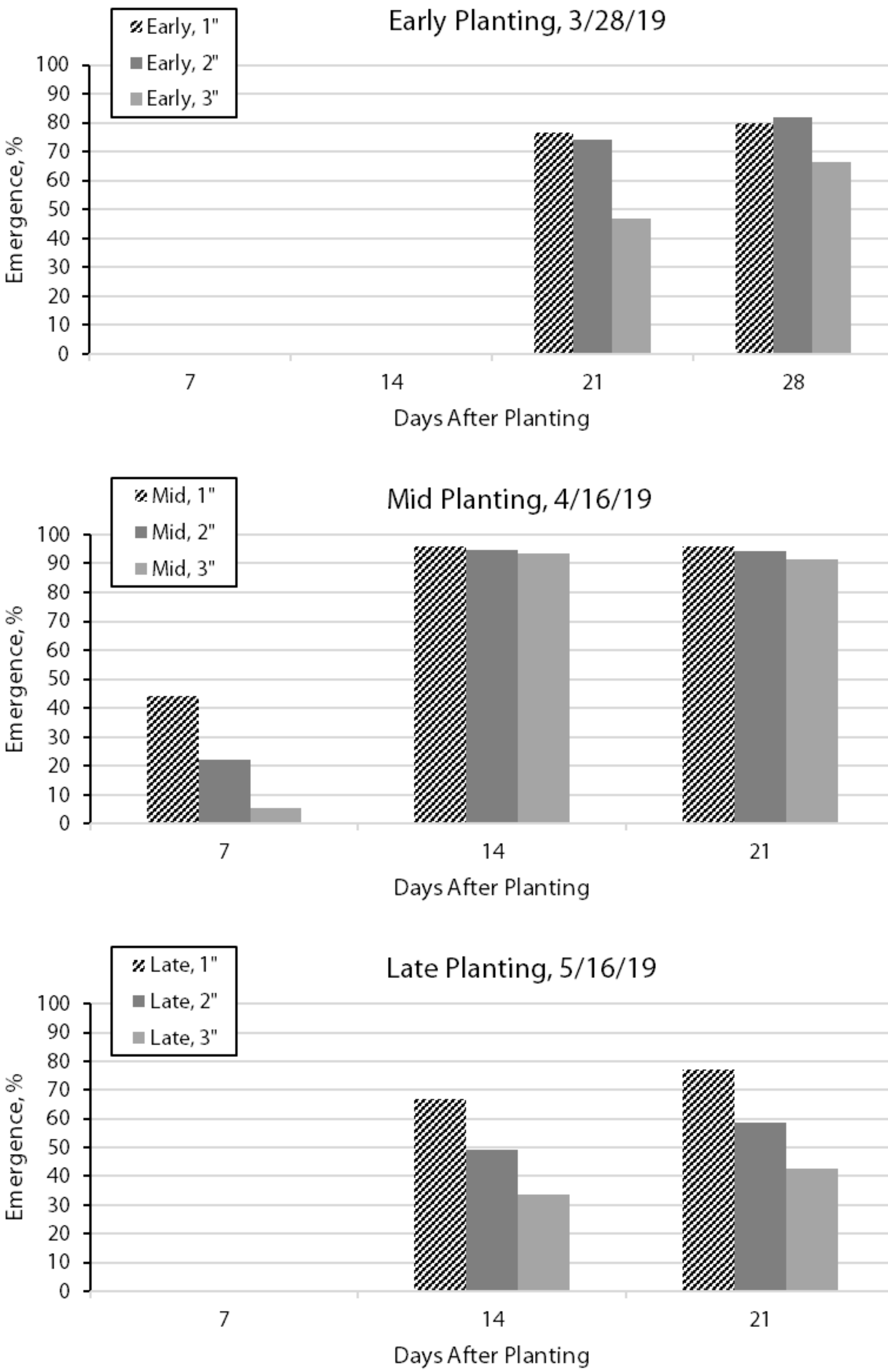


Figure 2. Emergence of corn at three planting dates and three depths.

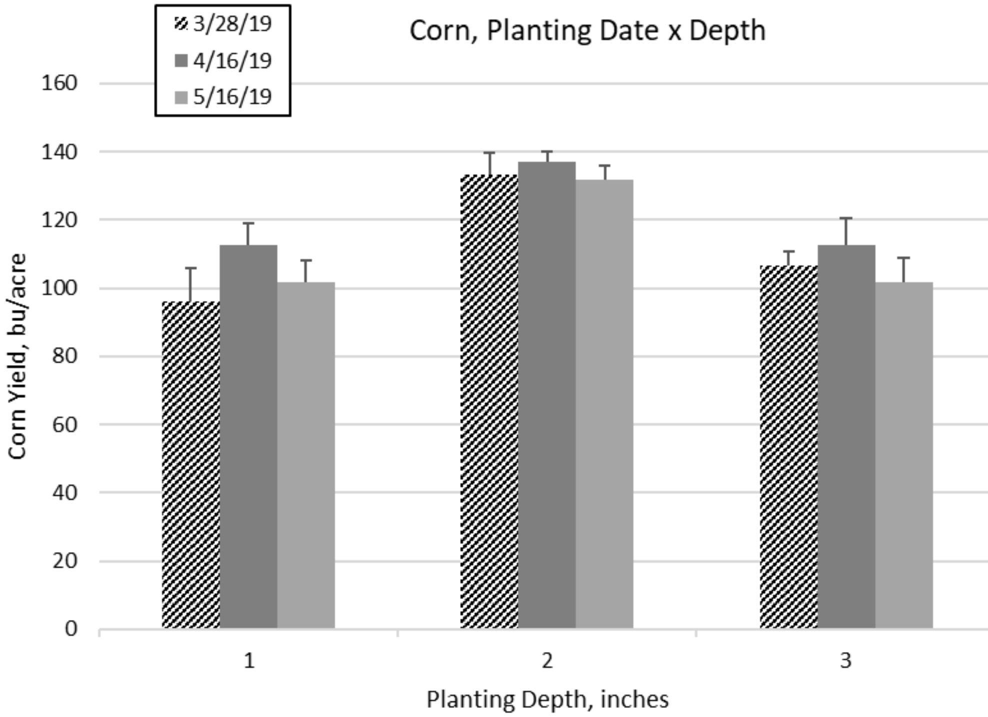


Figure 3. Corn yield in bushels/acre for three planting dates and three depths, averaged over all four cultivars. Mean + standard error are given.

Annual Summary of Weather Data for Parsons - 2019

2019 Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max	41.1	42.1	51.8	67.4	73.4	82.8	87.9	85.1	85.4	65.6	52.8	50.6	65.5
Avg. Min	23.3	24.3	31.4	44.7	55.1	63.0	67.8	67.9	66.5	43.1	29.3	28.4	45.4
Avg. Mean	32.2	33.2	41.6	56.0	64.3	72.9	77.8	76.5	76.0	54.4	41.1	39.5	55.4
Precip	2.27	1.53	3.00	2.8	19.27	7.23	3.21	9.64	8.00	4.48	1.71	1.57	64.69
Snow	1.8	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.8	4.6
Heat DD*	1018	891	726	278	112	3	0	0	0	364	718	790	4898
Cool DD*	0	0	0	8	90	240	398	356	329	34	0	0	1453
Rain Days	9	10	8	8	18	11	6	17	6	14	6	3	116
Min < 10	3	2	3	0	0	0	0	0	0	0	0	0	8
Min < 32	26	24	14	3	0	0	0	0	0	2	16	22	107
Max > 90	0	0	0	0	0	2	7	5	2	0	0	0	16

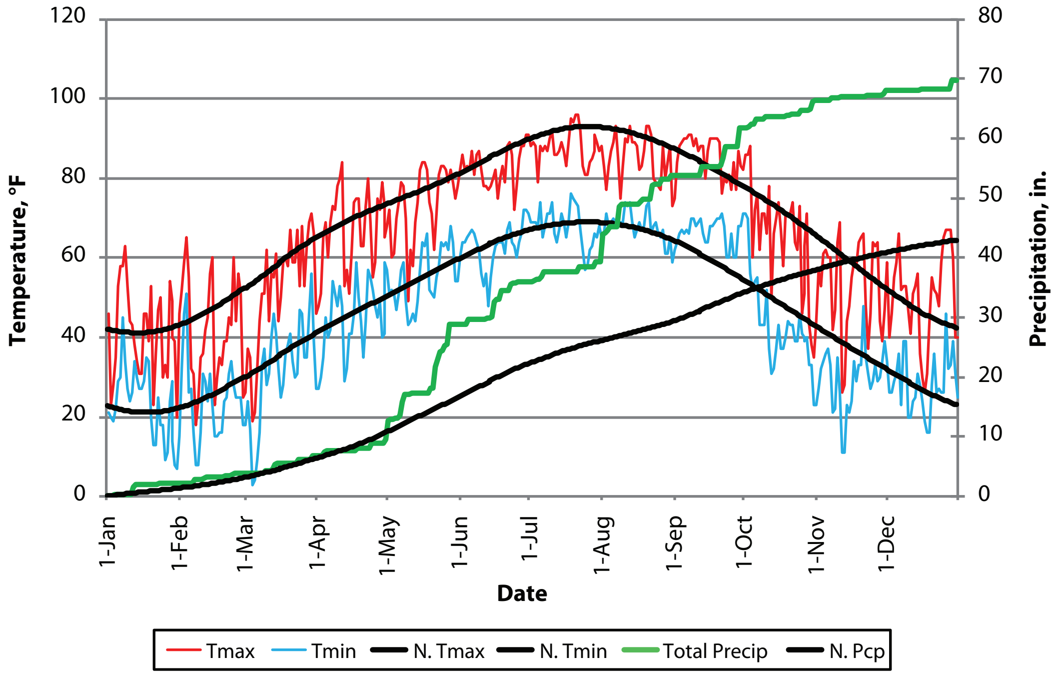
Normal values (1981-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	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	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	-0.9	-5.5	-5.3	0.3	-2.3	-1.6	-2.1	-5.2	4.1	-4.0	-3.8	6.4	-1.7
Avg. Min	1.5	-1.7	-3.6	0.2	0.1	-1.1	-0.7	1.3	8.9	-2.4	-6.0	3.8	0.0
Avg. Mean	0.3	-3.6	-4.5	0.2	-1.0	-1.3	-1.5	-2.0	6.6	-3.2	-4.9	5.1	-0.8
Precip	0.86	-0.24	-0.19	-1.6	13.34	1.7	-0.71	6.35	3.31	0.62	-1.23	-0.49	21.72
Snow	-1.0	-0.7	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-1.9	-4.1
Heat DD	-9	101	136	-22	27	-6	-1	-1	-52	104	144	-158	264
Cool DD	0	0	-2	-15	-7	-46	-45	-63	143	5	-2	0	-31

* 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.


120
100
80
60
40
20
0
80
70
60
50
40
30
20
10
0
Temperature, °F
Precipitation, in.
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Date
Tmax
Tmin
N. Tmax
N. Tmin
Total Precip
N. Pcp

Acknowledgments

We thank the following individuals, organizations, and firms that contributed to this year's research programs through financial support, product donations, or services.

AgChoice, Parsons and Weir, KS

AgriMAXX Wheat Co., Mascoutah, IL

Agseco, Girard, KS

American Bank, Baxter Springs, KS

Bartlett Co-op Association

Beachner Grain, St. Paul, KS

Beason Farm, Elk City, KS

Boehringer-Ingleheim, St. Joseph, MO

Jeff Clark, Columbus, KS

Dennis Clutter, Girard, KS

Coffeyville Livestock Market, Coffeyville, KS

Columbus Chamber of Commerce, Columbus, KS

Commercial Bank

Community National Bank & Trust

Corner Post Crop Insurance

CONICYT, Chile

Deere and Company, Moline, IL

DeLange Seed, Inc., Girard, KS

Dow AgroSciences, Indianapolis, IN

Ernie and Sharon Draeger, Columbus, KS

Dyna-Gro Seed, Richmond, CA

East Kansas Agri-Energy, Garnett, KS

Ecotone Forestry

Elanco Animal Health, Indianapolis, IN

Rich Falkenstien, Oswego, KS

Farmer's Cooperative Association, Inc., Baxter Springs and Columbus, KS

Fastenal, Parsons, KS

Faulkner Grain, Chetopa, KS

FMC Corporation, Edgerton, MO

FRMS Crop Insurance, Columbus, KS

Frontier Farm Credit, Parsons, KS

Hershel George, Uniontown, KS

Greenbush Southeast Kansas Education Service Center, Girard, KS

Heritage Tractor, Pittsburg, KS

Jessee Dean Insurance, Galena, KS

Joe Harris, St. Paul, KS

Kansas Alliance for Wetlands & Streams, Independence, KS

Kansas Center for Sustainable Ag & Alternative Crops, Manhattan, KS

Kansas Crop Improvement Association, Manhattan, KS

Kansas Department of Agriculture

Kansas Department of Wildlife, Parks and Tourism

Kansas Forage & Grassland Council, Manhattan, KS

Kansas Forest Service

Kansas Soybean Commission, Topeka, KS

Labette Bank, Altamont, KS

Labette Conservation District

Limagrain Cereal Seeds, Ft. Collins, CO

McCune Farmers Union Coop, McCune, KS

Merck Animal Health, Summit, NJ

MFA Incorporated, Columbia, MO

Midwest Fertilizer, Oswego, KS

Mix 30, Springfield, IL

MM Ranch, Chanute, KS

Modern Ag, Columbus, KS

Joe Murnane, Girard, KS

Steve Murphy, Girard, KS

National Science Foundation, Arlington, VA

Natural Ag Solutions, LLC., Moran, KS

O'Malley Implement Co., Independence, KS

Parsons Livestock Market, Parsons, KS

Pioneer Hi-Bred International, Johnston, IA

Primetime Video, Joplin, MO

Producers Coop, Girard, KS

R&F Farm Supply, Erie, KS

Marty Reichenberger, Independence, KS

Ridley Block Operations, Pittsburg, KS

South Coffeyville Stockyards, South Coffeyville, OK

Syngenta/AgriPro, Berthoud, CO

T&T Agronomy, LLC, Coffeyville, KS

Emmet & Virginia Terril, Catoosa, OK

Thomas Implement, Inc., Altamont, KS

U.S. Department of Agriculture National Institute of Food and Agriculture

U.S. Department of Agriculture Natural Resources Conservation Service

Westbred, LLC, Bozeman, MT

Wildcat Feeds LLC, Topeka, KS

Zoetis, Madison, NJ

Research and Extension Personnel

Dr. J.D. McNutt, Professor, Research Center Head
Larry Buffington, Custodial Specialist
Tamara Harrison, Office Specialist II
Marla Sexton, Accountant II
Karen Walters, Office Specialist IV, retired

Dr. Jaymelynn Farney, Associate Professor, Beef Systems Specialist
Micah Day, Animal Science Technician II
TaLana Erikson, Research Technologist
Terry Green, Research Technologist
Hunter Metcalf, Seasonal Worker
Bethany O'Brien, Animal Science Technician II
Larry Sale, Agricultural Technician I

Chuckie Hessong, Snap-Ed Regional Specialist

Beth Hinshaw, Extension Specialist 4-H Development

Dr. Lyle Lomas, Professor, Animal Scientist, Retired

Gayle Price, Professor, Extension Specialist FCS

Dr. Gretchen Sassenrath, Professor, Crop Production Agronomist
Tommie Johnson, Research Technician
Lonnie Mengarelli, Research Assistant

Steve Spencer, Microcomputer Support Technician

Dr. Daniel Sweeney, Professor, Soil and Water Management Agronomist
Garth Blackburn, Research Technologist
Dekon Strickland, Agricultural Technician I

SEREC
Agricultural Research
2020

Chemical Disclaimer
Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Experiments with pesticides on nonlabeled crops or target species do not imply endorsement or recommendation of nonlabeled use of pesticides by Kansas State University. All pesticides must be used consistent with current label directions. Current information on weed control in Kansas is available in *2020 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland*, Report of Progress 1155, available from the Distribution Center, Umberger Hall, Kansas State University, or at: ***bookstore.ksre.ksu.edu*** (type Chemical Weed Control in search box).

Kansas Agricultural Experiment Station Research Reports are available at: ***http://newprairiepress.org/kaesrr***
Publications from Kansas State University are available at: ***www.ksre.ksu.edu***

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

April 2020