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Forage Crops

Weather

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Stocker Steer Gains and Fly Numbers as Impacted by Burn Date and Type of Mineral on Tallgrass Native Range – Year 4

J.K. Farney, H. Allen,[1] and L. Muniz[1]

Summary

This study aims to evaluate effectiveness of two operational management systems for steer gains and fly control. The first strategy evaluated was pasture burn date of March (MAR) or April (APR). The second management strategy was free-choice mineral with spices (SPICE) or without spices (CON). Eight pastures (n = 281 steers; initial weight 566 lb) were used in a 2 × 2 factorial treatment structure. Steers were weighed individually, randomly assigned to treatment, and grazed for 89 days. Weekly, 33% of steers were photographed to count flies and evaluated for hair coat score. Steers that grazed pastures that were burned in March had a greater average daily gain than those grazing pastures that were burned in April and resulted in nearly 30 pounds more gain per calf during the grazing season. Steers that consumed the mineral that contained the spices/essential oils had a 0.10 pound per day advantage as compared to steers on control mineral. There was an interaction between pasture burn date and mineral type where steers gained the most on March burned pastures (with no difference in mineral type), had the second greatest gains on the April burned pastures with Spice mineral, and had the lowest gains on the April burned pastures with Control mineral. Weather plays a very important role in cattle performance following a complete pasture burn, and in a year with excessive spring moisture and extreme drought beginning in June, a March burn was the better management practice.

Introduction

Essential oils/spices have been offered as a potential method to control insects in cattle (Showler, 2017; Massariol et al., 2009), alter rumen microbial population (Elcoso et al., 2019), and replace feed antibiotics, all of which may improve production responses in beef as well as dairy cattle. In feedlot studies, cattle consuming a blend of essential oils had similar average daily gain, final body weight, gain to feed ratios, and carcass characteristics as steers fed monensin with or without tylosin (Araujo et al., 2019). Grazing stocker cattle on cool-season annual grass pasture or summer pasture did not show improvements in gains when cattle received a cinnamon and garlic essential oil product by either free-choice or hand-feeding (Beck et al., 2017). However, other studies at Kansas State University have found that feeding supplements of spices in mineral have increased gain in growing cattle on grass (Farney, 2020a; Farney, 2020b).

Burning pasture in April results in about 20 pounds more gain in grazing cattle than burning a pasture in March (Owensby, 2010). Smoke management plans are important for the state of Kansas as high smoke production in April creates smoky conditions that drift to large metropolitan areas. If weight gains and plant population changes are not too different when burning in March instead of April, earlier burning would provide the opportunity to develop a smoke management plan that allows for an increased burning season to dilute a single month's smoke.

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[1] Undergraduate intern, Department of Animal Science, College of Agriculture, Kansas State University.

The overall objective of this study is to evaluate management practices that may impact stocker steer gains on a 90-day double-stocking grazing system in tallgrass native range. Specific objectives are to evaluate the time of burning, and the inclusion of spices in the mineral supplement, and to determine whether the effects of both treatments are additive.

Experimental Procedures

The study was conducted at the Bressner Research unit in Yates Center, KS. The unit consists of eight pastures on 625 acres of tallgrass native prairie. Two management strategies were evaluated to determine effects on stocker steer gains in a 2 × 2 factorial arrangement. The two management strategies were timing of pasture burning and free-choice mineral supplementation. Within each management strategy there were two treatments being evaluated, thus a total of four treatments were applied to the cattle at the unit. The pasture burning management strategies evaluated were burning in March or burning in April. The pastures for the March burn treatment were burned on March 15, 2022, while the April burned pastures were burned on April 19, 2022.

The free-choice mineral supplementation strategies consisted of two treatments: (1) free-choice complete mineral (CON) where 25% of magnesium (Nuplex Mg/K, Nutech Biosciences, Inc., Oneida, NY), copper, zinc, and manganese came from chelated organic sources (Nuplex Chelate-3 blend, Nutech Biosciences); and (2) the same base mineral with the addition of spices (SPICE). The spices included were powdered forms of oils from garlic and the product Solace (proprietary blend of four spices; Wildcat Feeds Inc., Topeka, KS). The mineral analysis is listed in Table 1. The minerals were formulated for a 4 ounce/head/day intake and were offered free choice. Every week, 125% of that week's formulated mineral consumption for each pasture was placed into feeders and weighed. Any remaining mineral from the previous week was also weighed.

Gain Measures

Two hundred eighty-one steers (average initial weight 566 lb) were weighed individually on April 21, 2022, and assigned to pasture randomly based on order through the chute. Cattle were weighed at the end of the study on July 20, 2022, for a total of 89 days of grazing. Five steers were in the wrong pasture at some point during the study and thus their data were not used so 276 were used in analysis. Data collected included initial and final weights, and then average daily gain and total gain were calculated.

Fly Counts and Hair Coat Score

Weekly, 33% of the steers in each pasture were photographed with a Nikon digital camera with a 300 mm zoom lens, with the photographer's back to the sun. The steers were photographed with their entire side filling the viewfinder. Then photos were processed with ImageJ and flies were counted. Additionally, hair coat score was recorded from the photos with a score of 1–5, where a 1 was a 100% slick haired animal; 2 had 25% of body with long hair; 3 had 50% of body covered in long hair; 4 had 75% of body covered in long hair; and 5 was 100% long haired. Data collected included number of flies and hair coat scores for each week.

Results and Discussion

Performance of Steers

Steers that were on March burned pastures gained on average 0.35 more pounds per day (ADG) which resulted in around 30 pounds more total gain per steer over the 90-day grazing period than those that were on April burned pastures ($P < 0.001$; Table 2). There was a tendency ($P = 0.09$) for steers that were consuming the spice mineral to have a 0.09 pound/day increase in ADG, which resulted in, on average, 8 pounds more weight at the end of the grazing period (Table 2). There was an interaction between burn date and mineral where the steers that were on March burned pastures had a greater gain than cattle that grazed April burned pastures, with no difference in gain based on mineral type. For the April burned pastures, the steers on the SPICE mineral had a greater gain than those of the CON mineral (Table 2).

The spice mineral, averaged over the 4 years, has resulted in 0.10 pounds increase in ADG ($P = 0.003$) and that has been fairly consistent (2021 was the exception). Each of the 4 years of this study have had drastically different weather patterns, and that seems to drive the most substantial differences in gains for 90-day stocker calves. At the Yates Center location, in 2022 there was above average precipitation until June, then very little to no precipitation through the remainder of the growing season. Visually, the March burned pastures had a greater biomass in the early portion of the grazing season as compared to the April burn, and that may have been the reason for the increased gains observed with the March burn. Biomass samples were collected, but not yet analyzed to determine the differences in biomass production and forage quality during the growing season of 2022. Over the 4 years of the study, gains for the steers have not been different based on burn dates ($P = 0.33$). Within years, differences were driven by weather events (Farney et al., 2020b; Farney and Reeb, 2021; Farney and Frahm, 2022).

Fly Counts

Flies increased through the summer ($P < 0.001$). There were no differences in fly numbers based on whether cattle consumed the mineral or based on pasture burn date ($P > 0.10$; Table 2). There were some interactions of week by mineral and week × burn date that were detected based on $P < 0.01$. Differences in fly numbers were driven by the much greater fly population in the later part of the summer as compared to the earlier part of the grazing season. No individual weeks showed a difference in fly populations based on either mineral consumed or burn date (Figures 1 and 2). Hair coat scores were not different for any measures ($P > 0.10$, Table 2).

Conclusions

Weather plays a large role in how stocker steer gains will occur following a pasture fire. With early precipitation before a drought in the middle of a grazing period, a March burn seems to result in greater stocker steer gains than an April burn. Addition of spices/essential oils in a free-choice mineral increases average daily gain by ~0.1 pounds per day, and that has been repeatable, regardless of pasture conditions.

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Table 1. Analysis of minerals

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	5,546	5,529
Copper, ppm[3]	1,153	1,153
Zinc, ppm[3]	3,471	3,471
Manganese, ppm[3]	1,817	1,818
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 with similar base as control mineral with the 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. Performance measures and fly counts based on mineral and burn dates

	March		April			*P*-value		
Item	Control	Spice	Control	Spice	SEM	Burn	Mineral	Burn × mineral
In wt., lb	566	567	565	566	8.9	0.92	0.92	0.95
Out wt., lb	813	812	772	790	10.1	0.001	0.42	0.36
Gain, lb	248[a]	244[a]	207[c]	225[b]	4.0	<0.001	0.09	0.01
ADG, lb/d	2.76[a]	2.71[a]	2.30[c]	2.50[b]	0.04	<0.001	0.09	0.01
Fly counts, n	46	62	39	40	1.16	0.13	0.34	0.45
Score coat score	1.9	1.8	1.9	1.9	0.10	0.95	0.36	0.92

SEM = standard error of the mean.

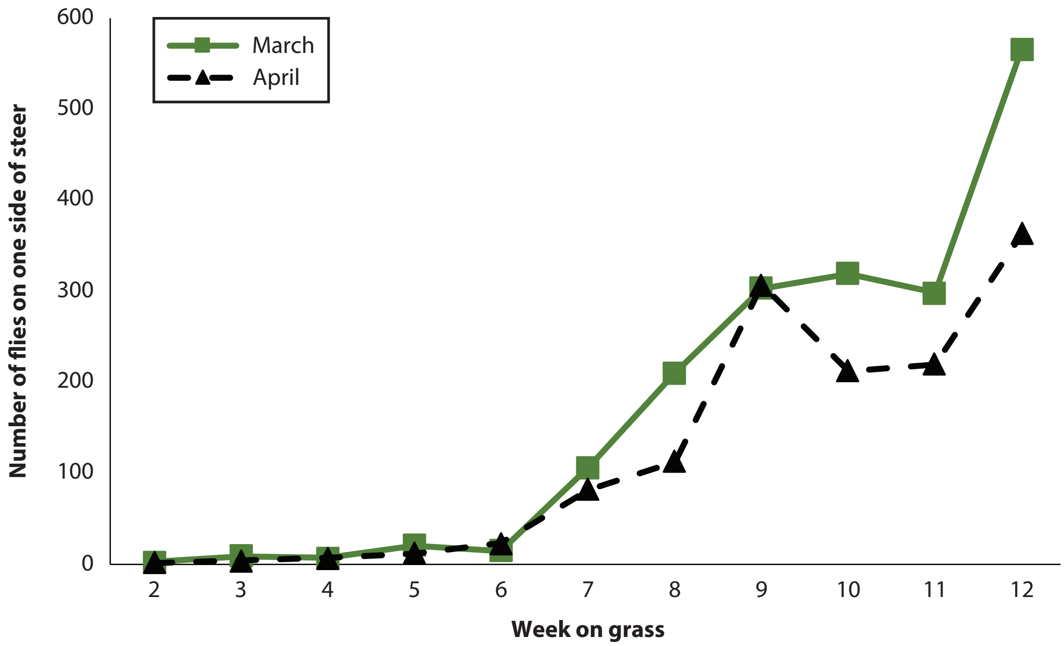

Figure 1. Average number of flies per steer per week by pasture burn date.
Average number of flies per steer per week ($P < 0.01$) are represented in the line chart.
March burn date: March 15, 2022. Line is represented by the solid green line with square markers.
April burn date: April 19, 2022. Line is represented by dashed black line with triangle markers.

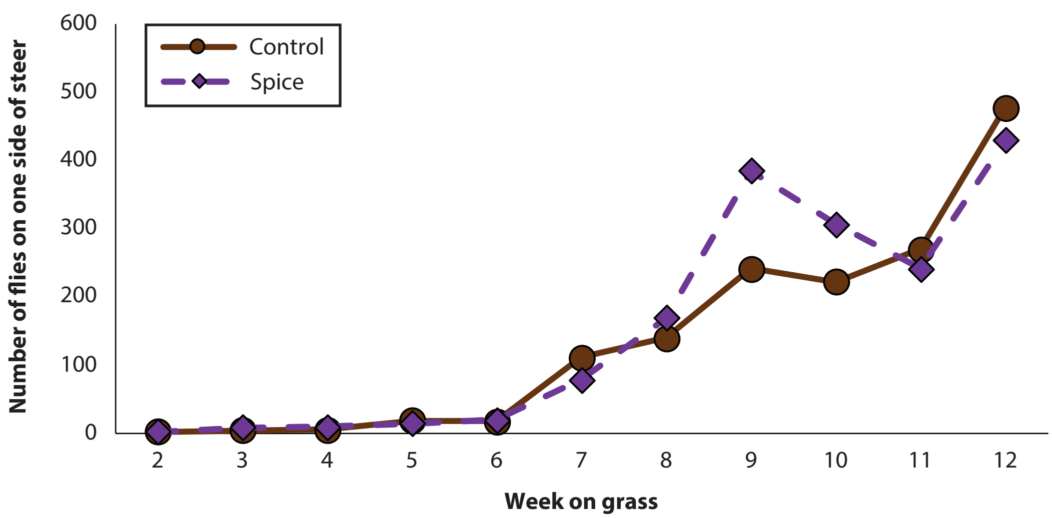

Figure 2. Average number of flies per steer per week by mineral treatments.
Average number of flies per steer per week ($P < 0.01$) are represented in the line chart.
CON: control mineral is represented by the solid brown line with circle markers.
SPICE: spice mineral is the same base mineral as control with 3 pounds/ton of garlic oil and 18 pounds/ton of Solus (Wildcat Feeds LLC). Represented by the purple line with diamond markers.

Effect of Corn Type and Form of Supplement on Grazing Steers – Year 2

J.K. Farney, H. Allen,[1] and L. Muniz[1]

Summary

Eighty stocker steers were grazed on bromegrass from the end of May to the middle of August and were provided five different feeds while on grass during the summer. Treatments evaluated included (1) mineral only; (2) free-choice supplementation in the form of liquid feed (MIX30) or (3) block format (Mintrate 40 Red); and hand-fed supplements of 60% corn:40% dried distillers grains at 0.5% of body weight on a dry matter basis offered daily where the corn was either an (4) isoline corn (ISO; parent genetic line) or (5) Enogen feed corn (ENO; includes alpha-amylase gene). Steers were weighed every 28 days while on grass and were measured for carcass quality by ultrasound prior to being sold. Hand-fed steers had greater gain than self-fed supplemented steers and these steers tended to have more backfat, marbling, and did have more muscle depth coming off grass than other supplemented steers. Steers that received free-choice mineral or self-fed supplements also had lower gains than steers being hand-fed supplement. During a drought year overall, supplemented steers had a greater gain than non-supplemented controls (receiving mineral only). This advantage became apparent after 56 days on grass when the drought was the most severe and the difference may have become more pronounced if the steers hadn't been removed from the pasture due to limited biomass. Overall, hand-feeding is the method that maintained a more consistent gain, regardless of pasture quality and biomass production. Evaluation of operational costs of production need to be evaluated before determining if the hand-feeding management strategy is the best for returns to the operation.

Introduction

Supplementation is important in cattle production because it could (1) fill the gap in a limiting nutrient; (2) allow an increase of gains on the same amount of acreage; (3) allow for an increased number of cattle on the same amount of acreage; (4) supply feed additives; (5) provide increased frequency of monitoring of animals from a husbandry perspective; and (6) stretch the forage supply. Cattle management is different based on geographic location, access to labor, distance to cattle from feed source, forage types, and economic goals. Various supplements for grazing cattle have been developed to meet operational objectives. Determining which supplement best fits an operation can be daunting.

Enogen feed corn is a product that was developed for the ethanol industry as it contains the alpha-amylase gene which improves efficiency of ethanol production. The amylase trait helps convert starch to sugar more efficiently, which helps in the production of ethanol. In addition to ethanol production benefits, researchers have found this same benefit in cattle production so that feed efficiency can be increased by 5%.

[1] Undergraduate intern, Department of Animal Science, College of Agriculture, Kansas State University.

The purpose of this study was to evaluate the effect of cattle gain of stocker steers grazing bromegrass during the summer (1) based on method of supplementation (hand-fed versus self-fed); and (2) type of corn (amylase gene included or not).

Experimental Procedures

Twenty brome pastures were used in a completely randomized research project at the Southeast Research and Extension Center in Parsons, KS. Treatments consisted of one of five different supplementation feeds: (1) control treatment where steers received free-choice mineral (CON); (2) MIX30 (Agridyne, LLC; MIX30; MIX30); (3) Mintrate 40 Red block (ADM Alliance Nutrition; BLOCK); (4) hand-fed supplement of 60% corn:40% DDG (DM-basis) daily where corn was Enogen feed corn (Syngenta, ENO); and (5) hand-fed supplement of 60% corn:40% DDG (DM-basis) daily where corn was an isoline corn (Syngenta, ISO). The isoline corn is the parent corn to the Enogen feed corn line that does not include the alpha-amylase gene. Enogen feed corn includes the alpha-amylase gene, which is involved in starch digestion. Hand-fed supplements were fed daily at 0.5% of body weight on DM-basis and adjusted every 28 days based on calf weights. The liquid feed supplement was fed in an open-topped tub. Blocks were fed free-choice to the steers and placed in bunks containing all pieces of the blocks. The loose mineral was fed in mineral feeders with weather guards to the cattle on the CON treatment and the hand-fed treatments (ENO and ISO). Mineral was supplied to the BLOCK and MIX30 groups through the free-choice supplements. Nutrient profiles of treatments are found in Table 1.

The blocks and liquid tubs were weighed weekly to estimate intake. A new block was added when less than ¼ of the old block was remaining in the feed tub. New liquid was added weekly after agitation in storage tote, and agitation in the feeding tubs was done with a paint stirrer.

Pastures were fertilized in March 2022, based on recommendations from soil tests for phosphorus and potassium and all pastures had 100 lb of nitrogen applied in 46-0-0 form.

Cattle Specifics

Weaned and vaccinated steers (571 ± 67 lb) were used and stocked at 4 head per pasture on 5-acre pastures. There were four pastures of each treatment. Steers were weighed on two consecutive days and placed on brome pastures (May 23 and 24, 2022). Steers were wormed prior to turnout with a white wormer (Valbazen, Zoetis Inc.).

Steers were tested by ultrasound (Aloka 500 with CPEC feedlot software) to detect any differences in ribeye area, backfat, and marbling on the last day of the grazing period (August 16, 2022; 84 days on grass). Cattle were turned out late and removed early from pastures as drought, through the fall of 2021 and limited rainfall in June through August, reduced the amount of forage available and thus grazing was terminated early in the grazing period.

Results and Discussion

Supplement offered during the summer did impact cattle gains ($P < 0.001$; Table 2). Steers on the hand-fed diet (ISO and ENO) had greater ADG and final weight off grass than CON, MIX30, and BLOCK treatments. There was no difference in ADG between ENO and ISO treatments (P = 0.62, Table 2). Supplemented cattle did gain more than CON steers (P = 0.04; Table 2); however, this difference was driven by the much greater gains found with ISO and ENO fed cattle as MIX30 and BLOCK had similar gains as CON cattle.

At day 28 of being on brome there was no difference in ADG between the treatments (P = 0.17). However, those that were supplemented with a protein and energy feed did have a higher ADG as compared to control steers (P = 0.03; control steers averaged 2.59 lb/d ADG and all supplemented steers averaged 2.49 pounds/day). This gain advantage was driven entirely by the ISO and ENO hand-fed treatments, as the MIX30 and BLOCK steers had a lower ADG than CON. During the next 28-day period, average daily gains were almost statistically different, where ENO supplemented steers had a greater gain than CON and BLOCK steers, with ISO and MIX30 being intermediate (P = 0.11). Hand-fed steers had a greater ADG than those fed a free-choice feed (P = 0.03). By the last 28-day period on grass the cattle did have varying ADG (P = 0.001). Steers on ENO and ISO treatments gained more than CON steers with MIX30 and BLOCK being intermediate (Figure 1). This difference was probably observed as the forage biomass availability was beginning to be depleted, thus the supplemented steers had some additional energy and protein that wasn't being supplied in the grass and mineral treatment only.

Ultrasound data at the end of the grazing period showed a tendency for backfat to be thicker when steers were supplemented with ISO and ENO compared with CON and MIX30 steers (P = 0.06). Supplemented steers all had more backfat than non-supplemented steers (P = 0.03). Backfat tended (P = 0.07) to be increased with the hand-fed steers as compared to other treatments, however, visual appraisal would not have resulted in a "dock" in price at the sale barn (Table 2). Marbling was not different when comparing all treatments, however, steers that were hand-fed tended to have a greater marbling score after the 84 day grazing period (P = 0.09). Loin muscle depth was greater for ISO and ENO supplemented steers as compared to CON and BLOCK supplemented steers (P = 0.001). Hand-fed steers supplemented with a corn/DDG feed had a greater loin muscle depth than self-fed steers (P = 0.0002). Steers that were supplemented had more muscle than CON steers (P = 0.03), but this was primarily caused by the extra muscling advantage of the ISO and ENO steers. There were no differences in ISO or ENO in carcass measures following a grazing period.

Conclusions

Similar to what has been found in 2 other years of data collection (Farney et al., 2021; 2022) hand-fed supplementation results in greatest cattle gains while on grass as compared to free-choice products. Supplementation during the drought of 2022 did improve steers' gains over those that were not supplemented, and this advantage would have become even more apparent if steers would have remained on the pasture longer. Since steers were removed from the pasture to reduce potential over-grazing and extremely limiting our steer performance because of low forage biomass, we were not able to capture the magnitude of advantage to supplementing cattle while on grass. Hand-fed supplemented steers had a tendency to have increased marbling, backfat, and loin muscle depth as compared to self-supplemented steers. Before implementing a hand-fed supplementation strategy, a producer must calculate all the costs of production that go into the additional labor, fuel, equipment, and infrastructure to complete this management practice as compared to self-fed supplements.

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Farney, J. K. and Bottorff, T. (2022) "Effect of Corn Type and Form of Supplement on Grazing Steers," *Kansas Agricultural Experiment Station Research Reports*: Vol. 8: Iss. 3. *https://doi.org/10.4148/2378-5977.8288*

Table 1. Nutrient profiles of supplements fed to steers

Item on dry matter basis	Free-choice mineral (CON)	MIX30 (MIX30)	Mintrate 40 Red Block (BLOCK)	60% corn:40% DDG (ENO or ISO)
Crude protein, %	5.69	38.35	40	18.3
NPN, %	---	18.98	12	---
Fat, %	---	24.52	1.5	6.66
TDN, %	---	109.5	---	90
Calcium, %	16.67	0.21	3	0.09
Phosphorus, %	3.33	1.33	1.5	0.55
Salt, %	22.54	2.77	12.5	---
Magnesium, %	2.51[1]	2.23	0.3	0.20
Potassium, %	0.89	1.79	1.0	0.83
Iron, ppm	5,546	---	---	75
Copper, ppm	1,153[2]	7.75[2]	250[3]	2.48
Zinc, ppm	3,471[2]	115.08[2]	1,000[4]	25.6
Manganese, ppm	1,817[2]	29.6[2]	750[4]	7.86
Selenium, ppm	22	0.34	6.6	---
Iodine, ppm	333	---	20	---
Cobalt, ppm	13	---	20[5]	---
Vitamin A, IU	141,667	17,451	50,000	---
Vitamin D, IU	14,167	3,854	5,000	---
Vitamin E, IU	172	101	50	---

Free-choice mineral formulated for stocker cattle (Wildcat Feeds LLC) to be consumed at 4 oz/hd/d; 60% corn:40% DDG nutrient profiles are based on average book values for each ingredient. Steers on the hand-fed supplement were also given the same free-choice mineral as control.

[1]Nuplex Mg/K, Nutech Biosciences, Inc. (Oneida, NY), contributed 25% of the magnesium in the minerals.

[2]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.

[3] Zinpro zinc methionine.

[4] CoMax patented form of cobalt from ADM.

[5] IntelliBond hydroxy copper.

Table 2. Steer gain and carcass measures during the grazing period

	Treatment						*P*-value			
Item	**CON[1]**	**MIX30**	**Block[2]**	**ISO[3]**	**ENO[4]**	**SEM[5]**	**Trt[6]**	**Hand vs. Self[7]**	**Supple. vs. No[8]**	**ISO vs. ENO[9]**
Start weight, lb	574	571	570	572	572	17.5	1.00	1.00	1.00	1.00
Final grazing weight, lb	681	669	685	732	746	19.1	**<0.0001**	**<0.0001**	**0.04**	0.41
Grazing ADG, lb/d	1.27[b]	1.33[b]	1.37[b]	1.90[a]	2.07[a]	0.13	**0.001**	**<0.001**	**0.02**	0.37
					Period average daily gain (ADG), lb/d					
d 28	2.59	2.00	2.21	2.54	2.83	0.24	0.17	**0.03**	0.47	0.40
d 56	0.90	1.11	0.83	1.41	1.58	0.22	0.11	**0.03**	0.19	0.59
d 84	0.32	0.89	1.20	1.75	1.79	0.22	**0.001**	**<0.001**	**<0.001**	0.88
					Ultrasound carcass measures: grazing phase					
Back fat, in.	0.10[c]	0.12[bc]	0.15[abc]	0.17[a]	0.16[ab]	0.01	**0.06**	**0.07**	**0.03**	0.90
Marbling[10,11]	5.27	5.33	5.37	4.92	5.15	0.18	0.42	**0.09**	0.70	0.37
Loin depth, mm	46.7[c]	48.6[bc]	46.7[c]	53.1[ab]	55.0[a]	1.65	**0.001**	**0.0002**	**0.03**	0.42

[abcd]Values indicate treatment differences within row with $P < 0.05$.
[1]CON: control treatment received free choice mineral (Wildcat Feed, LLC).
[2]Block: Mintrate 40 block (ADM Alliance Nutrition).
[3]ISO: 40:60 blend of dried distillers grains (DDG) and cracked corn offered at 0.5% of body weight (DM-basis) daily. Corn is isoline variety that is parent genetic line to the Enogen feed corn (Syngenta).
[4]ENO: Enogen feed corn (Syngenta) fed daily at 0.5% of body weight (DM-basis) in a 60%:40% of corn and DDG.
[5]SEM: standard error of means.
[6]Trt: *P*-value comparison between all 5 treatments.
[7]Hand vs. Self: *P*-value comparison between free-choice treatments (MIX30 and Block) and hand-fed treatments (ISO and ENO).
[8]Supple. vs. No: *P*-value comparison non-supplemented (CON) and supplemented (MIX30, Block, ISO, and ENO).
[9]ISO vs. ENO: *P*-value comparison between corn variety treatments (isoline or Enogen-feed corn).
[10]Ultrasound marbling score: 5.0–5.9 is Small 00–90 (CUP labs, 2007; *https://www.cuplab.com/Files/content/V.%201%20IMF%20or%20Marbling%207-1-07.pdf*).
[11]U.S. Department of Agriculture marbling scores: 300–399: Slight 0–90; 400–499: Small 0–90; and 500–599: Modest 0–90.

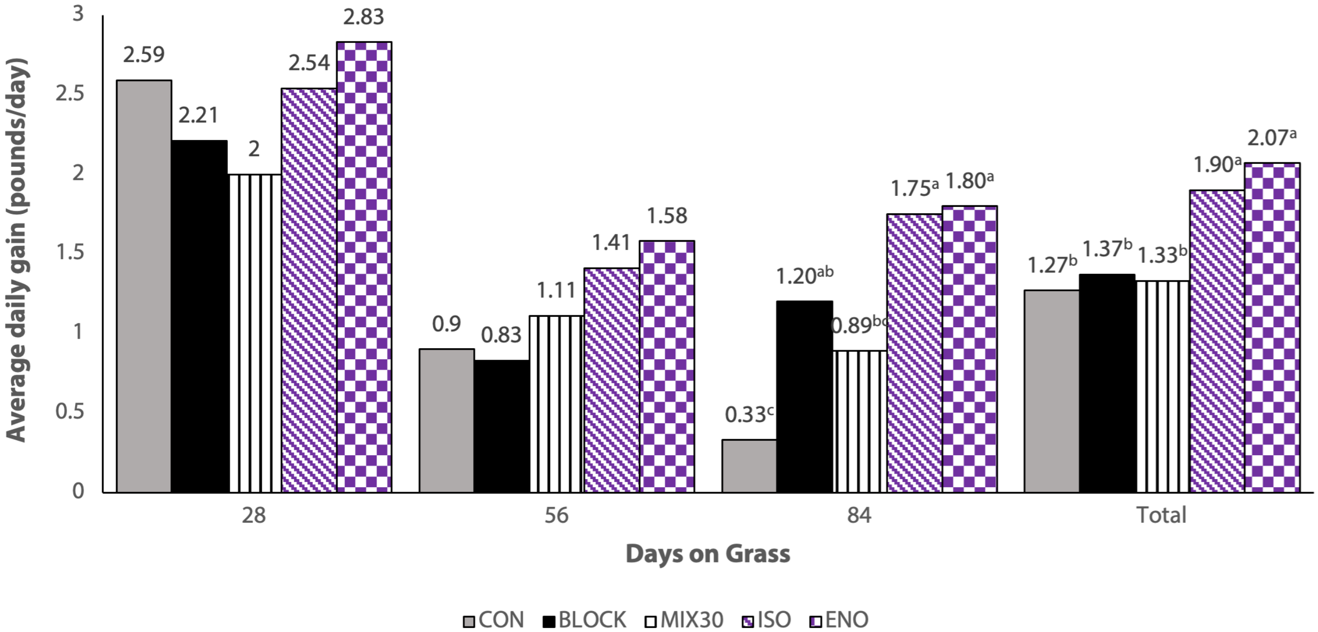

Figure 1. Average daily gains of steers by treatment measured for each 28-day period while on grass. Gains during the 28-day period when first on grass treatments were not different (*P* = 0.17). During the weight period between days 28 and 56 on grass there was no difference in ADG based on treatment (*P* = 0.11). The grazing period between days 56 and 84 on grass was different at *P* = 0.001. Overall average daily gain was different at *P* = 0.001.

[abc] Letters within period are different at $P < 0.05$.

CON: control treatment received free choice mineral (Wildcat Feed, LLC).

Block: Mintrate 40 block (ADM Alliance Nutrition).

ISO: 40:60 blend of dried distillers grains (DDG) and cracked corn offered at 0.5% of body weight (DM-basis) daily. Corn is Isoline variety that is parent genetic line to the Enogen feed corn (Syngenta).

ENO: Enogen feed corn (Syngenta) fed daily at 0.5% of body weight (DM-basis) in a 60%:40% of corn and DDG.

Evaluation of Implants, Clover, and Fescue Variety on Stocker Steers – Year 3

J.K. Farney, L. Muniz,[1] and H. Allen[1]

Summary

Sixty-four growing steers were used in a split-plot experiment, where the whole plot was pasture, and the split-plot was the implant level. Whole plot treatment was a 4 × 2 factorial with four levels of fescue (High Endophyte, Low Endophyte, Novel, or Endophyte Free) and two levels of legume (Legumes or No Legumes). The split-plot included four implant levels (No Implant, Synovex One Grass, Revalor-G, or Ralgro). Data collected were weights and ultrasound carcass characteristics when steers were coming off grass. Steers on High Endophyte had a lower average daily gain (ADG) and final weight than steers on novel endophyte, with those grazing pastures that had low endophyte and endophyte free were intermediate. There was no difference in cattle gains or carcass measurements based on the addition of legumes or the type of implant the steers received. The drought restricted the days on grass and potentially reduced the positive effects of implants.

Introduction

Fescue makes up a large portion of pastureland in the United States. Kentucky 31 (K31) is the most commonly-planted fescue type due to its hardiness and easy stand maintenance. Kentucky 31 is hardy due to the symbiotic relationship with a fungus commonly known as endophyte. The endophyte allows the fescue to be less susceptible to flood, drought, pests, and other environmental impacts. However, the endophyte produces ergot toxins that can cause metabolic issues and possibly vasoconstriction. Vasoconstriction can lead to increased respiration rates, sloughing of hoof wall and/or tails, pregnancy loss, breeding issues, and reductions in stocker calf gains.

A variety of options have been discovered and tested to help combat the issues pertaining to cattle performance, including fescue development, the addition of clover, or implants. The other fescue varieties have shown improvements to cattle gains, but the gains may come at the cost of stocking rates, pasture persistence, grazing days, or grazing management. Legumes often improve cattle gains but may impose a problem with return on investment. Implants have been proposed as a way to control the fescue toxicity issues. The use of implants in cattle during grazing has shown improved gains compared to cattle grazing without implants.

The purpose of this study is to identify management practices that result in the greatest economic return to the stocker operation and determine which management techniques reduce toxicity issues.

Experimental Procedures

Sixty-four growing steers were weighed on two consecutive days and allotted to one of sixteen fescue pastures. Four levels of fescue pastures were used: K31, high endophyte (HIGH); K31, low endophyte (LOW); endophyte free fescue (FREE); and novel endo-

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phyte fescue (NOVEL). Eight of the pastures also had ladino clover (6 lb/acre) to serve as an interseeded legume (two pastures per fescue type). Four steers were assigned to each pasture. The steers in each pasture were assigned to one of four implant treatments. The implant treatments included no implant, Ralgro (Merck Animal Health), Revalor-G (Merck Animal Health), and Synovex One Grass (Zoetis).

Steers were turned out on May 18, 2022, and grazed until August 10, 2022. Pastures were fertilized according to recommendations of soil test results in February 2022. Legumes were interseeded into pastures in 2014. Seedheads were clipped in all pastures June 2022.

At the end of the grazing period, steers were weighed off grass, and scanned with ultrasound for body composition.

Results and Discussion

In this third year of data collection, no interaction effects were detected ($P > 0.10$). Steers grazing high endophyte fescue had a lower average daily gain (ADG) than steers on novel endophyte pastures, with low endophyte and endophyte free being intermediate ($P = 0.03$; Table 1). There were no differences in ADG based on whether there were legumes or not in the pastures ($P = 0.67$; Table 2) and no differences based on implant type ($P = 0.19$; Table 3). There were no differences in carcass ultrasound measurements based on forage type, addition of legumes, or type of implant ($P > 0.10$; Tables 1, 2, and 3). Since the steers were only on grass for 84 days and a majority of that summer was excessively dry (extreme drought conditions), all steers underperformed, thus a reason why there were no differences in cattle gain based on implant. The advantages of low endophyte and low toxin producing fescues was not as obvious this year, as compared to others (Buessing and Farney, 2021; Farney et al, 2022) and could possibly be explained due to all pastures having limited biomass production.

References

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Table 1. Steer performance measures based on fescue type

Item	Endophyte Free	Novel Endophyte	Low Endophyte	High Endophyte	SEM	*P*-value
Initial wt, lb	656	656	656	656	14	1.00
Final wt, lb	753[ab]	785[a]	756[ab]	726[b]	17	0.10
Grazing ADG, lb/d	1.19[ab]	1.55[a]	1.26[ab]	0.85[b]	0.12	0.03
Loin muscle depth, mm	47	50	47	47	1.4	0.37
Marbling score[1]	5.66	5.58	5.74	5.38	0.19	0.64
Backfat, in.	0.13	0.12	0.15	0.13	0.01	0.37

SEM = standard error of the mean. ADG = average daily gain.
[ab] Different letters indicate $P < 0.05$.
[1]Ultrasound marbling score: 4.5–4.9 is Slight 50–90; 5.0–5.9 is Small 00–90 (CUP labs, 2007; *https://www.cuplab.com/Files/content/V.%201%20IMF%20or%20Marbling%207-1-07.pdf*).

Table 2. Steer performance measures based on legume presence

Item	No legume	Legume	SEM	*P*-value
Initial wt, lb	656	656	14	0.99
Final wt, lb	754	757	12.0	0.84
Grazing ADG, lb/d	1.19	1.24	0.09	0.67
Loin muscle depth, mm	47	49	1.0	0.32
Marbling score[1]	5.55	5.63	0.14	0.71
Backfat, in.	0.13	0.13	0.007	0.53

SEM = standard error of the mean. ADG = average daily gain. Legume = ladino clover seeded at 6 lb/acre.
[ab] Different letters indicate $P < 0.05$.
[1]Ultrasound marbling score: 4.5–4.9 is Slight 50-90; 5.0–5.9 is Small 00–90 (CUP labs, 2007; *https://www.cuplab.com/Files/content/V.%201%20IMF%20or%20Marbling%207-1-07.pdf*).

Table 3. Steer performance measures based on implant

Item	No Implant	Ralgro[1]	Revelor-G[2]	Synovex One Grass[3]	SEM	*P*-value
Initial wt, lb	656	656	656	656	14	0.99
Final wt, lb	742	768	751	762	18	0.74
Grazing ADG, lb/d	1.02	1.38	1.15	1.31	0.11	0.19
Loin muscle depth, mm	47	51	47	48	1.4	0.17
Marbling score[4]	5.67	5.58	5.51	5.62	0.20	0.95
Backfat, in.	0.13	0.13	0.13	0.13	0.01	0.97

[1] Merck Animal Health, Madison, NJ.
[2] Merck Animal Health, Madison, NJ.
[3] Zoetis, Parsippany, NJ.
SEM = standard error of means. ADG = average daily gain.
[ab] Different letters indicate $P < 0.05$.
[4]Ultrasound marbling score: 4.5–4.9 is Slight 50–90; 5.0–5.9 is Small 00–90 (CUP labs, 2007; *https://www.cuplab.com/Files/content/V.%201%20IMF%20or%20Marbling%207-1-07.pdf*).

Evaluation of Grazing Options During Summer for Growing Heifers – Year 3

J.K. Farney, L. Muniz,[1] and H. Allen[1]

Summary

Developing methods to provide high quality forage through most of the year is important for cattle operations. The purpose of this study was to determine forage management options to offset the summer "slump" with fescue. Four grass pasture treatments (10 pastures total; 4 acres each) were used in a completely randomized design and stocked with growing heifers (n = 49; initial wt 461 ± 65 lb). Pasture treatments consisted of novel fescue (FES), crabgrass (CRAB), bermudagrass (BERM), and sorghum-sudan interseeded into novel fescue (SS-FES). Heifers were weighed and they grazed pastures from May to September. Heifers on FES were continuously grazed. All other pastures were rotationally grazed. Sorghum-sudan was interseeded into fescue pastures in May. Average daily gain (ADG) for the entire grazing period was not different between pasture systems. Heifers on BERM and SS-FES had greater gain per acre than those FES pastures, with CRAB being intermediate. This result was primarily based on the increased stocking rates for those pastures. The extreme drought during the summer of 2022 resulted in little to no production of the sorghum-sudan and these pastures had the lowest biomass through the grazing period. Moisture is essential for success of interseeding sorghum-sudan into fescue pastures. Weather patterns impact animal performance as it impacts forage production. The best management practice may involve operations that have a variety of cool and warm-season grasses that producers can use to optimize forage production through varying weather events.

Introduction

Fescue is a cool-season hardy grass that can withstand intensive grazing. Approximately 60% of the annual forage production occurs from March-May. Then fescue has a "slump" during the summer when production is stopped, the plant goes into reproductive phase, and animal performance can be negatively impacted. In an ideal production system, high quality forage needs to be provided to cattle year-round to maximize overall production. One method to offset the "summer slump" with fescue is for producers to provide warm-season pastures and cool-season pastures and rotate cattle between the two during their respective growing season. However, that requires the producer to at least double the acreage or to reduce the cow herd by half. Another opportunity to improve fescue forage quality during the summer would be an addition of warm-season perennials such as clovers. Biomass production increase may be small, even though forage quality is improved. Therefore, producers are interested in adding warm-season annual grasses which produce substantial biomass into cool-season perennial pastures to maximize land usage.

The purpose of this study was to evaluate different grazing options for summer for growing replacement heifers.

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Experimental Procedures

Ten, 4-acre pastures were used in this study. Three pastures of crabgrass (CRAB), three pastures of bermudagrass (BERM), two pastures of Max-Q fescue (FES), and two pastures of Max-Q fescue interseeded with sorghum-sudan (SS-FES) were stocked with weaned heifers. Heifers on the FES were stocked with 4 head per pasture through the entire grazing period and allowed to graze the pasture continuously. The FES pastures were fertilized with 60 lb of nitrogen (N) per acre in February and 40 lb N/acre in September. Heifers on the SS-FES pastures were stocked with 7 head per pasture from May to the end of June and they rotationally grazed the pasture in 3 paddocks. Heifers on SS-FES grazed for 14 days on each paddock to try to keep the swath height close to 2 inches. At the end of June, the paddock that was just grazed (paddock 1) was also mowed to 2-inch height, and 25 lb/acre of sorghum-sudan was drilled into the standing fescue. Then 14 days later when heifers were removed from paddock 2, the paddock was swathed to 2 inches and drilled with sorghum-sudan. After sorghum-sudan was interseeded, 46 lb N/acre was applied. Once the sorghum-sudan was 2 feet tall, 4 heifers were rotated to the paddock and allowed to graze for 10 days before being rotated to the next paddock. The SS-FES pastures were fertilized with 40 lb N/acre in September. Heifers on the BERM pastures were stocked at 5 head per pasture and rotationally grazed between 2 paddocks with 28 days between rotations. The BERM pastures were fertilized with 50 lb N/acre in mid-April. Heifers on the CRAB were stocked at 4 head per pasture and rotationally grazed between 2 paddocks with 28 days of grazing per paddock. Five pounds of crabgrass seed was broadcast onto the pastures in April with 50 lb N/acre. The CRAB and BERM pastures were also fertilized with 50 lb N/acre in mid-June.

Heifers were placed on pasture on May 10, 2022. Heifers were weighed going to pasture after a 3-day rumen equivalence diet consisting of 50:50 blend of DDG:wheat middlings at 2% of body weight and weighed on two consecutive days. All heifers were weighed when grass was not sufficient to maintain heifers on September 13, 2022. Three of the "extra" heifers from the SS-FES pastures were weighed on June 21, 2022, to determine total gain for the SS-FES pastures.

Heifer average daily gain, total gain, and total season gain per acre were determined for each grazing period.

Results and Discussion

In contrast to the previous year (Farney et al., 2021) and in contrast to hypothesis, grazing the heifers on warm-season forages during the summer of 2022 did not result in greater average daily gains as compared to grazing a novel endophyte fescue pasture ($P = 0.66$, Table 1). Potentially the similarities in gains can be explained by the weather patterns of 2022 and the effects on biomass production. In general, temperatures were quite a bit cooler than normal in early summer, which hampered the growth of the crabgrass and bermudagrass pastures. There was also an extreme amount of rain in May, then little to no rain from June through end of 2022. The excessive drought resulted in little to no growth of the sorghum sudan, (Figure 1) and this treatment had the lowest biomass in July through September. We removed all the fescue grass to allow the sorghum-sudan to grow, and since there wasn't much sorghum-sudan production, this treatment had the lowest biomass. The fescue pastures had the greatest biomass through the grazing period which was probably the reason the heifers gained as much as those in the other treatments. Weather variability highly influences forage systems production and thus this project will need to be continued for several more years before making recommendations about grazing systems.

There was a tendency for heifers that were on SS-FES and BERM pastures to have a greater pasture gain per acre than heifers on FES pastures, with CRAB being intermediate ($P = 0.09$; Table 1). The SS-FES and BERM pastures had a greater number of heifers on the pasture, so if all heifers had the same individual daily gain then the greater stocking rate resulted in more gain per acre. The CRAB pastures had the same stocking rate as the FES pastures and had one less heifer than BERM. Even though statistically the CRAB heifers didn't have a difference in ADG compared to any others, numerically they had the greatest ADG, which is why those pastures resulted in intermediate production (as measured by total gain per acre).

References

Farney, J. K. (2021) "Evaluation of Grazing Options During Summer for Growing Heifers," Kansas Agricultural Experiment Station Research Reports: Vol. 7: Iss. 2. *https://doi.org/10.4148/2378-5977.8042*

Table 1. Gains for cattle based on type of pasture

	Pasture type					
Item	**FES**	**BERM**	**CRAB**	**SS-FES**	**SEM**	***P*-value**
Initial weight, lb	547	538	547	514	20	0.77
ADG, lb/d	1.09	1.30	1.34	1.18	0.14	0.66
Final weight, lb	682	699	711	660	28	0.67
Gain/acre, lb/acre	135[b]	200[a]	167[ab]	203[a]	18	0.09

FES = novel fescue. CRAB = crabgrass. BERM = bermudagrass. SS-FES = sorghum-sudan interseeded into novel fescue.

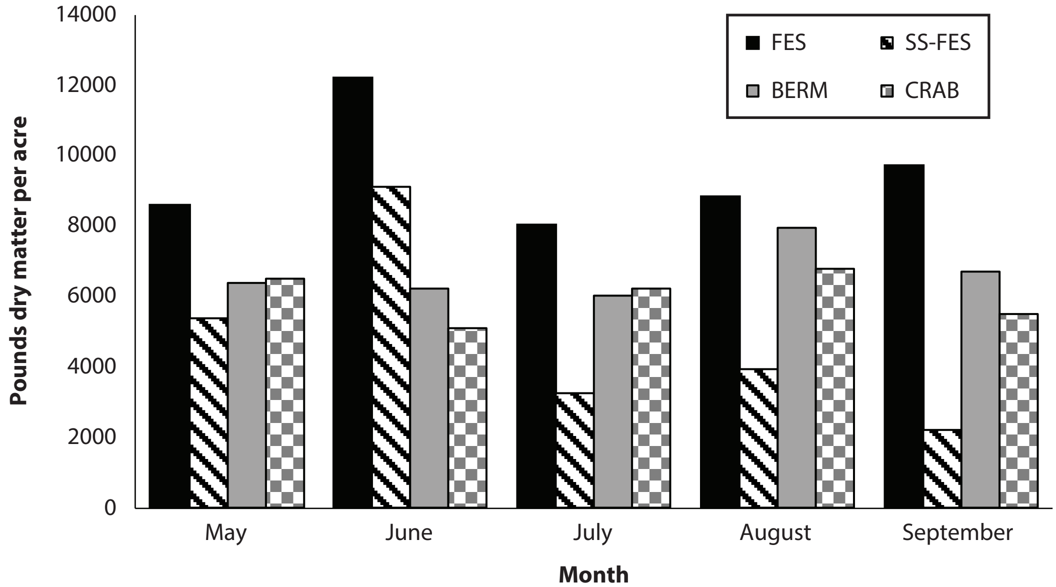

Figure 1. Average monthly forage biomass available based on forage type.
FES: novel endophyte fescue pasture stocked with 4 heifers.
SS-FES: novel endophyte fescue pasture interseeded with 25 pounds of sorghum-sudan in June.
BERM: bermudagrass pasture stocked with 5 heifers and rotationally grazed.
CRAB: crabgrass pasture stocked with 4 heifers and rotationally grazed.

Weaning Method Evaluation for Beef Cattle

J.K. Farney

Summary
Weaning is a stressful event for calves. Various management practices have been suggested to reduce weaning stress. The purpose of this study was to evaluate three different weaning management practices on calf gains at weaning. Eighty-eight bull and heifer calves were assigned to one of three weaning treatments at two research locations. The weaning management options were abrupt weaning, fence-line weaning, and use of a nose-flap weaning device. Calves were weighed at the start of the measurement period and then two weeks later after weaning was completed. Calves that were weaned using the nose-flap method had significantly lower gains than calves that were abruptly weaned or fence-line weaned. Bulls also gained more during this weaning period than heifers did. Generally, fence-line weaned calves have a greater gain than abruptly weaned calves, but in this study where the calves were abruptly weaned and only moved a few miles from the dams, we did not see a difference in gains during the weaning event between abrupt weaning and fence-line practices. The nose-flap device seemed to lead to a lower gain for calves during this period and more research on the device is needed before determining the best weaning management practice.

Introduction
Calves in the United States are commonly weaned from dams at around 200 days of age. Weaning is a period of high stress in calves and has been measured through things such as visual signs of stress (vocalizing and pacing), increases in physiological responses to weaning that are related to stress (cortisol, acute-phase proteins), and reductions in performance and impaired health (summarized from Bailey, 2013). A few management practices have been evaluated to reduce stress during weaning and have been found to work to reduce stress events. The method of weaning can have downstream effects on calf health and performance. Weaning method may have the greatest economic effect on the producer that is weaning and pre-conditioning calves on their operation.

Two lower-stress weaning practices are fence-line weaning and use of a nose-flap (aka nose clip).

Fence-line weaning is a practice where the calves are removed from the dams and placed into a pasture/pen that is next to the dam so that they can have still have contact through the fence, but can't nurse. Some benefits of fence-line weaning have been reported to be a lower weight loss as compared to abruptly weaned calves, calves spend more time eating, and there is less morbidity during feedlot receiving periods (Price et al., 2003; Boyles et al., 2007).

Nose-clips/flaps have also been called 2-stage weaning where calves wear a device in their nose that is designed to be a physical barrier to nursing (Figure 1). The first phase of this process is the calves wearing this device for 14 days while being on the dam and then removal of the device in phase 2 when calves are completely removed from the dam. In a study by Haley et al. (2005) they found that following separation in phase 2, calves have 97% less vocalization and spent 79% less time walking than abruptly weaned calves.

Each of these lower stress management practices require more labor, land, and/or costs than just removing the calf from the dam. Thus a comprehensive evaluation of all the factors that go into the different management practices need to evaluated for your management system. For fence-line weaning, a good fence between the dams and calves is a must. The calves will be "gathered" twice before being moved into a pre-conditioning program or being sent to a sale barn. Nose-flaps would be purchased, then calves that will be weaned with the nose-flaps will be gathered twice (once to put in the flap, once to take it out).

The purpose of this study was to evaluate the weight gains when comparing abrupt weaning, fence-line weaning, and the use of a nose-flap device.

Experimental Procedures

Eighty-eight bull and heifer calves were used in this project (average starting weight 407 ± 54 pounds, weaning age range 130–197 days of age). The calves were from two herds at the Kansas State University Southeast Research and Extension Center. The herd at Parsons included the younger cows (1st through 4th parity) and there were 44 pairs at the Parsons location. The herd at Mound Valley included the older cows (5th parity through 9th parity cows) and there were 44 pairs at this location. Calves at each location were assigned to one of three weaning treatments: abrupt, fence-line, or nose-flap. Calves were stratified to treatments based on birthdate and sex so that each treatment group was fairly equal at both locations. There was one pasture/pen of each treatment at each location.

At Parsons, calves were weighed on March 17, 2020. The abruptly weaned calves were moved to a drylot pen (hauled 0.19 miles) where they were provided free-choice prairie hay and fed 3 pounds of dried distillers grains (DDG) per day. Calves assigned to the nose-flap treatment had nose-flaps inserted on March 17, 2020. Then those dams and calves were placed back on fescue pasture with free-choice prairie hay and each dam was offered 5 pounds of DDG and each calf were fed 3 pounds of DDG per day. Cows and calves were fed from one line of bunks and each had to compete for feed resources. Calves on the fence-line weaned treatment were weighed and then placed into a brome pasture (5 acres) that was next to the fescue pasture where their dams were placed. The calves in the fence-line treatment were provided free-choice prairie hay and 3 pounds of DDG per day.

Calves at the Mound Valley location were weighed at the start of the weaning period on March 18, 2020. Calves in drylot were provided free-choice fescue hay and 3 pounds of DDG. Fence-line calves were placed into a drylot pen that was next to the fescue pasture where their dams were grazing with calves receiving 3 pounds DDG/head/day with free-choice fescue hay. Nose-flap calves were placed on a fescue pasture with their dams and provided free-choice fescue hay, and dams were fed 5 pounds of DDG/head/d and calves were fed 3 pounds DDG/head/d.

All calves were weighed 14 days after the weaning treatments occurred. At this time nose-flaps were removed. After the 14-day weaning period all calves were commingled until assigned to other research projects.

Data were analyzed for average daily gain differences based on weaning treatment, sex of calf, and the interaction. Gains were not different based on locations ($P = 0.30$) so location was used as a replication.

Results and Discussion

For the 14 days after weaning, overall the calves in this study gained weight. There were differences in average daily gain (ADG) based on weaning method. Calves that were abruptly weaned and fence-line weaned had significantly greater gain than those that had nose-flaps ($P < 0.001$). Fence-line weaned calves averaged 2.32 ± 0.23 pounds per day, abruptly weaned calves averaged 1.84 ± 0.21 pounds per day, and nose-flap calves only gained 0.16 ± 0.16 pounds per day. A greater number of calves on the nose-flap treatment lost weight during that 14-day period than with any other weaning method. Interestingly, more than half of the nose-flaps fell out of the noses of the calves before the 14-day period. Even though these calves could go back to nursing, they still gained the least over the 14-day observation period. Potentially, these calves only needed to wear the device for a short period to lead to weaning and they didn't nurse. An unknown source of stress may have led these calves to gain less than the other treatment groups. A third possible explanation is a competition effect for the DDG that were fed to cattle in the nose-flap treatment. Even though the calves were supplied the same amount of DDG as other treatments (3 pounds DDG/head/day) and the dams were each offered 5 pounds of DDG/day, they were all fed in one location in a long line of feed bunks. Potentially these calves consumed less DDG than other treatments as the dams might have consumed the feed faster or were just more aggressive, thus resulting in a lower gain for calves. Our results mirrored those by Boland et al. (2008) where nose-clip weaned calves had lower body weight gain than abruptly weaned and fence-line weaned calves, despite the lower measures of stress for calves with nose-clips (from blood analysis).

Bulls also gained on average, 0.60 pounds/day more than their female counterparts. In general, male cattle do gain more than female cattle. The genetics pool is very narrow within this herd of cows, so the results do not seem to be an effect of sires (50% of the calves were from one bull, 20% from another bull, and 30% from a third sire).

There was a tendency for an effect from the weaning method by sex of calf ($P = 0.11$; Figure 2). Fence-line weaned bull calves had the greatest ADG; abruptly weaned steers and heifers, and fence-line weaned heifers had intermediate gains; and regardless of sex, the nose-flap calves had the lowest ADG. There was a low number of replications within this demonstration, so this difference where bulls do better with fence-line weaning as compared to heifers, could just be an abnormal occurrence.

Conclusions

Utilizing this small sample size of calves, fence-line weaning and abrupt weaning with a very small travel distance resulted in similar calf gains during a 14-day weaning period. During the nose-flap wearing period the calves gained less than with other weaning methods. If a producer retains cattle on their own operation for a 60-day preconditioning period, our observations showed no difference in fence-line weaning as compared to abrupt weaning with a very small travel distance. The nose-flap procedure did not work well at the research station as the calves gained less and we observed a fairly low retention of the nose-flaps. For producers utilizing nose-flaps and still wanting to "bunk-break" calves by offering a supplement fed in a bunk, providing a creep-access might be the method to keep a similar rate of gain as that observed with the fence-line weaned and abruptly weaned calves.

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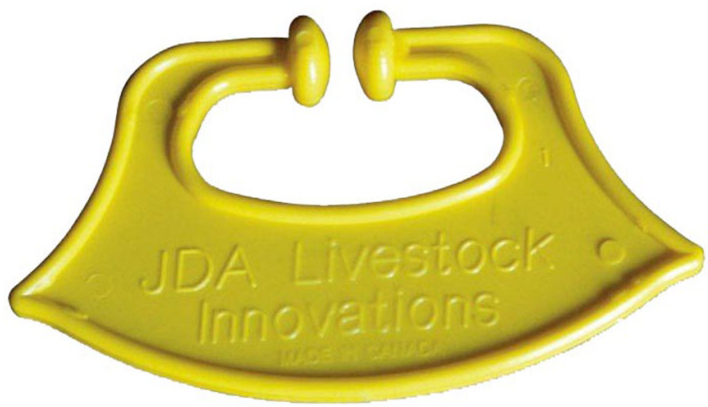

Figure 1. QuietWean nose-flap that was used in nose-flap treatment. Photo from QuietWean.com.

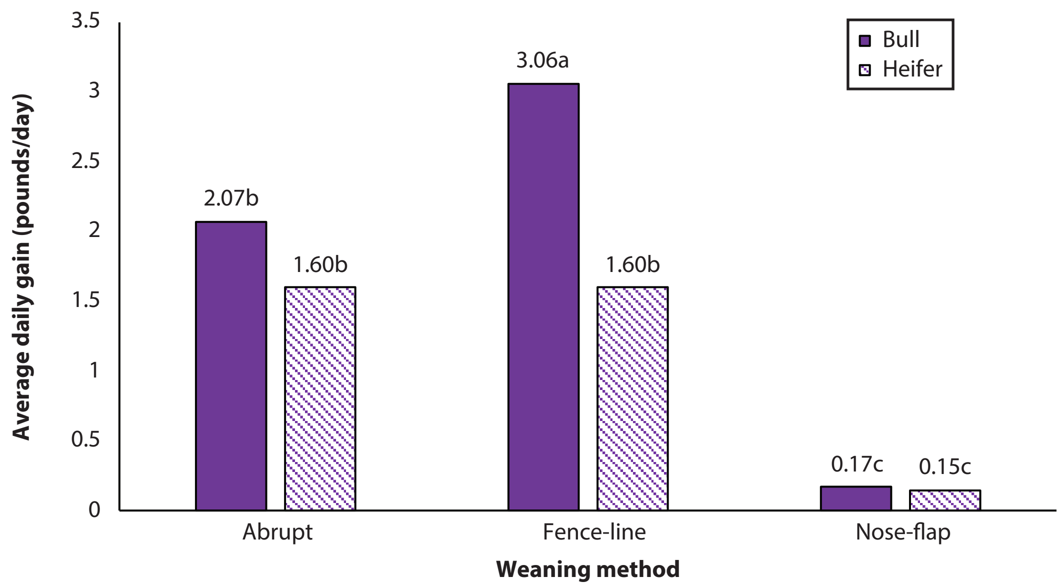

Figure 2. Average daily gain for each weaning method by sex of calf.
[abc] Different letters indicated difference at $P < 0.05$.

Wheat Variety Test Results for South Central Kansas – 2022

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Summary
South central Kansas is the highest producing wheat region in Kansas. This report summarizes the results of winter wheat variety tests for 2021-2022 in six locations.

Introduction
Selecting wheat varieties is a vital step in raising a successful winter wheat crop. In 2022, much of the Kansas wheat crop faced drought stress for the majority of the growing season. As a result, fields sown after fall crop harvest were impacted more by the lack of moisture than fields planted to wheat following wheat. With high crop production input costs, getting the most out of variety selection is important for wheat producers.

Each year's wheat crop encounters great weather variability in South central Kansas (Lollato et al., 2020). For this reason, wheat varieties can present different yield responses due to the environment (Jaenisch et al., 2021; Munaro et al., 2020) and soil characteristics (Lollato et al., 2019). This variability determines if, what, and/or when the crop will face yield-limiting factors such as drought, extreme temperatures, diseases, weeds, insects, nutrient issues, etc. Therefore, regional variety tests are an important tool to support growers' decision-making process. Generating regional data can help producers choose varieties that will perform well in their production systems, as well as improve management and variety-selection recommendations (Munaro et al., 2020).

Experimental Procedures
The South Central Kansas Extension Wheat Variety Tests were conducted in six replicated trials in five counties in south central Kansas: Andale and Clearwater (Sedgwick Co.), Caldwell (Sumner Co.), Newton (Harvey Co.), Arkansas City (Cowley Co.), and Harper (Harper Co.). The same 28 varieties were tested at each location.

Tillage practices and chemical applications were consistent with the host field and managed by the cooperating grower. The trials in Clearwater and Newton were no-till; minimum tillage in Caldwell and Arkansas City; and conventional till in Andale and Harper. Andale, Newton, and Caldwell trials received a fungicide application. Clearwater, Arkansas City, and Harper did not receive a fungicide application. All locations were non-irrigated.

Plots were six, 9-in. wide rows, about 30-ft long, and were sown using a Hege plot drill. All locations were drilled at 1.2 million seeds/a. Trials were planted on the following dates: Harper (10/5/21), Caldwell (10/5/21), Arkansas City (10/6/21), Andale (10/6/21), Newton (10/7/21), Clearwater (10/7/21). Harvest dates were: Arkansas City (6/16/22), Caldwell (6/16/22), Harper (6/16/22), Newton (6/27/22), Clear-

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water (6/30/22), and Andale (7/1/22). To compare the varieties, yield (Table 1) and test weight (Table 2) were assessed, however, test weight is not discussed in this manuscript.

The study was established as a randomized complete block design with 3 replications and 28 varieties. In each location, all 28 varieties (recommended for the area) were similarly managed, using common practices for the region. The 28 varieties had a range of yield potentials, maturities, abiotic tolerances, disease resistances/susceptibilities, and other agronomic characteristics that one year of yield data, one planting date, and one fertilizer/fungicide/herbicide management system may not highlight.

Grain yield was analyzed for each individual location through a one-way analysis of variance using PROC GLIMMIX of SAS v. 9.4. Varieties were considered fixed factors and replications were random effects. A combined analysis across locations was performed considering location and replication nested within location as random factors.

Results and Discussion

The main weather event this crop experienced was drought. The 2022 wheat crop had adequate moisture at sowing and establishment, a warmer than normal fall, and slightly cooler January to March with lower than normal precipitation. The cool dry conditions extended to the first week of May and the crop experienced drought stress. The second week of May brought temperatures 9–12 degrees above the long-term average. From late May through harvest, the 2022 south central Kansas wheat crop experienced above normal precipitation (Lollato et al., 2022). For wheat fields further in physiological development, the moisture arrived too late to have a major impact. Other fields received the moisture around grain fill time and yields benefited. None of the trials experienced heavy disease infestations, though isolated areas in the region were impacted significantly by wheat streak mosaic virus. A Belle Plaine trial was not included in this report as a result of heavy wheat streak mosaic virus infestation.

All six sites were impacted by drought, which lead to an average yield across all locations of 47.4 bu/a, down 10.5 bu/a from 2021. The highest yielding trials were Andale (61.9 bu/a) and Arkansas City (51.3 bu/a) (Table 1). The lowest yielding trials were Harper (36.6 bu/a) and Clearwater (38.0 bu/a). Overall, wheat yields ranged from 26.2 to 70.5 bu/a. The maximum yield difference between the highest and lowest yielding varieties in one location was 25.6 bu/a in Caldwell.

When evaluating the average variety yield across all sites, the five highest yields varied from 50.4 (LCS Atomic AX) to 52.7 bu/a (WB4401.) Nineteen varieties yielded in the top fourth in at least one of the six locations (Table 1). The varieties WB4401, LCS Helix AX, and AP18 AX yielded in the top fourth in four locations. No varieties were in the top 25% at all six locations. In the combined analysis, 22 varieties were in the highest statistical yielding group. Six varieties did not reach the top statistical group when yields were averaged across all locations: Strad CL+, Zenda, Uncharted, AM Cartwright, and Butler's Gold.

Conclusions

Overall, several varieties provided good yields in the south central trials. Variability among sites was observed, which highlights the importance of choosing different varieties to improve yield stability in wheat production systems. Each year has different weather conditions, and 2022 was a challenging year for wheat growers due to the drought condition. However, the results are important to highlight the varieties' responses in a drier than the average environment. While the trials provide valuable information for local growers, they should be utilized along with other variety selection resources. When selecting wheat varieties, it is important to use multiple years of yield data, along with information provided by K-State Research and Extension specialists and seed company representatives.

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Acknowledgments

These data are part of the 2022 South Central Kansas Extension Wheat Plots, a collaboration of K-State Research and Extension county agriculture agents in Sedgwick, Sumner, Harvey, Harper, and Cowley counties with the help of K-State Research and Extension specialists. Each trial is hosted by a local cooperating farmer who provides chemicals and tillage operations, if applicable. Our cooperating farmers for 2022 were Greg Neville (Andale), Kohls Farm (Clearwater), Tim Turek (Caldwell), Stan Jost (Sedgwick), Ken Bryant (Arkansas City), Davis Farms (Harper), and Doug Hisken (Belle Plaine).

Table 1. Wheat grain yield (bu/a) results for 2022 at Andale, Clearwater, Caldwell, Newton, Arkansas City, Harper, and the average for all sites

Variety	Source	All	Andale	Clearwater	Caldwell	Newton	Ark City	Harper
AM Cartwright	AgriMaxx	41.0	53.9	31.2	31.8	47.6	41.5	**40.2**
AP Bigfoot	AgriPro	**45.8**	58.1	33.7	39.4	45.2	50.4	**41.8**
AP EverRock	AgriPro	**45.8**	**63.7**	33.7	46.7	**50.1**	49.0	**31.7**
AP18 AX	AgriPro	**50.6**	**65.6**	**41.9**	**54.7**	43.1	56.6	**41.4**
Bob Dole	AgriPro	**47.5**	**62.9**	39.9	**53.2**	**51.0**	50.0	27.8
SY Monument	AgriPro	**49.6**	**63.6**	**41.8**	**51.4**	47.7	**62.9**	30.2
SY Wolverine	AgriPro	**47.4**	62.9	37.7	46.1	**52.8**	51.8	**32.9**
AG Icon	AGSECO	**47.9**	60.3	39.3	**49.7**	43.9	**59.8**	**34.1**
AG Radical	AGSECO	**48.7**	**67.6**	35.8	45.2	**50.7**	**60.2**	**39.1**
KS Ahearn	KWA	**47.1**	**69.4**	**44.9**	46.1	**49.6**	40.6	**39.3**
KS Hatchett	KWA	**47.2**	59.8	36.8	44.8	**48.8**	49.3	**43.7**
KS Providence	KWA	**51.7**	**68.4**	38.8	X	**54.4**	51.5	**45.3**
Zenda	KWA	44.4	**62.0**	36.3	45.0	**51.2**	44.6	**33.3**
LCS Atomic AX	LCS	**50.4**	**64.5**	40.3	**48.8**	**51.1**	55.2	**42.5**
LCS Helix AX	LCS	**51.5**	**65.3**	**47.7**	**55.1**	**52.6**	55.0	**33.7**
LCS Julep	LCS	45.6	58.6	36.0	38.3	**50.7**	45.5	**44.2**
LCS Photon AX	LCS	**47.1**	55.3	37.1	**49.6**	45.4	54.8	**40.4**
LCS Valiant	LCS	**50.2**	**66.6**	35.8	**57.4**	**56.3**	52.0	**35.3**
Butler's Gold	OGI	39.9	54.2	31.6	42.8	35.0	40.0	**35.9**
Doublestop CL+	OGI	**47.6**	56.2	34.8	**48.6**	**51.3**	52.4	**39.5**
Smith's Gold	OGI	**46.9**	57.9	38.9	46.6	**49.3**	49.5	**39.3**
Strad CL+	OGI	45.1	53.8	33.6	**49.5**	41.0	50.5	**35.1**
Uncharted	OGI	42.4	55.2	34.2	44.3	42.1	46.6	26.9
Paradise	Polansky	**47.0**	58.8	39.2	47.2	44.0	52.9	**40.0**
Rock Star	Polansky	**49.3**	**68.2**	38.4	**48.5**	46.0	52.9	**41.8**
WB4269	WestBred	**47.4**	**61.8**	**42.2**	**54.1**	**50.9**	52.3	28.1
WB4401	WestBred	**52.7**	**70.5**	**41.9**	**50.1**	**52.4**	56.0	**36.2**
WB4699	WestBred	**48.4**	**68.9**	39.7	42.0	**51.7**	54.3	26.2
Average		47.4	61.9	38.0	47.3	48.4	51.3	36.6
Min		39.9	53.8	31.2	31.8	35.0	40.0	26.2
Max		52.7	70.5	47.7	57.4	56.3	62.9	45.3

*Values, highlighted in gray and bold, belong statistically to the highest yielding group. We cannot say values within the group are different from each other.

X - Plots lost to planting or harvest errors. Not enough data to post.

Table 2. Wheat test weight (lb/bu) results for 2022 at Andale, Clearwater, Caldwell, Newton, Arkansas City, Harper, and the average for all sites

Variety	Source	All	Andale	Clearwater	Caldwell	Newton	Ark City	Harper
AM Cartwright	AgriMaxx	57.5	56.0	57.3	57.8	56.2	57.7	60.3
AP Bigfoot	AgriPro	58.4	**57.2**	57.3	59.3	56.7	58.9	60.9
AP EverRock	AgriPro	58.0	**56.8**	57.7	59.6	57.4	59.2	57.6
AP18 AX	AgriPro	57.5	56.4	56.7	57.5	55.7	58.1	60.5
Bob Dole	AgriPro	57.5	**57.0**	57.4	59.4	54.9	58.7	57.8
SY Monument	AgriPro	57.5	55.1	57.0	59.6	54.6	60.1	58.8
SY Wolverine	AgriPro	57.1	53.6	56.4	60.0	56.5	59.8	56.4
AG Icon	AGSECO	58.1	**56.9**	57.7	59.7	55.2	59.9	59.2
AG Radical	AGSECO	57.8	**56.7**	57.2	58.7	55.3	59.4	59.2
KS Ahearn	KWA	57.2	55.5	57.4	57.3	56.4	57.4	58.6
KS Hatchett	KWA	57.3	56.3	56.6	57.3	56.8	57.5	59.1
KS Providence	KWA	58.2	**56.7**	56.8	X	57.2	58.8	**61.5**
Zenda	KWA	**59.5**	**58.1**	58.5	60.2	57.5	60.6	**61.5**
LCS Atomic AX	LCS	58.0	**57.6**	57.0	59.3	57.0	58.4	58.9
LCS Helix AX	LCS	**59.1**	**57.8**	**59.6**	**61.4**	57.5	59.3	58.7
LCS Julep	LCS	**59.9**	55.6	**59.3**	**61.6**	57.3	**60.8**	**64.9**
LCS Photon AX	LCS	**60.0**	**57.4**	**60.1**	**60.7**	**58.8**	60.1	**62.8**
LCS Valiant	LCS	**58.8**	**57.6**	58.1	59.6	57.3	60.0	59.7
Butler's Gold	OGI	58.1	**57.2**	55.6	60.1	56.3	58.3	60.8
Doublestop CL+	OGI	**59.9**	**58.0**	57.7	60.5	**59.8**	**61.5**	**62.5**
Smith's Gold	OGI	**59.2**	**56.9**	**59.8**	60.2	57.2	59.5	**61.7**
Strad CL+	OGI	58.6	**57.0**	57.2	60.7	56.4	60.1	60.8
Uncharted	OGI	57.0	55.9	56.6	57.4	56.1	57.9	X
Paradise	Polansky	57.8	56.3	56.4	59.4	56.5	58.7	59.2
Rock Star	Polansky	58.4	**57.4**	57.7	59.6	55.8	59.7	60.0
WB4269	WestBred	58.2	56.2	58.1	**60.7**	57.1	59.0	58.3
WB4401	WestBred	57.1	54.3	56.1	58.8	55.9	58.0	60.2
WB4699	WestBred	56.0	55.5	55.3	57.6	55.4	56.7	55.4
Average		58.1	56.5	57.4	59.4	56.6	59.1	59.8
Min		56.0	53.6	55.3	57.3	54.6	56.7	55.4
Max		60.0	58.1	60.1	61.6	59.8	61.5	64.9

*Values, highlighted in gray and bold, belong statistically to the highest yielding group. We cannot say values within the group are different from each other.

X - Plots lost to planting or harvest errors. Not enough data to post.

Fungicide Efficacy on Fusarium Head Blight of Hard Red Winter Wheat in Parsons, KS

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Summary
In 2022, a field experiment was conducted to investigate the efficacy of fungicide programs on Fusarium head blight (FHB) and deoxynivalenol (DON) levels. Fungicide treatments were evaluated in plots of the hard red winter wheat cultivar 'KanMark' inoculated with *Fusarium graminearum* in Parsons, KS. Treatments consisted of a single application of Prosaro, Caramba, Miravis Ace, Prosaro Pro, or Sphaerex at early anthesis (Feekes 10.5.1), or dual application of Miravis Ace at early anthesis followed by (*fb*) Prosaro Pro, Sphaerex, or Folicur at 4 days after early anthesis. All fungicide programs numerically reduced FHB visual symptoms and resulted in increased yield compared to the untreated check, although differences were not statistically significant in all cases. The double application treatments (Miravis Ace *fb* Prosaro Pro, and Miravis Ace *fb* Spharex) resulted in the highest increase in test weight. Miravis Ace applied at early anthesis *fb* Prosaro Pro applied at 4 days after early anthesis resulted in the lowest DON levels (79% less than the untreated check).

Introduction
Fusarium head blight (FHB), also called scab, is a serious disease of wheat caused by the fungal pathogen *Fusarium graminearum*. Over the last decade an average total yield loss of 1.14% has been attributed to FHB in Kansas, although in epidemic years, statewide losses > 3.0% have been reported (Hollandbeck et al., 2021). These losses amount to millions of dollars of lost revenue. Under favorable conditions (warm, wet weather with high relative humidity during flowering and early grain formation), FHB can reduce grain yield and test weight, and result in the production of mycotoxins (such as deoxynivalenol, DON, vomitoxin) which contaminate grain. Deoxynivalenol is harmful to both humans and livestock and can lead to vomiting, feed refusal, and adverse neurological symptoms. The U.S. Food and Drug Administration has established a 2-ppm threshold for DON in wheat grain, a 1-ppm limit for finished wheat products that humans may consume, and 5- to 0-ppm for grains and grain by-products destined for animals (FDA, 2018). Thus, harvesting grain with high levels of DON may lead to price discounts or rejections at the elevator.

Management recommendations for FHB include the selection of moderately resistant wheat varieties, avoiding planting wheat after non-till corn, tillage, and timely fungicide applications. In the past, the primary fungicide group labeled for the control of FHB was the demethylation inhibitor group (DMI, triazoles FRAC group 3). Previous work has found that the application of a single DMI fungicide at early flowering (Feekes 10.5.1) results in a 40–50% reduction in visual FHB severity (Paul et al., 2008). Recently, Miravis Ace (13.7% pydiflumetofen + 11.4% propiconazole) and Prosaro Pro (17.39% prothioconazole + 8.7% tebuconazole + 8.7% fluopyram) have been introduced to the market and contain an active ingredient from the succinate dehy-

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drogenase inhibitor group (SDHI, FRAC group 7), along with DMIs. An additional product, Sphaerex (10.91% metconazole + 18.19% prothioconazole, FRAC group 3), has recently been labeled for use in Kansas. It is important to understand how these products compare to the products that are currently being used to control FHB by producers in Kansas. In addition, although single applications of fungicides are more common in Kansas for FHB control, there may be scenarios where two applications may be worthwhile. Thus, the objectives of this study were to 1) compare the efficacy of newer fungicide products (Sphaerex and Prosaro Pro) with industry standard fungicide products Miravis Ace and Prosaro; and 2) compare the efficacy of dual fungicide applications with single fungicide applications.

Experimental Procedures

A field experiment was established at the Southeast Research and Extension Center of Kansas State University in Parsons, KS, on October 5, 2021. The FHB susceptible hard red winter wheat cultivar 'KanMark' was planted in 5 × 28 ft plots (5 rows/plot) with a seeding rate of 1.2 million seeds/a. Plots were arranged in a randomized complete block design with four replications.

Plots were inoculated with *F. graminearum* infested corn spawn (isolates X-3639 and Pt104) on March 31 and April 7, 2022, at a rate of 15 g per square meter per application. This location was mist irrigated regularly to the point of soil saturation to stimulate perithecia development (fungal fruiting bodies) on corn spawn.

Treatments consisted of single or double applications of fungicides (Table 1). Single application treatments included:

- Prosaro (19% prothioconazole + 19% tebuconazole; Bayer Crop Science);
- Caramba (8.6% metconazole; BASF Corporation);
- Miravis Ace (13.7% pydiflumetofen + 11.4% propiconazole; Syngenta);
- Prosaro Pro (17.39% prothioconazole + 8.7% tebuconazole + 8.7% fluopyram; Bayer Crop Science); and
- Sphaerex (10.91% metconazole + 18.19% prothioconazole; BASF Corp.) at early anthesis (Feekes 10.5.1).

Double application treatments included:

- Miravis Ace applied at early anthesis was *fb* Prosaro Pro, Sphaerex; or
- Folicur (38.7% tebuconazole; Bayer Crop Science) applied 4 days later.

Fungicide treatments were applied with a CO_2-powered backpack sprayer at a pressure of 30 psi calibrated to 20 gal/a. The sprayer was equipped with three flat fan TT110015-VP nozzles spaced 50 cm apart on a 100 cm boom. Early anthesis treatments were applied on May 6 at early anthesis (Feekes 10.5.1) and second applications were made on May 10.

Visual disease severity (FHB index) was evaluated on May 23 by rating four clusters of 10–15 plants per plot (40–60 individual plants per plot). Plots were harvested with a small plot combine on June 29. After harvest, sub-samples of grain were visually rated for percent Fusarium damaged kernels (FDK) and shipped to the mycotoxin testing laboratory in the Department of Plant Pathology at the University of Minnesota, St. Paul. Yields were adjusted to 13% moisture.

Data were analyzed using the GLIMMIX procedure of SAS. Means were compared using Fisher's protected LSD at a 5% level of significance using the lsmeans statement. Prior to the analyses, FHB index and FDK data were arcsine-square-root transformed and DON data were log-transformed, as needed to stabilize variances.

Results and Discussion

Mean yields were not statistically different between treatments (P-value = 0.11), although yields were numerically higher for all fungicide treatments than for the untreated check, except for Prosaro (Figure 1A). Grain test weight was greater for all fungicide treatments than for the untreated check (Figure 1B). Single applications of Prosaro, Caramba, and Prosaro Pro at early anthesis were less effective than Miravis Ace and Sphaerex. Miravis Ace *fb* Prosaro Pro and Miravis Ace *fb* Sphaerex had test weights 7% greater than the untreated check. Findings are consistent with data reported by Moraes et al. (2022) who found that test weights were higher when Prosaro *fb* Caramba compared to single Prosaro applications at early flowering. These results are particularly relevant for seed production.

The untreated check had the highest values of FHB index (P-value = 0.05) and DON (P-value = 0.02) when compared to Miravis Ace *fb* Prosaro Pro (Figure 1C and E). Miravis Ace *fb* Sphaerex and single application of Prosaro, Miravis Ace, and Sphaerex also resulted in lower FHB index than the untreated check, 57%, 61%, 63%, and 50%, respectively. The FHB index values for the treatment Miravis Ace *fb* Folicur were higher than expected, given the level of control observed in the Miravis Ace single application treatment. Future locations and years of this study will evaluate if this trend persists. Observed DON levels were 79% less in Miravis Ace *fb* Prosaro Pro than the untreated check, as well as Sphaerex and Miravis Ace *fb* Sphaerex, which resulted in a 55% and 61% reduction, respectively. The FDK values (P-value = 0.05) were similar among fungicide treatments (Figure 1D).

Conclusion

All fungicide programs lowered both FHB index (visual severity) and DON accumulation and resulted in higher test weights when compared to the untreated check. The DON reduction is critical as elevated DON levels can result in discounts or rejections translating into an economic loss. Results from this single location-year experiment are preliminary. This experiment will be repeated in future years and additional locations.

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Table 1. List of fungicide treatments for Fusarium head blight in wheat

Product/Trade name	[a]FRAC/Code	Timing	Rate, fl. oz./a
Untreated check	---	---	---
Prosaro 421 SC	3	Early anthesis	6.5
Caramba 0.75 SL	3	Early anthesis	13.5
Miravis Ace SE	3, 7	Early anthesis	13.7
Prosaro Pro 400 SC	3,7	Early anthesis	10.3
Sphaerex	3	Early anthesis	7.3
Miravis Ace *fb* Prosaro Pro	3,7/3,7	Early anthesis *fb* 4 days after	13.7/10.3
Miravis Ace *fb* Sphaerex	3,7/3	Early anthesis *fb* 4 days after	13.7/7.3
Miravis Ace *fb* Folicur 3.6F[6]	3,7/3	Early anthesis *fb* 4 days after	13.7/4

[a]FRAC = Fungicide Resistance Action Committee.

Early anthesis = Feekes growth stage 10.5.1 or early flowering that is when yellow anthers (flowers) appear or extrude from the center of the wheat spike. *fb* = followed by.

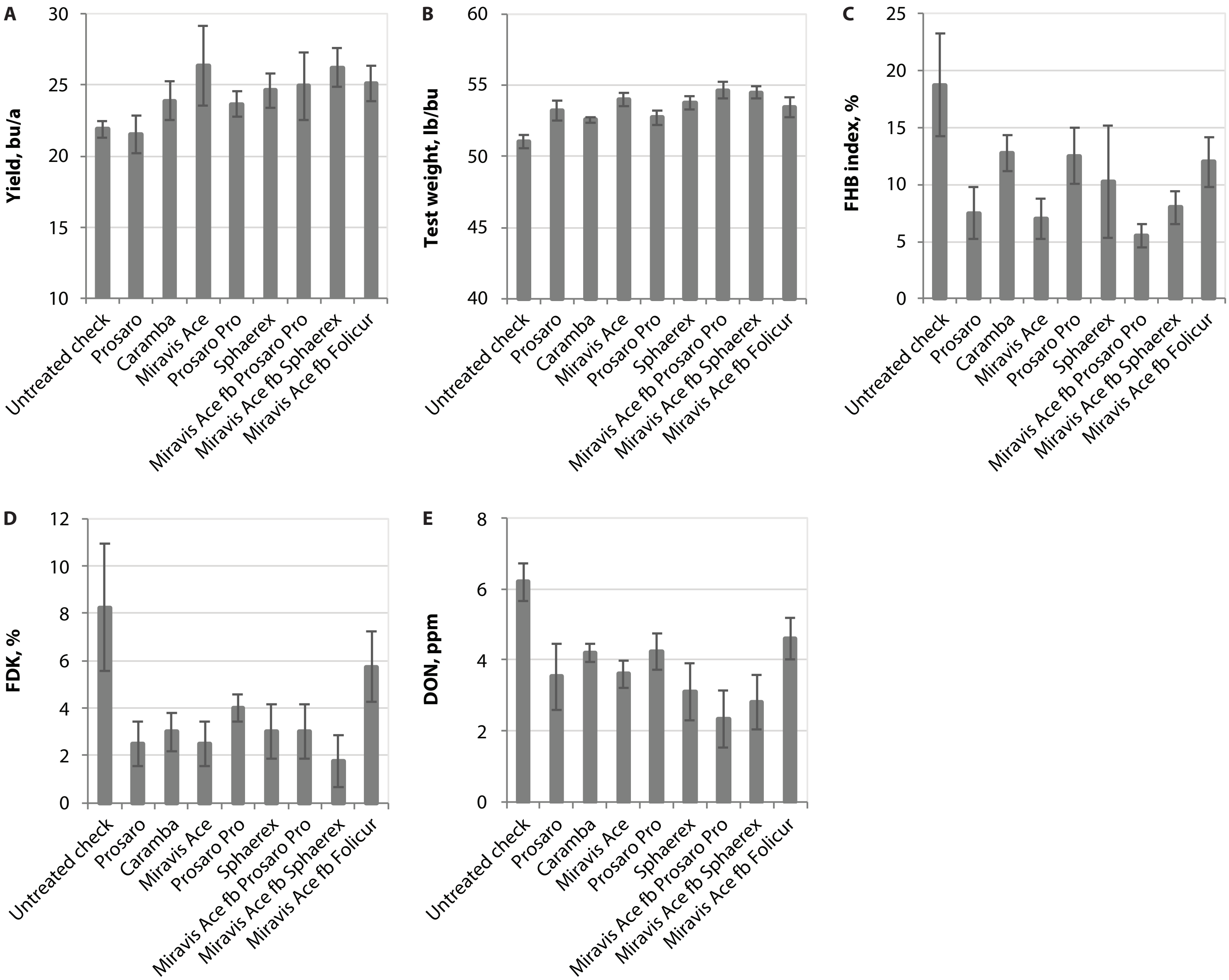

Figure 1. (A) Mean yield, (B) test weight, (C) Fusarium head blight (FHB) index, (D) Fusarium damaged kernels (FDK), and (E) deoxynivalenol content (DON) for untreated check and fungicide treatments for hard red winter wheat cultivar 'KanMark' in Parsons, KS. Error bars represent the standard error of the mean estimates. *fb* = followed by.

Hard Red and Soft Red Winter Wheat Variety Testing – 2023

G.F. Sassenrath, J. Lingenfelser,[1] and X. Lin[1]

Summary
This is a summary of the winter wheat production conditions in southeast Kansas in 2021-2022 and the results of the winter wheat variety testing. Wheat production in 2022 benefited from dry conditions at flowering and harvest. Overall yields of hard red wheat were above multi-year averages, while soft red wheat yields were below the 15-year average. As in previous years, soft red winter wheat out-yielded hard red winter wheat varieties, but the extent was not as dramatic as in previous years.

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 2021-2022 winter wheat growing season in comparison to previous years and the historical averages. Thirteen hard red and thirteen soft red wheat varieties were tested at Parsons.

Experimental Procedures
The Kansas State University Crop Performance Tests were conducted in replicated research fields throughout the state. This report summarizes winter wheat production for Parsons, KS. Wheat varieties were tested in Parsons silt loam soil at the Southeast Research and Extension Center (SEREC) in Parsons. 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/outreach-and-services/crop-performance-tests/).

Wheat was drilled in 7-in. rows at 1.2 million seed/acre (approx. 90 lb/acre) in conventional tillage with an Almaco plot drill in Parsons and harvested in June. Plots were 7-ft wide by 27.5-ft long. Fertilizer was applied before planting at a rate of 50-46-30 lb/acre N-P-K (dry), with an additional 60-46-30 lb/acre N-P-K (dry) applied in February for both hard red and soft red cultivars. No fungicide or herbicides were applied in wheat.

State reported crop yield data were downloaded from the National Agricultural Statistic Service Crop database (*https://quickstats.nass.usda.gov/*). Weather data were collected from the Kansas Mesonet website (*http://mesonet.k-state.edu/agriculture/degreedays/*) for a weather station located at the SEREC in Parsons. Cumulative rainfall was calculated on a water year basis from October 1, 2021, through September 30, 2022.

Results and Discussion
The rainfall during autumn and early winter (water year 2022, WY22) was very near average (Figure 1). The spring green-up period had high rainfall events, interspersed with long dry periods. These long dry periods coincided with wheat flowering, and

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reduced Fusarium infection rates. While rainfall during the WY22 was above the severe drought of 2012, the 27.4 in. of rain was well below the 12-year average of 38.8 in.

Statewide, acres planted to wheat have been steadily declining in Kansas, in contrast to acreage planted to corn and soybeans (Sassenrath et al., 2023[2]), with only 7.3 M acres of wheat planted in 2021 (compared to the maximum of 14.1 M acres planted in 1982). The percentage of planted acres harvested in 2022 (90.4%) was also slightly below the 50-year average of 91% planted acres harvested. Statewide average yield in 2022 was exactly at the 50-year average yield of 37 bu/acre, but below the recent 10-year average of 43.2 bu/acre, and well below the high yield of 57 bu/acre harvested in 2016.

Hard red wheat in Parsons yielded better in 2022 than in 2021, with much less variability across cultivars (Figure 3A). The average hard red winter wheat in Parsons was 74.6 bu/acre (Table 1). Soft red wheat yield was reduced slightly in 2022, but also had much less cultivar variability (Figure 3B). While the soft red wheat yielded better than the hard red wheat, the difference was not as great as measured in previous years. Test weights were higher in 2022 than in 2021 in both hard and soft wheat, but lower than in previous years.

Conclusions

Winter wheat did well in 2022. The hard red wheat, which tends to have more disease, benefited from the dryer conditions during flowering. Conversely, the soft red wheat had slightly lower yields due to the dryer conditions.

Acknowledgments

This data is part of the 2022 Kansas Performance Tests with Winter Wheat Varieties (*https://www.bookstore.ksre.ksu.edu/pubs/SRP1172.pdf*).

[2] Sassenrath, G.;Lingenfelser, J., Lin, X.. (2023) "Corn and Soybean Production – 2022 Summary," *Kansas Agricultural Experiment Station Research Reports*: Vol. 9: Iss. 2. *https://newprairiepress.org/kaesrr/vol9/iss2/*

Table 1. Multiyear comparison of hard red winter wheat yields from variety trials at Parsons, KS

		2017		2018		2020				2021		2022	
Company	**Variety**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**	**Fusarium rating**	**Stripe rust rating**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**
AgriMAXX	AM Cartwright					**82.9**	60.8	1	1	**70.5**	55.3	65.5	55.9
AgriMAXX	AM Eastwood	47.2	55.5	**56.8**	58.5	67.2	57.9	3	8	33.9	51.7		
Syngenta AgriPro	SY Benefit	56.9	57.7	45.2	57.4	77.5	59.5	1	7	37.5	50.3		
Syngenta AgriPro	Prolific											**82.2**	57.6
AGSECO	AG Icon			47.4	57.2	80.5	60	2	4	42.2	75.9		
AGSECO	AG Radical					76.1	56.6	0	3	28	50	**75.2**	56.0
KWA Wildcat Genetics	Everest	60.5	58.1	48.6	59.3	78.9	60.8	1	8	49.8	54.1	64.0	57.8
KWA Wildcat Genetics	Providence											66.5	56.5
KWA Wildcat Genetics	Zenda	60.7	58.4	43.5	59.7	**86.1**	60.8	1	2	**66.1**	55.2	**75.3**	58.2
Polansky	Paradise									**79.2**	54.2	73.7	56.2
Polansky	Rock Star									**67.5**	54.6	**78.2**	55.6
WestBred	WB4269	55	57	48.5	58.9	**86.8**	60.3	2	3	**61.8**	54.3	67.1	55.7
WestBred	WB4401					**108.8**	61.5	1	1	**92**	57.8	73.0	53.8
WestBred	WB4422											**85.0**	58.0
WestBred	WB4523											72.3	54.1
WestBred	WB4699					**94.5**	58.7	2	2	39.5	50.7	**82.6**	56.0
Overall average, hard red winter wheat		57.1	57.4	51.7	58.1	81.1	59.2			55.5	55.1	74.6	56.3

Yields above average are highlighted in bold.

Table 2. Multiyear comparison of soft red winter wheat yields from variety trials at Parsons, KS

		2017		2018		2020				2021		2022	
Company	**Variety**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**	**Fusarium rating**	**Stripe rust rating**	**Yield, bu/a**	**Test weight, lb/bu**	**Yield, bu/a**	**Test weight, lb/bu**
AgriMAXX	473	**83.2**	57.9	**65.1**	57.5	**106.1**	59	0	1	**94.0**	55.2		
AgriMAXX	492									**99.9**	56.3	81.0	57.5
AgriMAXX	503					**113.9**	60.1	0	1	**102.5**	56.2	80.6	55.7
AgriMAXX	505					**112.2**	60.7	2	5	**100.3**	57.2	**88.9**	57.7
AgriMAXX	513									**99.3**	55.0	**86.9**	56.7
AgriMAXX	514									**93.3**	54.4	**87.5**	55.3
AgriMAXX	516											83.8	55.9
AgriMAXX	EXP 2105											**87.1**	55.1
Beachner	GB0206									**96.4**	53.7	**86.2**	55.8
Beachner	GB0208									89.9	55.1	**88.7**	56.2
Beachner	Roane									71.7	56.4		
Becks	726									**101.0**	54.8		
Becks	727									**95.2**	56.3		
Becks	730									76.3	53.9		
DuPont Pioneer	25R40	79.5	56.8	**66.1**	56.7	**105.8**	58.1	3	1				
DuPont Pioneer	25R50			57.1	57	97.5	59.3	0	1			81.8	54.6
DuPont Pioneer	25R61	71.4	57.8	**61.6**	57.9	87.5	58.3	0	7				
DuPont Pioneer	25R74	80.8	57.6	**65.4**	56.3	**110.4**	61.6	0	1			**92.6**	54.8
DuPont Pioneer	25R76											79.1	55.8
Dupont Pioneer	25R77	**84.4**	57.9	54.2	56.9	103	61.6	2	3				
WestBred	WB2606											82.8	56.3
Overall average, soft red winter wheat		78.2	57.5	59.9	57	102.4	59.5			90.4	54.9	85.2	56.0

Yields above average highlighted in bold.

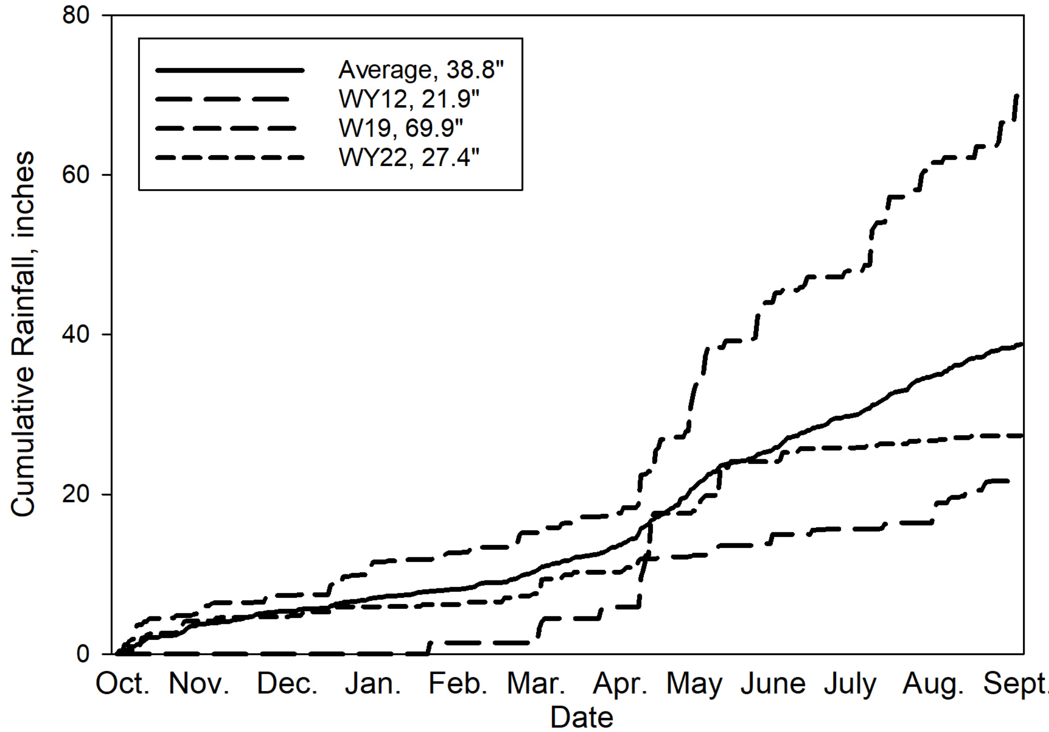

Figure 1. Cumulative rainfall during the 2022 water year (WY22; October 1, 2021 - September 30, 2022).

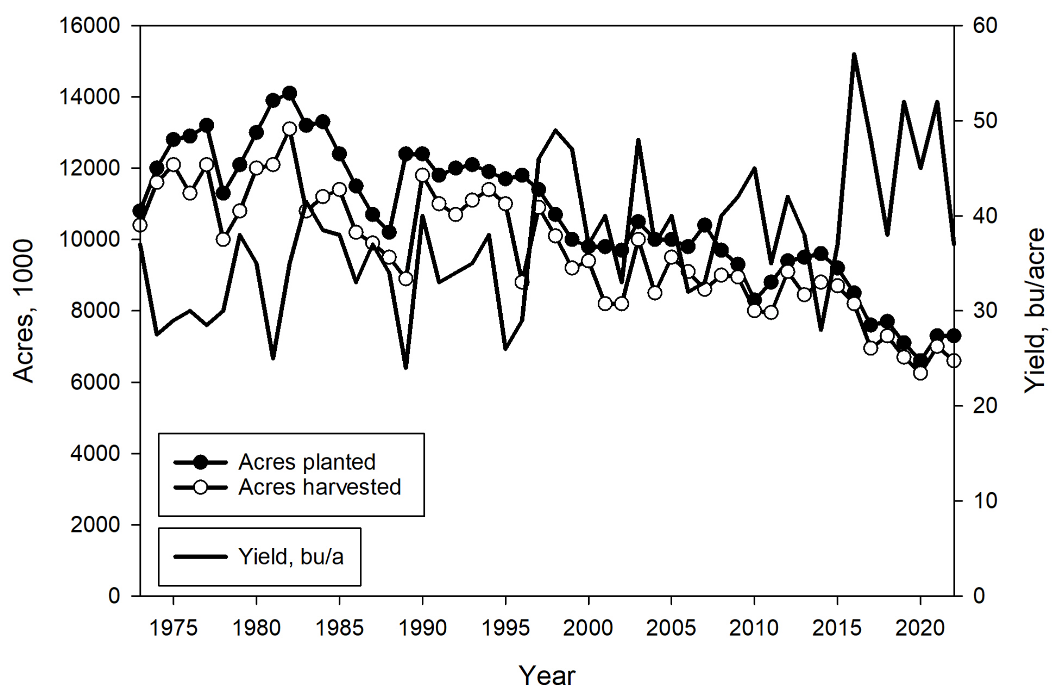

Figure 2. Statewide historical wheat production, acres planted, acres harvested, and yield (bu/acre).

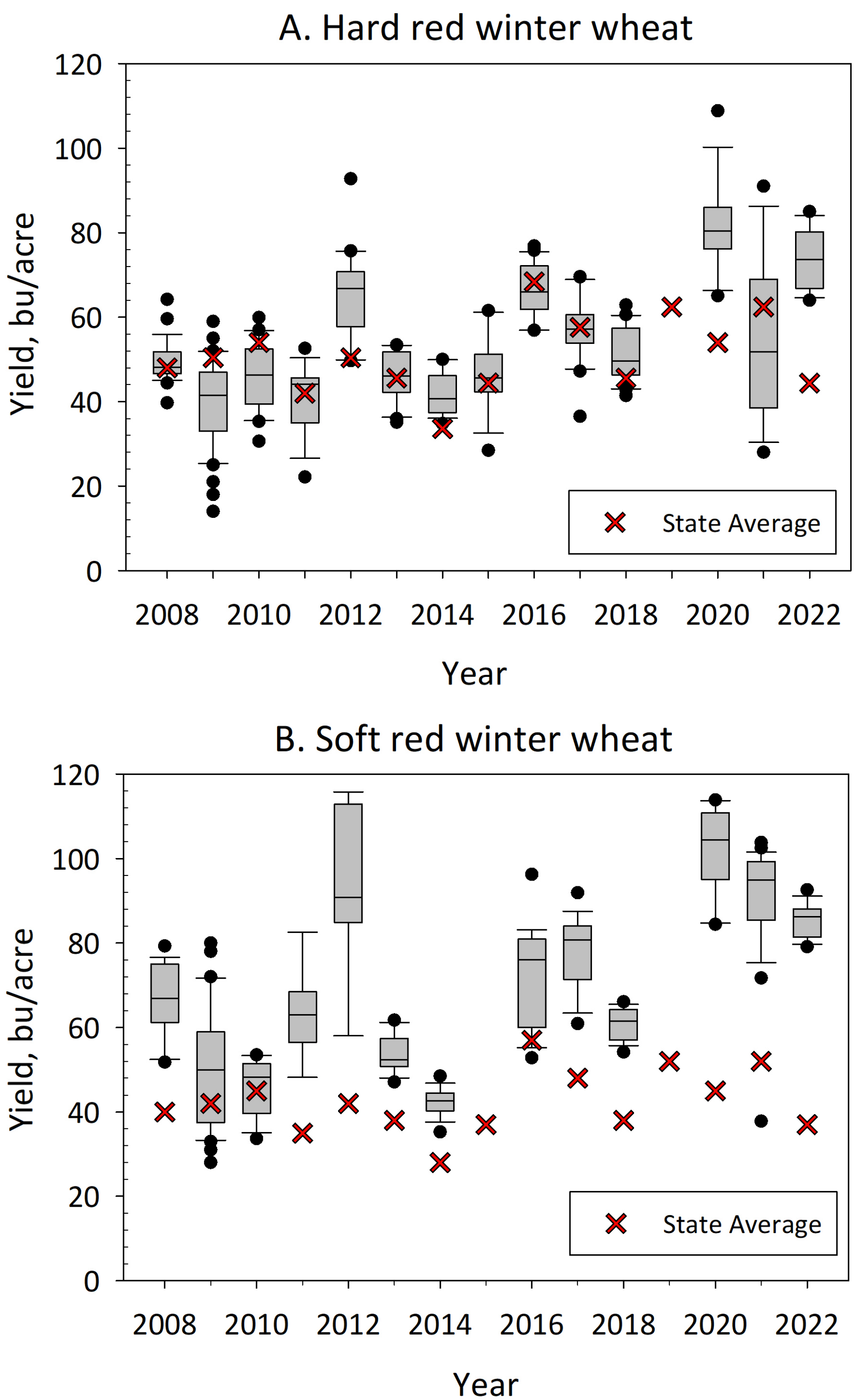

Figure 3. Winter wheat yield for (A) hard red wheat and (B) soft red wheat from variety trials in southeast Kansas from 2008 through 2022. In 2019, variety testing was abandoned due to flooding and poor stands. The line in the middle of the box plots is the median yield of all varieties. The upper and 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. For comparison, average reported state yields for hard red winter wheat from Kansas are highlighted as a red X.

Climate Long-Term Trends Impacting Wheat Production Systems in Kansas

O.M.M. Tavares,[1] F. Marin,[1] R. Lollato,[2] and B.C. Pedreira

Summary
Winter wheat production is of major importance in Kansas. The purpose of the study was to verify the evidence of climate change in a long-term weather data series from Wellington and Parsons, KS, to understand whether climate change has been affecting yield production.

Introduction
In the last 10 years, 8 million acres of wheat were planted resulting in 320 million bushels, which highlights wheat as a major crop for Kansas. In addition, wheat products and derivatives can be found in many foods, including baked goods, baking mixes, and batter-fried and breaded foods. Future climate and weather may be different due to climate changes, which may affect both crop growth and U.S. farmers' profitability.

Assuming that climate change would affect crop yield in the future, this project aims to analyze long-term climate data series in the state of Kansas to understand the impact that climate change has already caused on the weather variables. Trends and breaks in the weather data were studied using Mann-Kendall and Pettitt non-parametric statistics equations, respectively. In addition, we analyzed the crop yield trend using a process-based crop model (DSSAT-CERES-Wheat) to check if and how the weather has already affected long-term wheat yields. This study demonstrated the importance of knowing whether climate change is affecting crop growth and development. Thus, with this knowledge, cropping systems can be adapted to upcoming climates, ensuring food security.

Experimental Procedures
In this study, weather data from two weather stations, one in eastern (Parsons) and another in central (Wellington) Kansas were used to provide a broader geographical representation of the state. Wellington's weather station data were collected from 1865 until 2021 and Parson's from 1925 until 2021.

To study climatic trends, the weather data (maximum and minimum temperature and rainfall) were analyzed to identify the weather pattern through years and variations in a specific weather variable at a certain time. Due to the amount of data, the analyses were done using Python language.

Two different statistical procedures were used to analyze the weather data: Mann-Kendall and Pettitt, respectively. Mann-Kendall's (Mann, 1945; Kendall, 1975) equations were used to identify data trends, highlighting whether any variable presented a pattern change. After that, Pettitt's test (Pettitt, 1979) was used to identify the exact point when the variation in the weather pattern was statistically different. In this

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manuscript, we are presenting the results of Mann-Kendall and Pettit analyses. Later, this study will evaluate the impact of climate changes using these same climatological historical series, simulating the wheat yield over time using process-based crop models (DSSAT-Ceres-Wheat).

Results and Discussion

The Mann-Kendall test for Parsons showed the existence of a trend in the three variables analyzed. Maximum and minimum temperatures showed a decreasing trend and rainfall increased. In Wellington, the analyses pointed to different results for the three variables. The maximum temperature highlighted the existence of a decreasing trend, the minimum temperature did not present trends, and rainfall data had an increasing trend. Based on these results, the climate has changed in central (Wellington, Figure 1) and eastern (Parsons, Figure 2) Kansas.

For the variables minimum and maximum temperature, the decreasing trend represents negative slopes, which indicate a reduction in temperature values, and in the same way, the increasing trend represents positive slopes, indicating a temperature rise. The observed results for Parsons showed the trend of reduced minimum and maximum temperature values. For Wellington, only the maximum temperature showed the existence of a trend but also indicated decreasing values over those years.

Precipitation can be analyzed the same way as the temperatures were. The increasing precipitation trend was assumed to represent positive slopes, and the increase in rainfall. Both locations used in this study showed increasing values for precipitation, and those values match others found in studies from this same area.

In a study of analysis of temporal and spatial distribution for precipitation in Kansas, Rahmani et al. (2015) used data from 1890 to 2011 from 23 stations across the state to determine trends, gradual changes, and abrupt changes in the historical series using methods of Mann-Kendall, CUSUM, and Pettitt. The results showed that all but two stations had an increase in rainfall and that those kinds of increases tended to rise inside the state from west to east. From that we can assume the increase in rainfall in both studies' areas. Also, this same study showed significant change points in 12 of the 23 weather stations analyzed. Ahn et al. (2016) used those same methods for the analysis of trend and variability in hydrological extremes in the U.S. and found significant increasing trends for most of the weather stations.

Pettit's analysis shows the exact breakpoints (statistical change) at each variable (maximum and minimum temperature and rainfall) at the two locations in our study. All the weather stations analyzed demonstrated abrupt changes in the data series. It included the minimum temperature data for Wellington (Figure 1A), which despite not presenting a trend with the Mann-Kendall method showed a breakpoint at 1970, indicating the possibility of change in the data. For Wellington, the maximum temperature showed a breakpoint in 1967 (Figure 1B) and rainfall in 1957 (Figure 1C). For Parsons, the minimum temperature had breakpoints in 1975 (Figure 2A), the maximum temperature in 1972 (Figure 2B), and rainfall in 1939 (Figure 2C). Those results correspond to those reported by Rahmani et al. (2015) who demonstrated breakpoints in the available weather data for stations from 1940 to 1980.

These changes in temperature and rainfall may modify wheat physiological responses during the growing season in Kansas, which may or may not affect wheat yield in central-east Kansas. These climatological series will be used in the DSSAT-Ceres-Wheat model to evaluate the impact in wheat yield.

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Acknowledgments

Funding for this study was provided by grant #2022/05705-1, São Paulo Research Foundation (FAPESP).

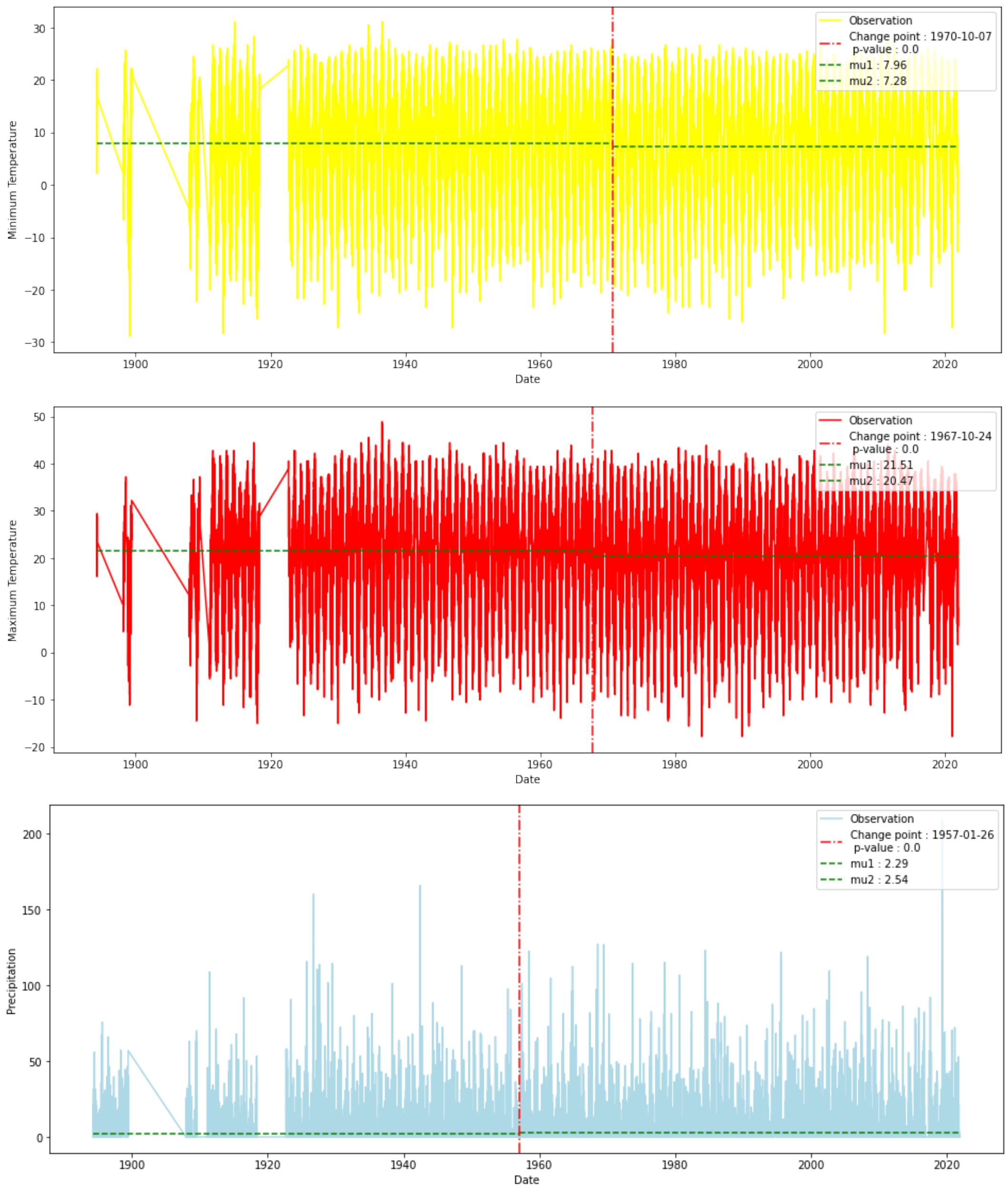

Figure 1. Minimum (A) and maximum (B) temperatures (Celsius), and precipitation (C; millimeters), respectively, in Wellington from 1895 to 2021. The dashed line highlights the change point.

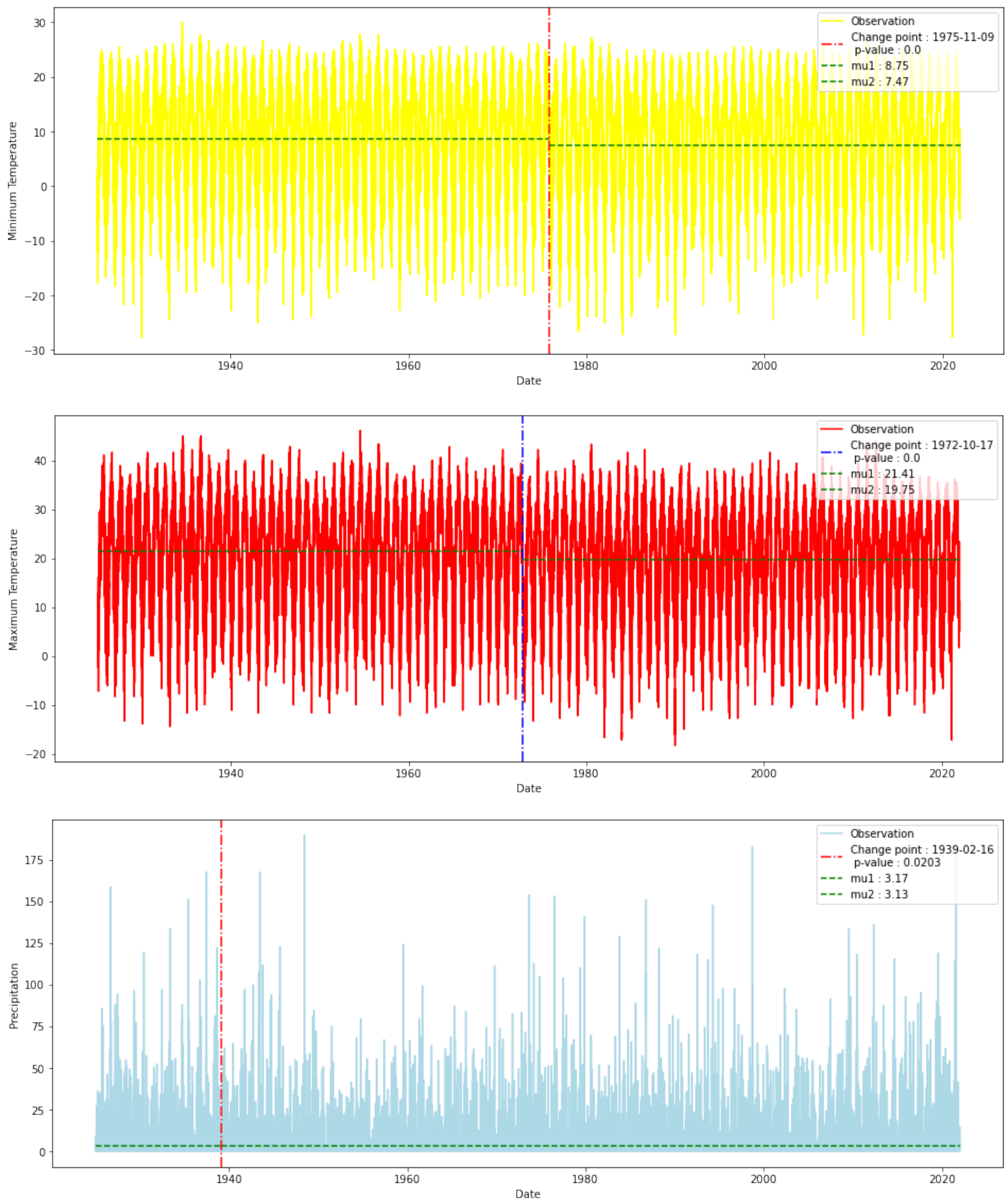

Figure 2. Minimum (A) and maximum (B) temperatures (Celsius), and precipitation (C; millimeters), respectively, in Parsons from 1925 to 2021. The breakpoints are highlighted by the red dashed line for A and C, and by a blue dashed line in B.

Corn and Soybean Production – 2022 Summary

G.F. Sassenrath, J. Lingenfelser,[1] and X. Lin[1]

Summary
Soybean and corn varieties were tested in replicated field trials at the Southeast Research and Extension Center in Parsons through the Kansas State University variety testing program. In total, nine corn varieties and three maturity checks were tested. Fourteen full season and ten double-cropped soybean varieties were tested, with three maturity checks. Additionally, sorghum and sunflower varieties were tested. The 2022 summer crop growing season was challenging. High temperatures and low rainfall reduced crop production. Crop production was severely impacted by the hot, dry conditions, both across the state and in the cultivar trials at Parsons. No yield results are available for the variety tests from Parsons.

Introduction
Variety testing is performed annually at several locations throughout Kansas. The Southeast Research and Extension Center tests crop varieties of corn, soybeans, wheat, sorghum, and sunflowers. Cultivar selection is an important determinant of potential yield. The crop variety tests performed through the Kansas State University variety testing program allows a comparison of variety performances under common growth conditions and management practices in multiple regions throughout the state.

Environmental conditions are key factors in determining crop success, together with soil characteristics, fertility, and management practices. Of the environmental factors, temperature and moisture (rainfall) are primary determinants of crop performance. Temperature is critical at certain crop developmental stages, and plays a role in yield potential. Cumulative Growing Degree Days (GDD) are commonly used to estimate crop growth and developmental stage.

This report summarizes corn and soybean performance in Kansas over the past fifty years. The temperature and precipitation conditions during 2022 are summarized and compared to previous years and historical averages.

Experimental Procedures
The Kansas State University Crop Performance Tests were conducted in replicated research fields throughout the state. Individual variety results are available at the K-State Crop Performance Test webpage (*http://www.agronomy.k-state.edu/outreach-and-services/crop-performance-tests/*). This report summarizes crop production for southeast Kansas, focusing on crops grown at Parsons, and southeast Kansas. In 2022, crop varieties of corn, soybeans, sorghum, and sunflowers were planted in 30-in. rows in upland fields (Parsons silt loam soil) at the Southeast Research and Extension Center in Parsons using conventional management and fertility. All crop variety trials are managed with conventional tillage. All crops germinated and appeared healthy. Due to

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adverse weather conditions during the growing season, all variety tests at Parsons were abandoned.

State reported crop yield data were downloaded from the National Agricultural Statistic Service Crop database (*https://quickstats.nass.usda.gov/*). Weather data were collected from the Kansas Mesonet website (*http://mesonet.k-state.edu/agriculture/degreedays/*) for a weather station located at SEREC in Parsons. Cumulative rainfall was calculated throughout the year and during the summer growing season (March - September). Cumulative growing degree days were calculated using base of 50°F during the summer growing season. The number of days of high temperatures (greater than 90°F) were calculated during the summer growing season.

Results and Discussion

Rainfall during the 2022 summer growing season (beginning with corn planting in March) was near the 12-year average (Figure 1) until early July. Two large rainstorms (4 in. on May 4; 3.48 in. on June 1) kept the total rainfall near average during the early season. However, during the three-month period from June 26 until the end of September, the area received only 2.14 in. of rain, compared to a 12-year average of 12.23 in. The US Drought Monitor (*https://droughtmonitor.unl.edu/Maps/MapArchive.aspx*) indicated the area became abnormally dry in July 5, 2022, with extreme drought by August 9, 2022, and exceptional drought by September 20, 2022. The exceptional drought conditions remain in the area. The summer growing season had total precipitation just slightly above that measured during the very dry 2012 growing season (Figure 1).

Temperature during the 2022 summer growing season was also above average (Figure 2). The cumulative growing degree days (GDD, base 50) were well below the exceptional year of 2012, but more than 240 GDD above the 12-year average. The extent of high temperatures can be seen by the number of days with temperatures above 90°F (Figure 3). The total of high-temperature days in 2022 was only 1 day less than during the 2012 growing season, and substantially (25 days) above the 12-year average.

The area planted to corn has been increasing steadily over the past 50 years (Figure 4a). In 2022, 5.5 M acres of corn were planted in Kansas, down slightly from 2021. Of this, 81% of corn acres were harvested for grain, with a significant uptick in corn harvested for silage (Figure 4b). This is well below the 50-year average of 89% corn grain harvest, most likely because of the hot, dry conditions. Grain yield statewide (115 bu/acre) was also below the 50-year average (125 bu/acre). Silage yield was also reduced from a 50-year average of 15 ton/acre to just 11 ton/acre statewide.

Soybean acreage has also trended upwards over the past fifty years (Figure 5), with 5.05 M acres planted in 2022, an increase from the previous 4 years. Planted soybean acres are more consistently harvested, with an average of 97% of planted acres harvested. This year saw an increase in abandoned soybean acres, as only 95% of planted acres were harvested. Soybean yield has been steadily increasing over the past 50 years, from a 10-year average of 22.4 bu/acre from 1973-1984, to 39 bu/acre from 2013-2022. The average statewide yield in 2022 of 27.5 bu/acre was significantly less than in the previous 10 years, but more than the drought season of 2012.

Conclusions

The 2022 growing season was challenging. Lack of adequate rainfall in the latter half of the year, combined with high temperatures, impaired crop production.

Acknowledgments

Data included in this report are part of the 2022 Kansas Performance Tests with Soybean Varieties (*https://bookstore.ksre.ksu.edu/pubs/SRP1173.pdf*), and the 2022 Kansas Performance Tests with Corn Hybrids (*https://bookstore.ksre.ksu.edu/pubs/SRP1174.pdf*).

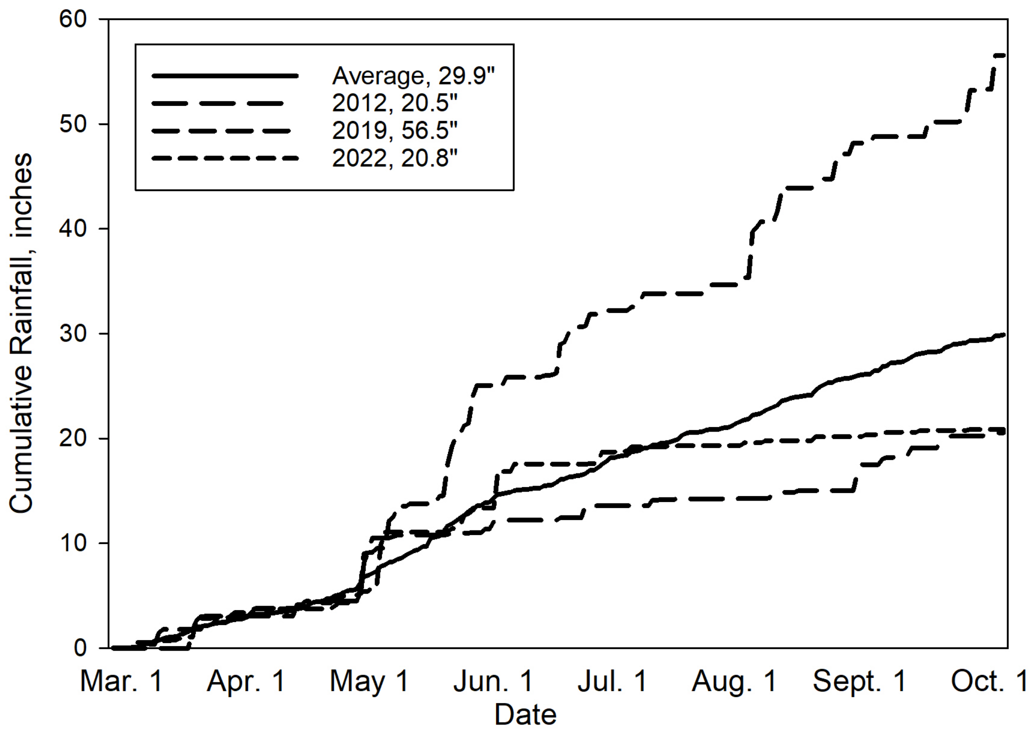


Figure 1. Cumulative rainfall during the summer growing season (March - September) for 2022. Extreme years (2012 and 2019) are shown in comparison with the 12-year average.

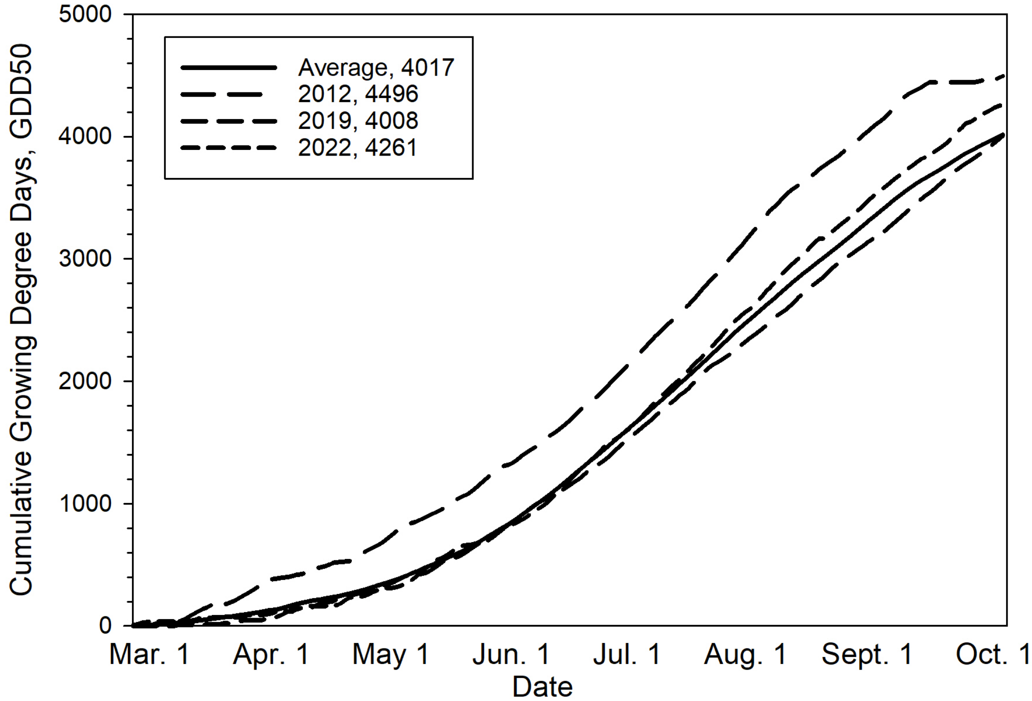


Figure 2. Cumulative growing degree days (50) during the summer growing season (March - September) for 2022. Extreme years (2012 and 2019) are shown in comparison with the 12-year average.

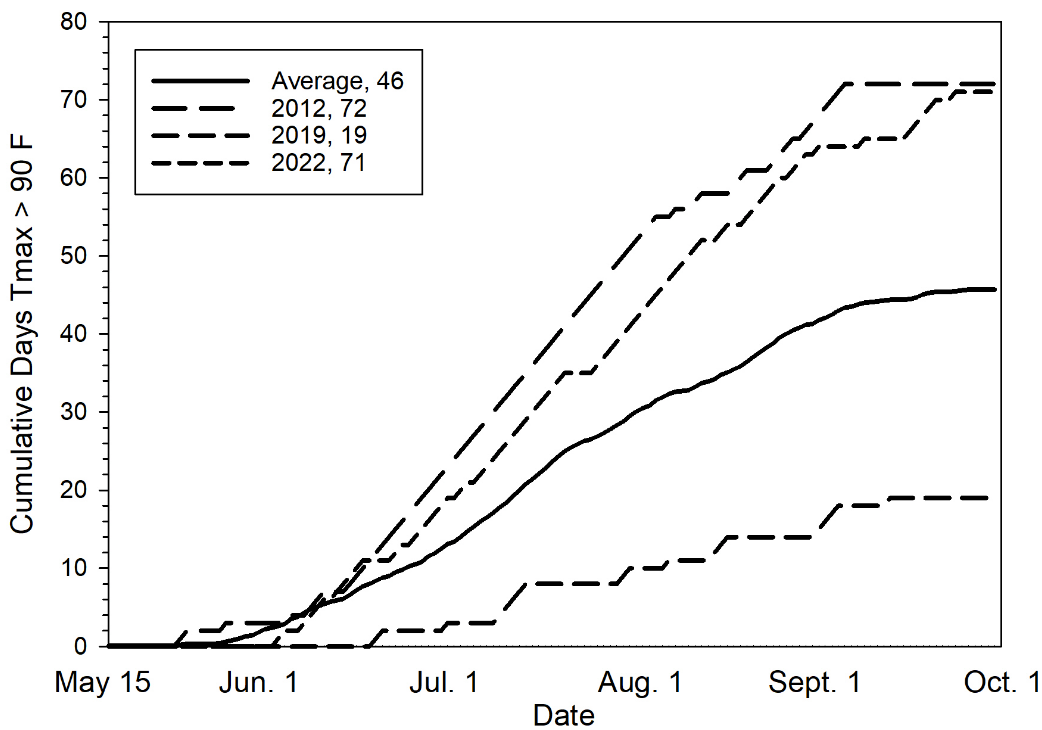
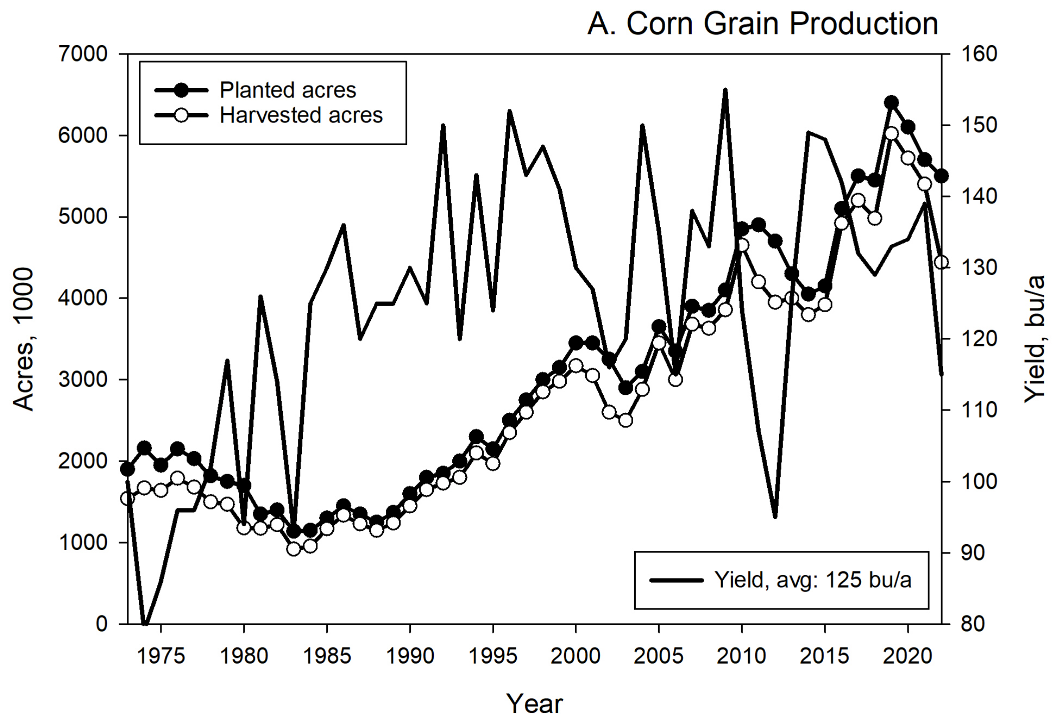


Figure 3. Cumulative number of high temperature (>90°F) days during the summer growing season (March - September) for 2022. Extreme years (2012 and 2019) are shown in comparison with the 12-year average.



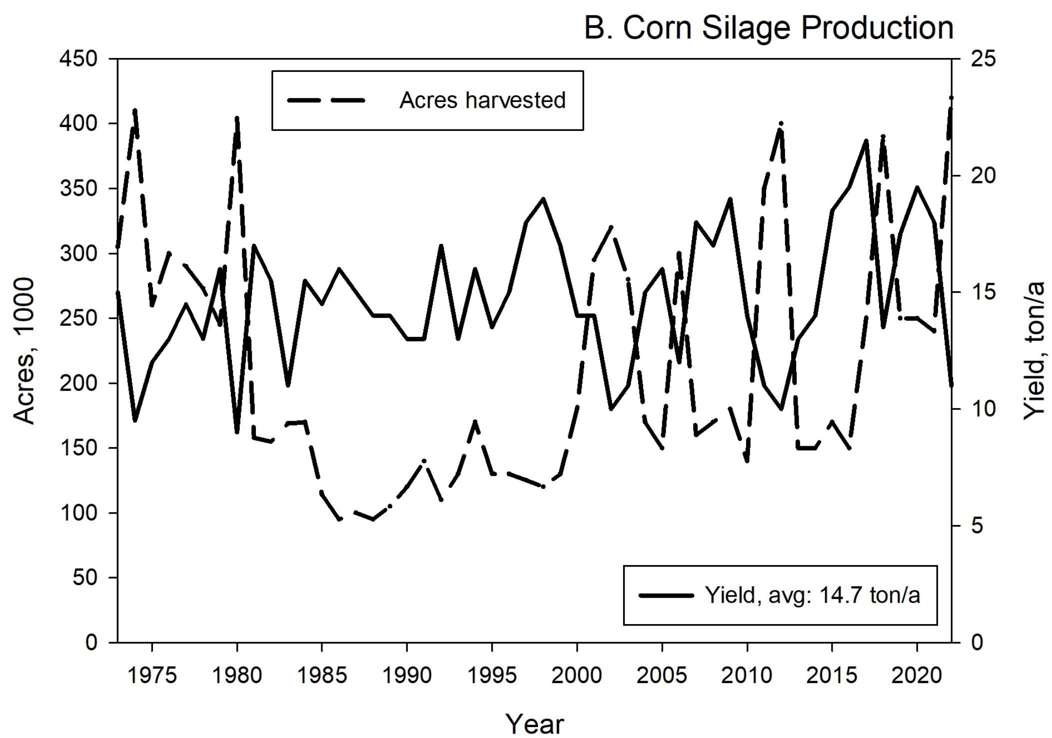


Figure 4. Historical corn production for Kansas. Upper. Corn grain, acres planted, acres harvested, and yield (bu/acre). Lower. Corn silage production, acres harvested and yield (ton/acre).

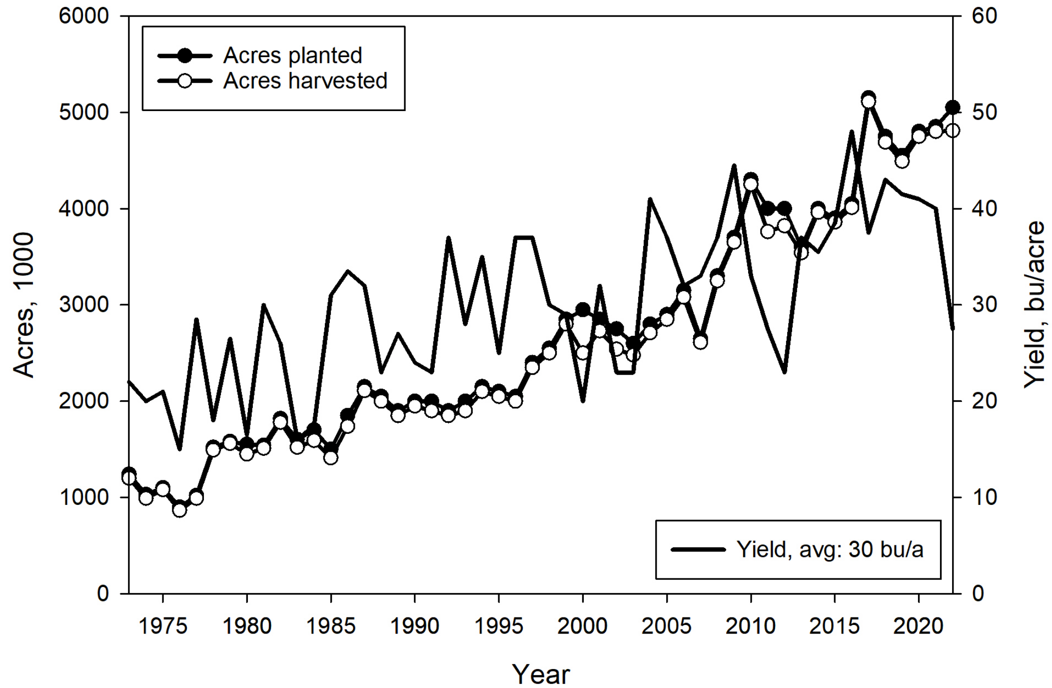


Figure 5. Historical soybean production for Kansas. Soybean acres planted, acres harvested, and yield (bu/acre).

Control of Soil-Borne Disease of Soybean

G.F. Sassenrath, C. Little,[1] X. Lin,[2] and S.R.G. Moraes

Summary
Soil-borne diseases are a significant cause of reduction in crop yield. Alternative management of soils can enhance the natural disease-controlling organisms in the soil. This study explores the impact of alternative production methods on a primary soybean disease, charcoal rot, caused by the fungus *Macrophomina phaseolina*. Treatments that could potentially enhance or control the disease were implemented, and soil tests were conducted for nutrient and disease presence. Manure increased the nutrient levels in the soil, as expected, but did not impact the disease control. Solarization increased the temperature within the plots, and increased the number of colony forming units of *M. phaseolina*. Environmental conditions during the 2022 growing season were much hotter and drier than normal, leading to reduced soybean yields.

Introduction
Suppressive soils have been defined as soils that can inhibit the growth of naturally occurring soil-borne diseases. These soils are capable of suppressing or controlling disease-causing organisms, including fungi (e.g. *Fusarium virguliforme,* cause of sudden death syndrome, SDS), *Macrophomina phaseolina* (cause of charcoal rot), Phytophthora root rot (*Phytophthora sojae*), and nematodes (e.g., soybean cyst nematode, *Heterodera glycines*). How the native soil microbial communities reduce disease is not known. Knowledge of factors that contribute to and support these beneficial microbial communities is also unknown.

One example of this natural improvement in soil microbial community reducing disease was demonstrated in our previous research (Sassenrath et al., 2017, 2019) that demonstrated that a high-glucosinolate mustard (*Brassica juncea*) reduced fungal populations that caused charcoal rot in soil and in soybean plants. Here, we expand on those results by exploring the interaction between soil health and disease pressure. Management practices that increase, decrease, or maintain disease pressure were tested in field studies to determine the impact on soil health, fungal pathogen presence, and soybean growth and yield.

Impact of Soil Health on Soybean Disease
Crop plants that are disease hosts increase the number of disease-causing organisms in the soil. We have previously shown the increase in colony forming units (CFU) of *M. phaseolina* in the soil after soybean production (Sassenrath et al., 2019). Other factors reduce soil-borne diseases include high-glucosinolate mustard as a cover crop (Sassenrath et al., 2017, 2019) and increasing the soil temperature (e.g., "solarization"). Use of animal manures greatly increases the diversity of the soil microbial community, and beneficial microorganisms in particular. In addition to improving the soil nutrient balance, manure may contribute to reduced disease pressure (Graham et al., 2014) and soybean cyst nematode populations (Bao et al., 2013).

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Diseases are primary factors that reduce the yield and quality of soybeans in Kansas and throughout the world. Soil-borne diseases are prevalent in eastern Kansas crop fields. Certain plants have been shown to produce chemicals that act as biofumigants that control or reduce harmful soil fungi. Animal manures have also been used to alter the soil microbiome to improve the control of disease organisms. Our working hypothesis is that improving the overall soil health by supporting healthy soil microbial communities can reduce disease pressure. Creating suppressive soils by altering management practices will reduce disease pressure. This research explores the relationship between soil health and disease pressure. The research tests the ability of cover crops, animal manure, and solarization to control or reduce charcoal rot in soybean production through improved soil microbial communities.

Experimental Procedures

Replicated plots were established at the Southeast Research and Extension Center in Parsons during the spring of 2022. Plots included: fallow, mustard cover crop, soybean, corn stubble, cow manure, and plastic sheets. Temperature sensors (Hobo, Onset, Inc., Bourne, MA) were installed at 2-in. depth in the soil in plots of one replication and temperatures were recorded continuously. Plastic sheets provide a "solarization" treatment, increasing soil temperature and potentially reducing soil microbes. Corn stubble was spread to about a 2-in. layer; corn stubble provides more carbon for soil microbes, increasing their abundance, but may also act as a host for *M. phaseolina*. Animal manure provides an additional food source for the microbes and adds additional microbes to the soil; manure has been shown to reduce some pathogens in soil. Mustard cover crop has been shown to reduce the number of CFUs of *M. phaseolina*, while soybeans are a host and increase the CFUs of *M. phaseolina*. The fallow treatment was left unplanted and served as a control.

Soil samples were collected in spring prior to implementing treatments, mid-season, and after harvest. Soils were analyzed for nutrients at the K-State Soil Testing Lab, for microbial activity and "Soil Health Score" at Ward Labs (Lincoln, NE), and for the number of CFUs of *M. phaseolina* in the Department of Plant Physiology at Kansas State University.

Results and Discussion

Nutrients changed in response to treatments (Table 1). As anticipated, the cow manure treatment had the highest levels of organic matter (OM), potassium (K), and phosphorus (P). This treatment also led to the highest Soil Health Score. Surprisingly, the solarization treatment (plastic film) had the highest total nitrogen (N) and microbiologically active carbon.

Interesting differences were observed in the environment within the soil in the different treatments (Figure 1). The plastic sheets (yellow line) raised the temperature more than 10 degrees above the fallow treatment (blue line), and temperatures remained elevated at night. Animal manure (grey line) also raised the daytime temperature, but temperatures decreased at night to that of fallow. Temperatures under corn stubble (orange line) were much lower throughout the day compared with the soil temperatures under fallow.

The only statistically significant difference in the number of CFUs was recorded in the solarization treatment (Figure 2), which showed a buildup in CFUs of *M. phaseolina* during the growing season. The corn stubble, cow manure, and soybean treatments had very similar levels of CFUs. The number of CFUs decreased slightly in the fallow and mustard seed treatments.

The summer growing season of 2022 was challenging for crop production due to high temperatures and low rainfall (Sassenrath et al., 2023). Crop establishment in the plots (mustard seed and soybeans) was impaired due to insufficient rainfall. Average yields for plots were very low (~5 bu/a) and well below the 12-year average at the station (Figure 3). Overall, statewide soybean yields were below average.

Conclusions

The soil microbiome controls many of the functions of the soil. It is possible, through alternative management practices, to alter the soil microbiome to support helpful organisms, such as arbuscular mycorrhizae, while controlling disease-causing organisms. Preliminary evidence from this study showed a minor change in microbial composition and activity with treatments. However, the unusually hot and dry weather may have compromised the results, as soybean yields were greatly reduced.

Acknowledgments

This research is supported by funding from the Kansas Soybean Commission and the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1018005.

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Table 1. Changes in soil nutrients with treatment

	Organic matter, %	Potassium, ppm	Mehlich P, ppm	Total N, ppm	Soil health score	Microbially active carbon, %
Mid-season						
Corn stubble	1.9	74.5	23.0	13.4	9.6	47.6
Cow manure	2.4	150.5	47.3	16.1	13.4	54.3
Fallow	2.0	66.8	18.5	13.2	10.3	48.8
Mustard seed	2.1	78.5	23.0	15.6	12.0	42.8
Plastic film	2.0	62.3	19.5	21.2	13.9	64.9
Soybeans	2.0	73.8	20.3	12.9	11.7	53.1
At harvest						
Corn stubble	2.0	80.3	27.3	19.6	10.4	36.7
Cow manure	2.2	160.3	53.0	27.8	13.2	43.3
Fallow	2.0	60.8	25.8	20.1	12.1	63.4
Mustard seed	2.0	74.5	29.0	21.8	15.3	73.4
Plastic film	2.0	60.3	29.0	33.3	12.1	91.0
Soybeans	2.0	71.8	25.5	19.2	14.1	68.4

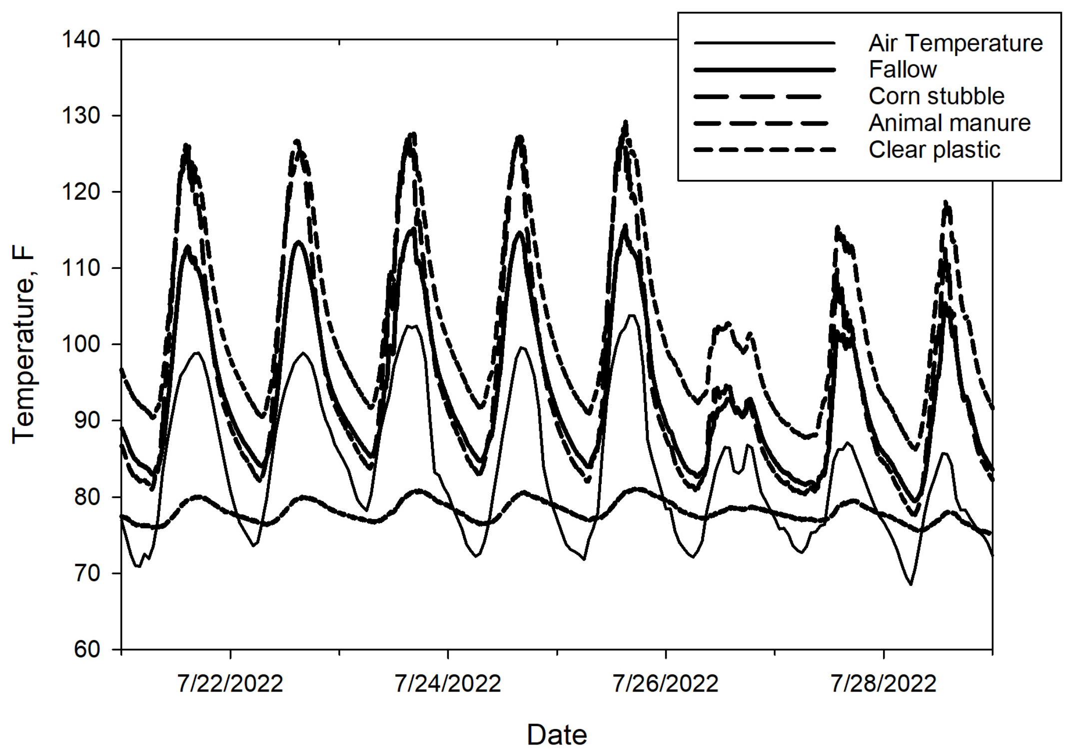

Figure 1. Temperatures (°F) at 2-in. soil depth in the different treatments.

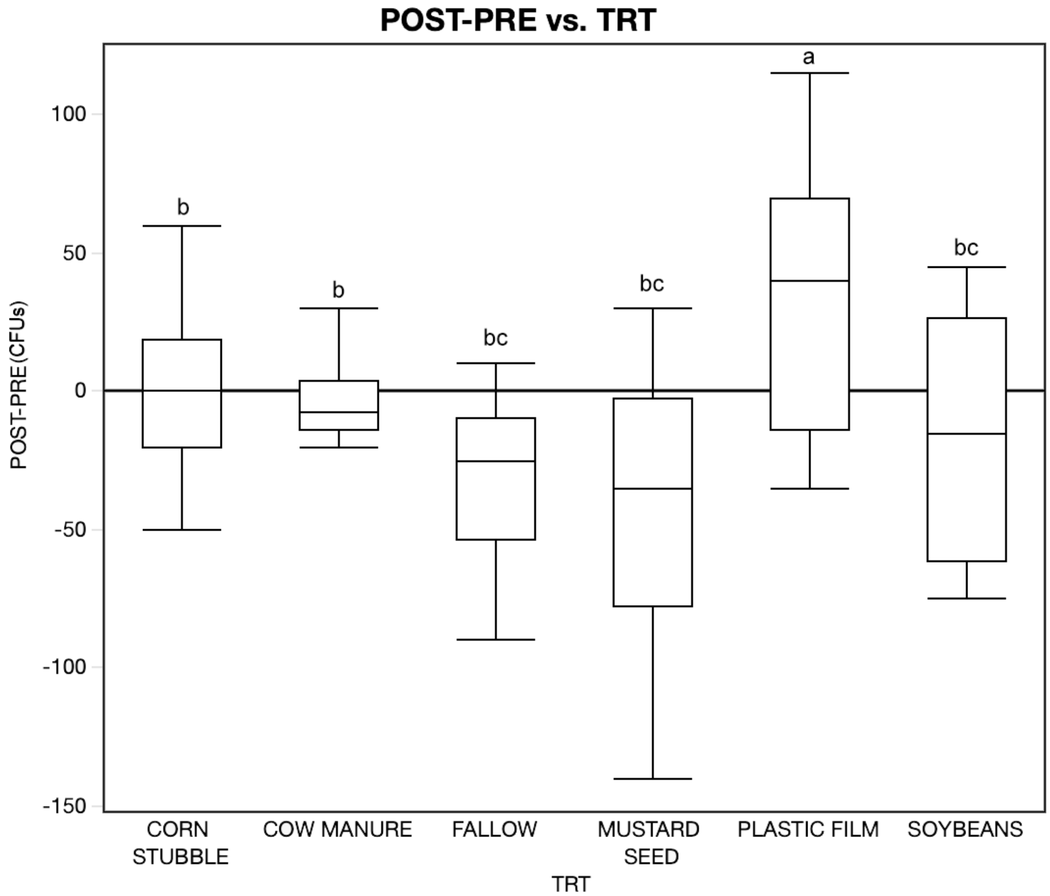

Figure 2. Change in the number of colony forming units (CFUs) of *Macrophomina phaseolina* from prior to planting to at harvest. The line in the middle of the box plots is the median yield of all varieties. The upper and lower quartiles are given by the upper and lower edges of the boxes. The maximum and minimum values are given by the upper and lower "whiskers" extending from the box. Letter values above the whiskers indicate the statistical differences between populations.

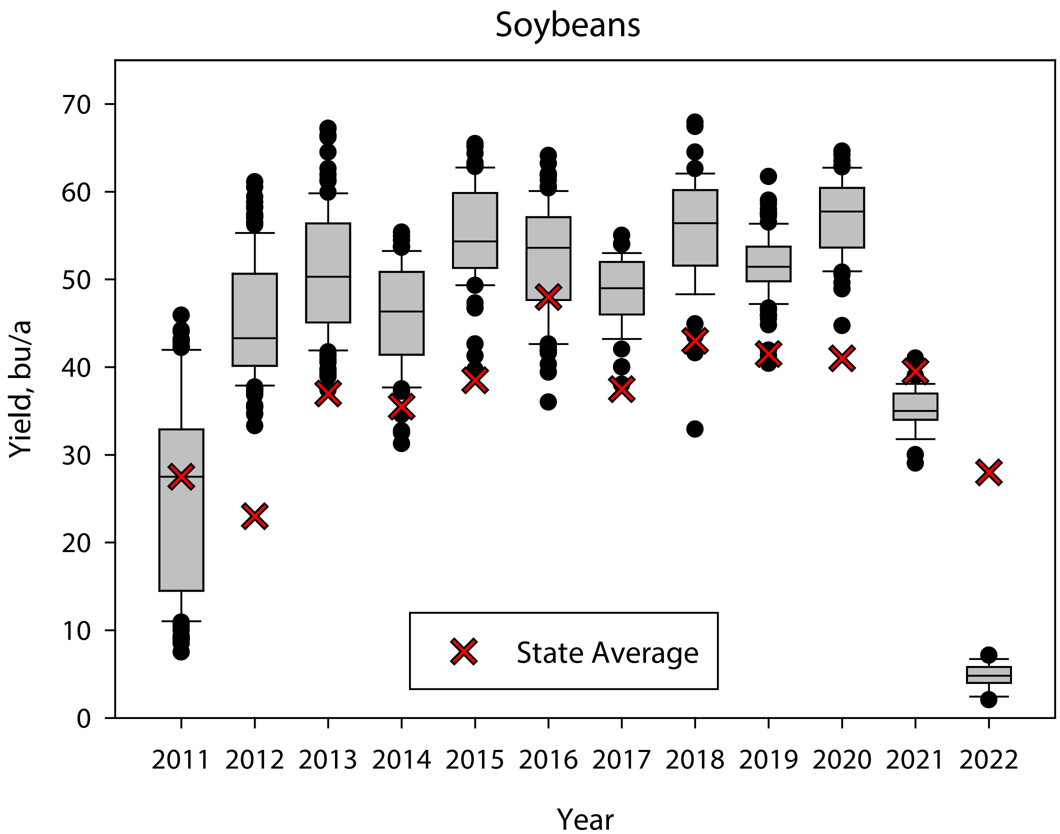

Figure 3. Soybean yields from variety trials in southeast Kansas from 2008 through 2022. For comparison, average reported state yields for hard red winter wheat from Kansas are highlighted as a red X.

Early Soybean Planting in a Water-Limited Growing Season

S.R.G. Moraes, B.C. Pedreira, V. Sharda,[1] R.B. Onofre,[2] and G.F. Sassenrath

Summary

Appropriate management, with a longer growing season during reproductive growth stages, can increase biomass and yield in soybean. Our objective was to determine the impact of three planting dates, two seed populations, and three maturity groups on grain yield in southeast Kansas. However, due to the severe drought in 2022, with a total rainfall of 18.84 inches during the soybean growing season (55% lower than the 10-yr average), the growing conditions were very limited, resulting in an average yield of 1.7 bu/a.

Introduction

Soybean (*Glycine max* (L.) Merr.) is one of the most important crop commodities in the U.S. Kansas has about 6% of the United States' soybean acreage. Soybean yield for 2022 totaled 132 million bushels, averaging 27.5 bushels per acre, which is down 12.5 bushels (31%) compared with 2021 (USDA, 2023). Several factors contribute to crop yield, including genetic traits, environmental conditions, and management practices. Thus, changing weather patterns across the United States have been stimulating researchers to re-examine how agronomic practices interact with the environmental conditions and impact yield.

Although soybeans can be planted at a wide range of dates, many research findings in neighboring Midwestern states have indicated that producers can profit from early planting dates. Though some studies have shown that the scale of the response to early planting can vary between years (Pedersen and Lauer, 2003), locations (Lueschen et al., 1992), and cultivars (Grau et al., 1994), more recent studies show a general trend of higher yields associated with earlier planting dates (Nleya et al., 2020). To explore that, our study was designed to understand the effect of planting date, plant population, and maturity group on yield in southeast Kansas.

Experimental Procedures

The trial was conducted at the Southeast Research and Extension Center in Parsons, KS, during the 2022 growing season. The soil was a Parsons silt loam, and 0- to 6-in. soil samples were collected in April 2021 (Table 1). According to Köppen, the local climate is classified as Cfa (warm, humid, hot summer). Weather data were recorded at a weather station located 1500 ft from the experimental site (Figure 1).

The experiment was established in a randomized complete block design with a factorial arrangement (planting dates vs. plant population vs. maturity group) with three replications. In each of the three planting dates [04/08/2022 (Early), 04/29/2022 (Middle), and 05/23/2022 (Late)], three soybean cultivars [maturity group (MG) 4.1, 4.7, and

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5.4] were seeded at two target populations (100,000 and 150,000 seeds/acre). Each plot was composed of four 30-in. rows, for a total plot size of 10 ft wide × 40 ft long.

Soybean cultivars used in the study were 4121RXF/SR, 4720RXF/SR, and 5420RXF/SR, which are commonly grown by growers in southeast Kansas. Seeds were treated with the Acceleron Seed Applied Solutions (Standard) (a.i. pyraclostrobin, metalaxyl, fluxapyroxad, and imidacloprid). The seed treatment provides protection of root rot pathogens, including *Fusarium* spp., *Rhizoctonia solani*, *Pythium* spp., and *Phytophthora* spp.

The field was fertilized with 9 lb of N, 45 lb of P, and 45 lb of K per acre, using diammonium phosphate and potassium chloride, and cultivated on April 7. Post-emergent herbicide was applied on May 16, and plots were harvested on October 21, 2022.

Soybean growth stages (Fehr and Caviness, 1977) were determined in each plot 18 times throughout the growing season. Total aboveground biomass at V6 - R1 (6/13/2022), R2 - R3 (7/19/2022), R4 - R5 (8/15/2022), and R6 (9/12/2022) was collected in each plot, 1 linear m was randomly collected from the first or fourth rows. Samples were oven-dried at 60°F until constant weight and weighed.

Charcoal rot severity and *Macrophomina phaseolina* colony-forming units per gram of lower stem and roots (CFU/g) were assessed at the R7 stage, in 6 plants from each plot. Severity was reported on a scale from 1 to 5 (Paris et al., 2006). Colony-forming units (CFU) were calculated according to Mengistu et al. (2007). Dry samples were ground in a Wiley Mill Model ED-5 to pass through a 1-mm mesh screen. The mill was thoroughly cleaned between samples using a suction device. For each sample, 0.05 g of powdered tissue was placed in a microcentrifuge tube with 1 mL of 10% sodium hypochlorite (NaClO) and briefly vortexed. The tubes were shaken for 3 one-minute intervals with 15-second breaks in between and rinsed over a 45-μm pore size sieve with distilled water. The disinfected material was poured into a 50-mL falcon tube containing PDA medium that was previously autoclaved and amended with rifampicin (0.1 g/L) and tergitol (1 mL/L). After 3 days of incubation at 86°F, the CFUs were counted and converted to CFU per gram of ground tissue.

To determine grain yield, the two center rows were harvested in each plot after plants reached physiological maturity using a small plot combine (Gleaner K2). Grain yield was adjusted for 13% moisture. Immediately before harvesting, eight plants were taken from each plot to determine the number of pods per plant, the number of seeds per pod, and the 100-seed weight.

Biomass, charcoal rot severity, and *M. phaseolina* colony-forming units data were analyzed using the method of generalized linear mixed models (PROC GLIMMIX) in SAS. Biomass data were analyzed separately for V6 - R1, R2 - R3, R4 - R5, and R6. The means were estimated by least-squares mean (LSMEANS) and comparisons were performed using the probability of the difference (PDIFF) of the Student's t-test ($P < 0.05$). Test weight, grain yield, number of pods per plant, the number of seeds per pod, and 100-seed weights were not analyzed statistically due to the high variability resulting from the dry weather.

Results and Discussion

The days required to emerge were similar for the three planting dates, and there were no differences among varieties or plant populations (Table 2). The planting date affected the duration of the vegetative (VE to V6) and reproductive (R1 to R6) stages. Later planting dates resulted in a shorter period for each growth stage.

In 2022, the growing season was very dry and water stress limited plant growth (Figure 1). Total rainfall during the soybean growing season (April 8 to October 21, 2022) was 18.84 in., which is 55% lower than the average rainfall in the last 10 years (April to October). Plants were shorter, and the canopy did not close, reducing biomass. Soybean biomass was higher in the early planting dates when compared with middle and late dates during the whole season (Figure 2A). Only biomass at V6 - R1 was influenced by maturity group, population, and planting date × maturity group interaction. Greater biomass was observed in early planting, 5.4 MG, and 150,000 plants/a.

Because of the low disease pressure in this field, plant vascular tissue darkening (indicative of charcoal rot infection) was not observed. Tissues of the stem and root (inside and out) did not show high numbers of microsclerotia. However, the early planting date reduced charcoal rot severity compared with middle and late planting dates. The *M. phaseolina* colony forming units per gram at the lower stem and root did not differ for plant population, maturity group, or planting dates (Figures 2B and C).

Soybean grain yield is determined by the number of pods per plant, seeds per pod, and seed weight. However, most of the precipitation occurred prior to June 1 (Figure 1), before the reproductive stage, when floral abortion was intense in the field (R1-R2). After that, soil moisture remained very limited at the R3 and R4 growth stages, negatively impacting the number of pods, and drought at R5 and R6 reduced the number of seeds per pod and the seed size (Figure 3A, B, and C). Consequently, low test weight (53.8 lb/bu) and insignificant yield (1.7 bu/a) were registered in the 2022 growing season (Figure 3D).

Conclusion

Despite the early planting date presenting the greatest total biomass, number of pods per plant, and lower charcoal rot severity, soybean yield was not successfully assessed due to the weather conditions. Thus, the evaluation of planting dates, population density, and maturity groups cannot be conclusive due to the extreme drought conditions during the 2022 growing season in southeast Kansas. The trial will be repeated in 2023.

Acknowledgments

We appreciate the Kansas Soybean Commission for funding this proposal and Channel Seeds for donating the soybean seeds.

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Table 1. Soil chemical properties in the experimental area

pH	Mehlich-3 P	Extractable K	NH_4^+	NO_3^-	OM
	mg/kg				g/kg
5.7	16	95	1.6	25	3.1

Table 2. Total days from planting to emergence, duration of vegetative (VE to V6), and reproductive (R1 to R6) period in soybean

	Average number of days		
Planting date	Emergence	Vegetative period	Reproductive period
Early	13	42	85
Middle	11	35	72
Late	10	33	53

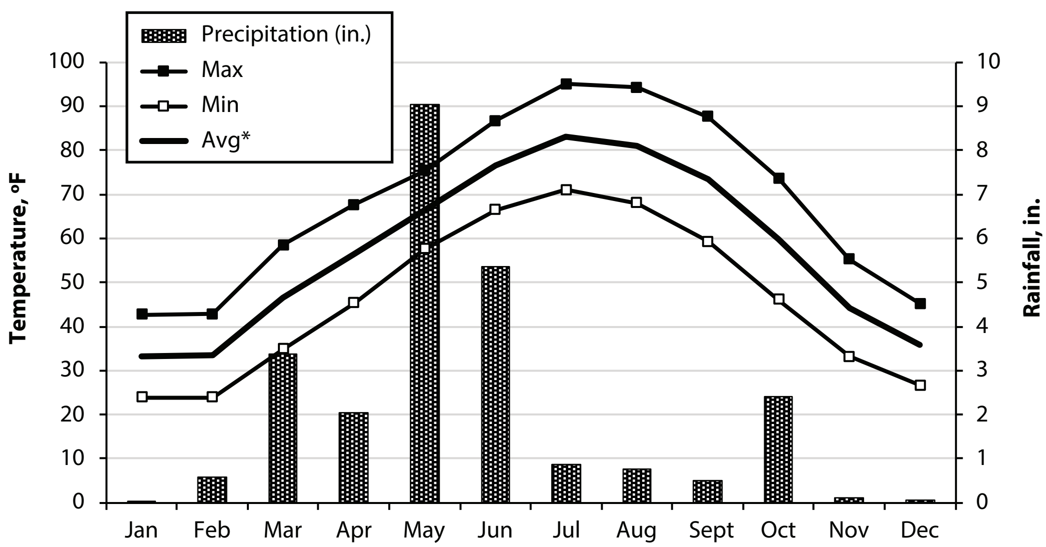

Figure 1. Monthly rainfall (in.), maximum, average, and minimum temperature (°F) in Parsons, KS, from January to December 2022.

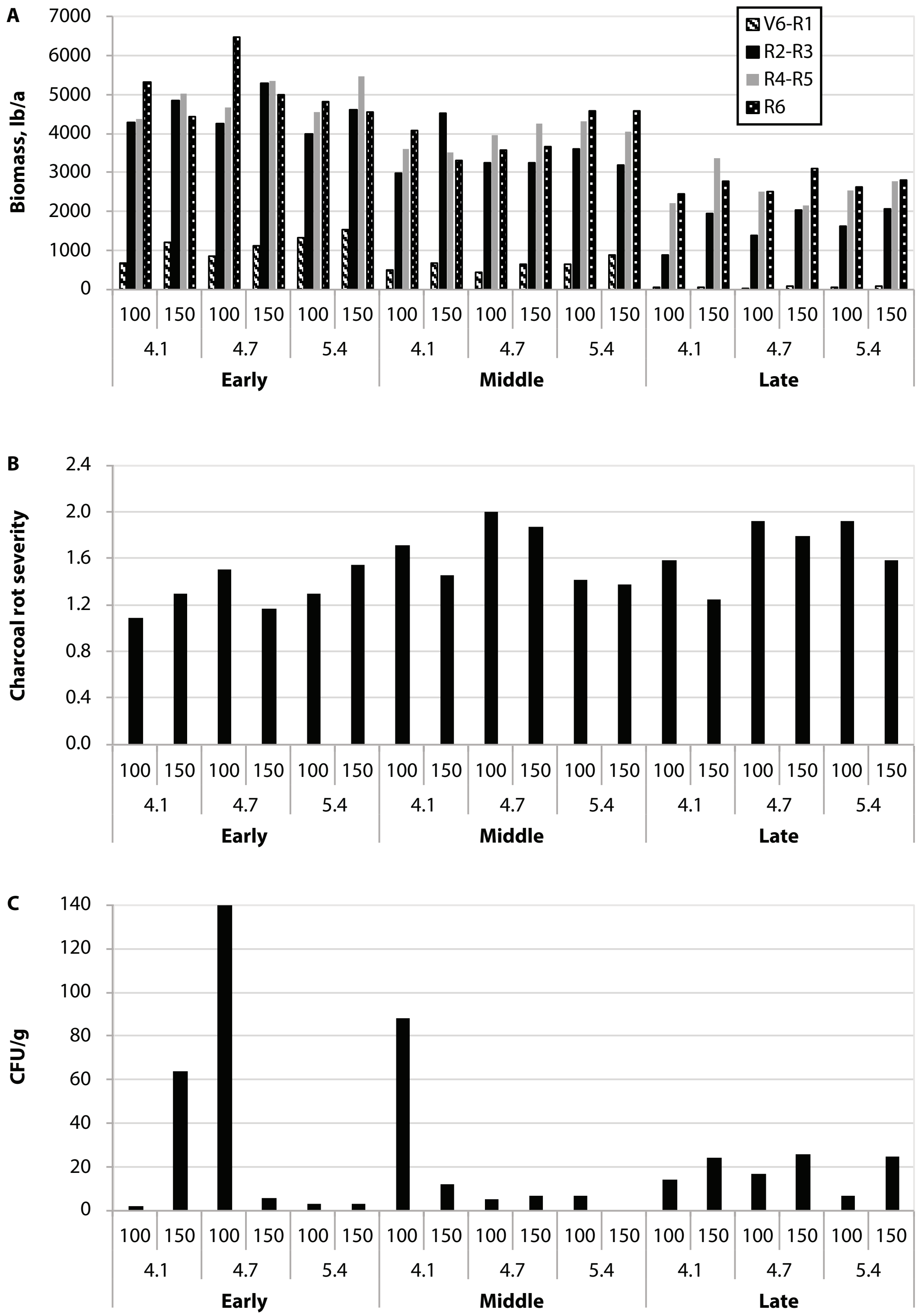

Figure 2. Biomass (A), charcoal rot severity (B), and *M. phaseolina* colony forming units (CFU) per gram (C) of two plant populations and three varieties at early, middle, and late planting dates.

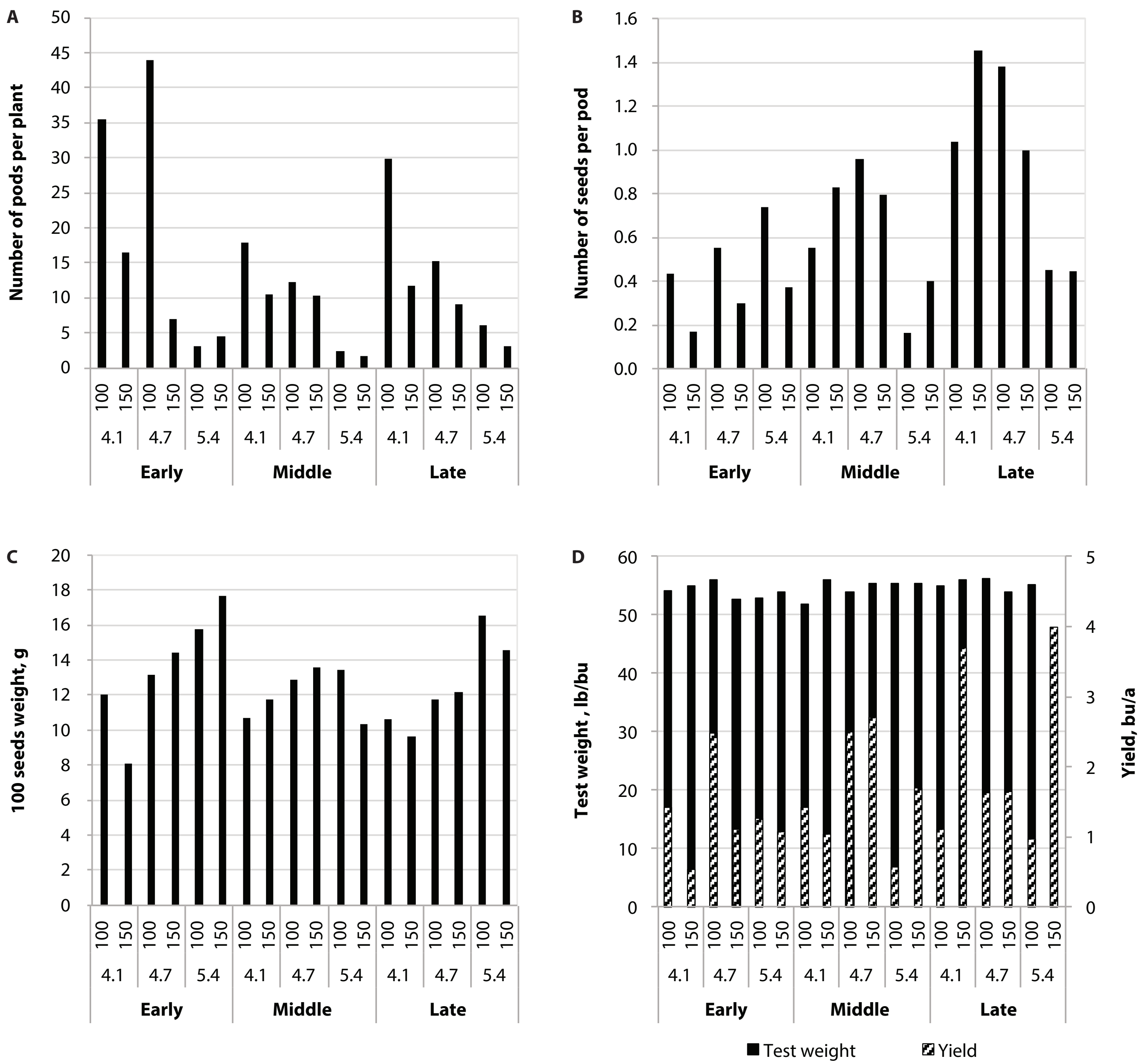

Figure 3. Number of pods per plant (A), number of seeds per pod (B), 100 seeds weight (C), and grain test weight and yield of soybean (D) of two plant populations and three maturity groups at early, middle, and late planting dates.

Critical Soil Health Parameters to Improve Crop Production

G.F. Sassenrath, B.C. Pedreira, and C.B. Pires[1]

Summary
Soil health is a critical determinant of plant performance. This manuscript describes how the physical, chemical, and biological components within the soil interact to create good soil health. Soil structure is important to provide support for plants, nutrient and water cycling, decreased compaction, and more efficient carbon storage. Measurements of soil properties are presented that can be done in the field on any soil.

Introduction
Soil health is an important topic these days. But what is soil health and why is it important? More importantly, how can we reliably measure soil health?

Soil health can be thought of as the ability of the soil to function in the way it is supposed to function—to do what it is supposed to do. The functioning of the soil for crop production can be defined as the productive capacity, or, from a crop production standpoint, the bu/acre or $/acre the soil is able to produce. The primary functions of soils are to serve as support for plants, sequester carbon, and to cycle nutrients and water which are critical for crop production. We often think of these functions as a one-way street, but they are actually cycling within the soil. They are described as "cycles" because the soil captures nutrients and water, stores it, and then makes it available to plants when they need it. The plant material is then broken down by soil microbes (bacteria and fungi) after harvest, and the nutrients are recaptured within the soil and stored for later use. The health of the soil determines the ability of the soil to support and continue these cycles.

Soil health is difficult to measure directly, so it is determined as the measured physical, chemical, and biological characteristics (Figure 1). The "inherent" properties of soils are based on the materials that were deposited to form the soil. How we manage the soil greatly influences the other properties of the soil, and determines the soil health.

The physical characteristics of the soil are dependent on the amount of sand, silt, or clay that the soil is composed of. The chemical components of soil include pH, nutrients, and water. The biological components include everything from large animals (e.g. armadillos, moles, voles, etc.), earthworms, arthropods (insects, spiders, etc.), bacteria, fungi, nematodes, and plants. The physical, chemical, and biological factors work together to create the soil ecosystem. All of the individual components are intimately integrated to build the functionality of the soil ecosystem. How we manage the soil determines the components that make up the soil and how well they function. While moderation of the physical soil characteristics can take centuries to modify, or be as rapid as a flood bringing in sand, the chemical and biological components respond rapidly to management practices. Optimal soil conditions decrease soil compaction, reduce limitations

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to root growth, improve water infiltration and storage capacity, increase aeration, and improve nutrient uptake, storage, and delivery to plants.

Soil aggregates are soil particles that cohere or bind to each other to form a defined soil structure. The formation and characteristics of soil aggregates are dependent on the physical, chemical, and biological components of the soil. The soil aggregates are also a key indicator of soil health. A soil that has stable aggregates indicates a better soil structure, while soil aggregates that quickly disperse indicate poor soil structure. Because of their central role in soil health, this report includes a review of soil aggregates in soils from six representative management systems.

Experimental Procedures

Soil Health Buckets were obtained from the Kansas Soil Health Alliance (*https://kssoilhealth.org/*). Soil samples were collected from fallow fields and fields planted to wheat, under both tilled and no-till management. Soil was also collected from a long-term hay meadow field. All soils were Parsons silt loam. Soil sampling was performed using a sharp-shooter shovel. A 6-in. deep slice of soil from each location was collected and transferred to a gallon zip-lock plastic bag and brought to the lab for analysis and demonstration.

The soil structure was first determined based on the Visual Evaluator of Soil Structure (VESS; *https://www.farmingforabetterclimate.org/improving-farm-profitability/soils-fertilisers-and-manures/assess-your-soil-structure/*). The VESS provides a simple framework that uses a qualitative approach to evaluate the physical characteristics of soil structure, including the size, shape, orientation, and distribution of soil aggregates. The VESS evaluation can be used in a variety of settings, including agricultural fields, gardens, and other areas to provide an assessment of soil physical structure and indicate potential concerns.

To measure the health of soil aggregates, small soil aggregates were collected from the samples and put into coffee filters. Tap water was slowly dripped onto the soil samples from water bottles with small holes in the lids. This simulates rainfall and shows how quickly soil will be lost from the soil surface during a rain event.

Results and Discussion

Soil structure impacts how well roots will be able to grow into the soil, the aeration of the soil, and the water available to the plant. Examination of soil using the VESS rating indicates the soil structure and relative compaction. For both no-tilled soils, the soil aggregates readily crumbled into smaller fragments with no clods, giving the soil a rating of Sq1, indicating the soil was very friable (Figure 2A, C). Friable is a term to describe how easily the soil crumbles between the fingers. Friable, or mellow, soil is very good for plant establishment, as the plants have good aeration and readily-available water for growth. There is minimal compaction, so roots are able to grow easily. The tilled wheat soil broke apart more readily on the surface soil due to the wheat roots. The deeper soil was difficult to break apart and had large clods, rating this soil as firm or compact (Sq3; Figure 2B). The tilled fallow soil was very difficult to break apart, requiring two hands and some force to separate the soil at all depths (Figure 2D). Large clods were evident, demonstrating how compact this soil was (Sq4). The soils were all moist; when dry, the tilled fallow soil would have been very difficult to break apart. The soil from the hay meadow showed abundant roots and was fairly easy to break apart (Figure 2E). The soil was primarily held together by the dense roots (Sq2). The higher ratings (Sq3 and Sq4) indicate that the soil is compacted, and steps should be taken to improve how friable the soil is.

Carbohydrates (sugars) are the currency of life on earth. They are a key factor in all aspects of our food systems, field to table. Carbohydrates are formed by plants through the conversion of sunlight and CO_2 during photosynthesis into stable energy sources used by most life on earth (in one form or another). These sugars are exchanged by organisms in the soil as they "barter" for needed items. Plants make sugars and excrete them into the soil; fungi and bacteria take up these carbohydrates in exchange for nutrients needed by the plant. Fungi and bacteria also excrete carbohydrates into the soil. The abundance of carbohydrates in the soil is related to the functionality of the biological components of the soil. Glomalin is a sugar-protein formed in the soil and roots by arbuscular mycorrhizal fungi. Glomalin, together with fungal hyphae and plant roots, create soil aggregates that bind together the soil particles into a structure. These aggregates stabilize the soil, reducing erosion, protecting carbon, and enhancing water and nutrient cycling within the soil.

Soil structure is critical to support plants, provide water and nutrient cycling, and reduce the loss of soil particles through erosion. To estimate the soil aggregate stability, we used a small rainfall simulator. The tilled fallow lost significantly more soil than the no-till fallow (Figure 3). This greater loss of soil particles is because of poor soil structure in the tilled soil. While it was originally thought that tillage was needed to improve soil structure and create a good seed bed, research has shown that tilling actually destroys the soil structure by breaking up aggregates. Tillage also breaks up the fungal hyphae and plant roots. Additionally, the excessive aeration of the soil with tillage causes the organic matter to be broken down more rapidly, further releasing carbohydrates that stabilize the soil aggregates and carbon dioxide to the atmosphere (CO_2).

Conclusions

Agronomists have long thought that tillage is required to "open" the soil and provide a good seed bed for plant establishment. New research has demonstrated that, while originally tillage may have been needed to convert historical grasslands into soils suitable for crop production, continued tillage creates more problems than solutions. Tillage destroys the soil structure, collapsing the pores formed by fungal hyphae and plant roots. Tillage creates conditions of poor aeration, lower organic matter, and surface crusting. Reducing tillage builds the soil microbial community that is responsible for the soil and water cycling that is critical for crop production.

The Soil Health Buckets used in this study are available from the Kansas Soil Health Alliance. In addition to the visual assessment of soil health and the measurement of aggregate stability, additional tests on infiltration and water uptake by soils in the field and the slake test help landowners measure soil health in their fields.

Acknowledgments

We appreciate the producers who collaborated in this research project. This research is supported by funding from the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1018005. For more information about VESS, visit *https://www.farmingforabetterclimate.org/improving-farm-profitability/soils-fertilisers-and-manures/assess-your-soil-structure/*.

Table 1. Assessment of soil structure

Structure quality	Size and appearance of aggregates	Visible porosity and roots
Sq1 Friable	Aggregates readily crumble with fingers; aggregates are mostly less than 0.25 inches	Highly porous Roots are present throughout the soil
Sq2 Intact	Aggregates easy to break with one hand Mix of porous, rounded aggregates from 0.1 to 0.25 inches. No clods present	Most aggregates are porous Roots are present throughout the soil
Sq3 Firm	Most aggregates break with one hand Mix of porous aggregates from 0.1 to 0.4 inches. Some non-porous aggregates (clods) may be present	Macropores and cracks present Porosity and roots both within aggregates
Sq4 Compact	Requires considerable force to break aggregates with one hand Mostly large aggregates greater than 0.4 inches Blocky and non-porous aggregates Horizontal or platy structures may be seen	Few macropores and cracks All roots are clustered in macropores and around aggregates
Sq5 Very compact	Difficult to break up soil Most aggregates are more than 0.5 inch; very few less than 0.25 inches Angular and non-porous aggregates	Very low porosity Macropores may be present. May contain anaerobic zones (grey-blue color). Few roots if any, and roots are restricted to cracks

Based on the Visual Evaluator of Soil Structure (VESS): *https://www.farmingforabetterclimate.org/improving-farm-profitability/soils-fertilisers-and-manures/assess-your-soil-structure/*.

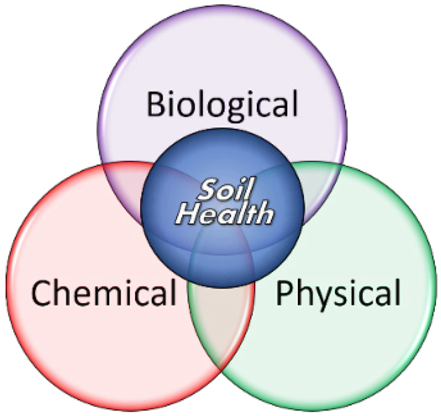
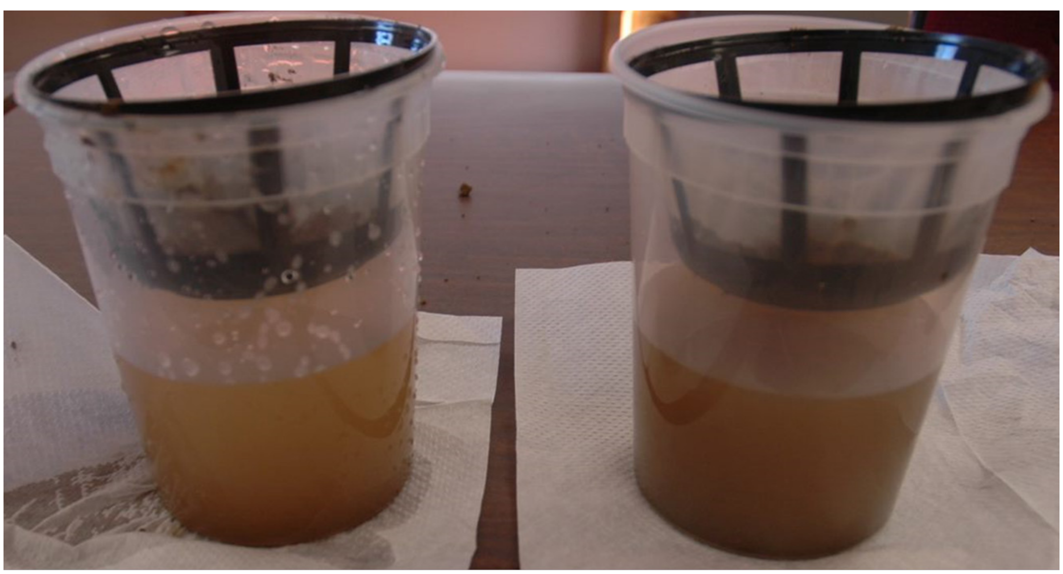


Figure 1. Soil interactions determining soil health.

A. No-till wheat B. Tilled wheat C. No-till fallow D. Tilled fallow E. Hay meadow

Figure 2. Comparison of six soils A) no-till wheat, B) tilled wheat, C) no-till fallow, D) tilled fallow, and E) hay meadow, rated using the Visual Evaluator of Soil Structure (VESS; ***https://www.farmingforabetterclimate.org/improving-farm-profitability/soils-fertilisers-and-manures/assess-your-soil-structure/*****).**



A. No-till fallow B. Tilled fallow

Figure 3. Rainfall simulation runoff comparison of A) no-till fallow and B) tilled fallow.

Improving Resilience of Corn to Weather through Improved Fertilizer Efficiency

N. Huang,[1] G.F. Sassenrath, and X. Lin[2]

Summary
Fertilization is a critical management tool to improve crop productivity. Corn requires more N fertilizer than some other crops, but the fertility needs of the crop vary based on the growing environment. In this study, we used a modeling approach to examine the historical record and delineate the interaction between fertilizer and weather on the sensitivity of corn yield to climate in southeastern Kansas. Providing optimal fertilizer can improve corn yield. However, too much fertilizer can be expensive and wasteful. This study demonstrated that the climate resilience of corn is moderated by how much fertilizer is applied. The model results concluded that the optimal N fertilizer rate should be adjusted based on weather conditions.

Introduction
The addition of fertilizer has long been recognized as a key factor to increase the yield of crops. However, rising fertilizer costs have led to exploration of other methods of maintaining high crop yield, while reducing economic costs and negative environmental impacts.

Corn acreage in Kansas has been steadily increasing. Corn has the potential to yield well in southeast Kansas, but can be limited by hot, dry growing conditions, especially near anthesis. Corn also requires substantial inputs of artificial fertilizers for optimal productivity, increasing production costs and risk. Crop growth and development can be modeled by calculating the growing degree days (GDD). Additional information on potential crop growth and performance can be obtained by calculating Extreme Degree Days (EDD). The EDD are a measure of the impact of high damaging temperatures on crop growth and yield.

This study was conducted to explore the interaction between nitrogen fertility in corn and the growing environment. The research used a modeling approach to examine historical data trends and delineate nitrogen fertility strategies to optimize crop yield at reduced costs.

Experimental Procedures
The research focused on the 14 counties in southeast Kansas. The county-level corn yield data were collected from the U.S. Department of Agriculture National Agricultural Statistics Service census dataset (*https://www.nass.usda.gov/*). Corn-specific nitrogen fertilizer use for each county was obtained from a published dataset (Zhang et al., 2021). Daily weather data were collected from the Parameter-elevation Regressions on Independent Slopes Model (PRISM; Daly et al., 2008). Growing-degree days were calculated from daily maximum and minimum temperature, and represented the heat

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accumulated between the base of 50°F and the maximum 86°F during the corn growing season (GDD = (T_{max} + T_{min})/2). Extreme-degree days during the growing season were calculated from the daily maximum temperature. The EDD represented the accumulation of high temperatures above 86°F and is calculated as: EDD = T_{max} – T_{upper} for maximum daily temperatures that exceeded the upper temperature of 86°F. Temperatures above 86°F reduce corn growth and development.

To delineate the interaction of corn fertilizer with climate, we developed a series of fixed-effect models using the historical data from the fourteen counties in southeast Kansas. The models accounted for factors that influenced corn growth and yield development, and included GDD, EDD, precipitation, and nitrogen fertilizer applied.

Results and Discussion

The 2012 growing season was the hottest year with highest cumulative extreme degree days over the past 12 years (Figure 1). The hot and dry conditions experienced during 2012 led to the lowest corn yield in the past 30 years (Sassenrath et al., 2023). The fixed-effect path analysis models delineated how each of the environmental factors impacted corn grain production over the past 39 years (1981–2019). The integrated contribution of GDD, EDD, and precipitation to corn yield impacted the yield with a change from a cumulative reduction of 3.5% (Greenwood) to an increase of 11% (Labette) in the counties in southeastern Kansas (Figure 2), with each county experiencing different impacts of each climatic variable. Increased precipitation always benefited corn yield, especially in Labette County (4.6%). The changes in EDD had a greater impact on corn yield than did the change in GDD. Corn yield increased with higher GDD in all counties. While corn yield benefited from more heat units (higher GDD), excessive temperatures (high EDD) reduced yield. Increasing EDD reduced the corn yield (-0.7% to ~ -4.8%) in 6 counties. The remaining eight counties saw a decrease in EDD over the 31-year study period, with a gain in corn yield.

To determine the interaction of N fertilizer and environment, historical data were separated into six scenarios of three temperatures (cold, normal, or warm) and three precipitation ranges (dry, normal, and wet). Optimal N fertility rates were determined from the models based on the historical yield trends under the different environmental conditions. Optimal N rate decreased with greater EDD for all precipitation levels (Figure 3). There were three conditions with inadequate data, so no N rates were obtained (warm temperatures, low EDD under dry and normal precipitation, cold temperatures, high EDD, and wet conditions). As precipitation increased, the crop would be able to use higher rates of N. Corn yield was positively sensitive to more precipitation and higher N fertilizer use could enhance the positive sensitivity. Hence, corn yield could benefit from greater N application in a wet climate. However, under hotter years (higher EDD) higher N application led to a yield decline. Therefore, less N should be applied in hot years (high EDD) to reduce the harm of extremely high temperatures on corn yield. The N application should be adjusted based on climate conditions to improve the utilization of N and reduce economic costs. The optimal N fertilizer rate increased with increasing precipitation. Under wet conditions, the optimal N fertilizer rate ranged from 207 lb N/acre to 338 lb N/acre. The optimal N fertilizer rate increased with higher GDD but decreased with higher EDD. In summary, higher rates of N fertilizer will be more beneficial to corn yield in wet (more precipitation) and warm (higher GDD) years. Under dry (less precipitation) and hotter (high EDD) climates, the N application should not be more than 120 lb N/acre. Under the average environmental conditions, the amount of optimal N application increased from west to east in southeastern Kansas, with the highest optimal N application of 166 lb N/acre in Cherokee County (Figure 4).

Conclusions

Application of fertilizer is an important tool to increase crop yields. Previously, fertilizer was an inexpensive tool to reduce the risks of crop production. However, with the increasing costs of fertilizers, it is important to manage fertilizers for best economic return. In addition to being expensive, excess N that is not used by plants can be lost to waterways or to the atmosphere. In wet years (higher precipitation), corn is able to better utilize the applied nitrogen. Warmer temperatures (higher GDD) increase corn growth and production, and hence corn can utilize more applied N. However, in very hot years (high EDD), excess application of N decreases yield, and lower rates of applied N are more beneficial.

Acknowledgments

This research is supported by funding from the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1018005.

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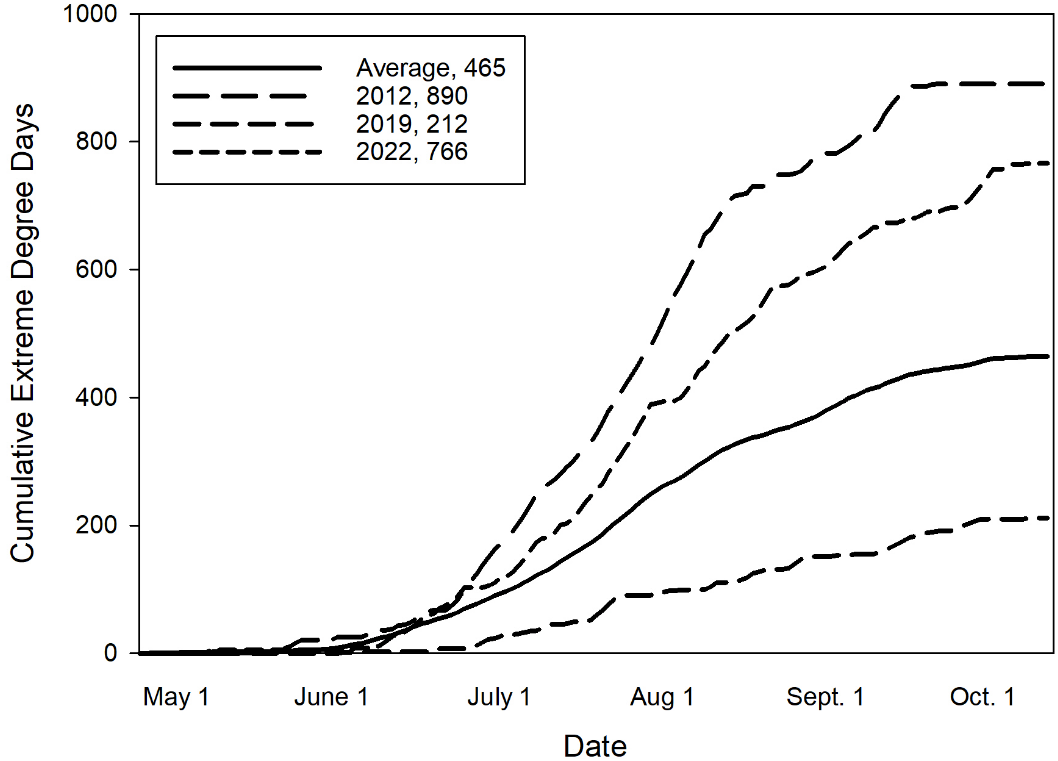

Figure 1. Cumulative extreme degree days (EDD, base 86) during the summer of 2019 (green), 2012 (red), 2022 (blue), and average of 12 prior years (black).

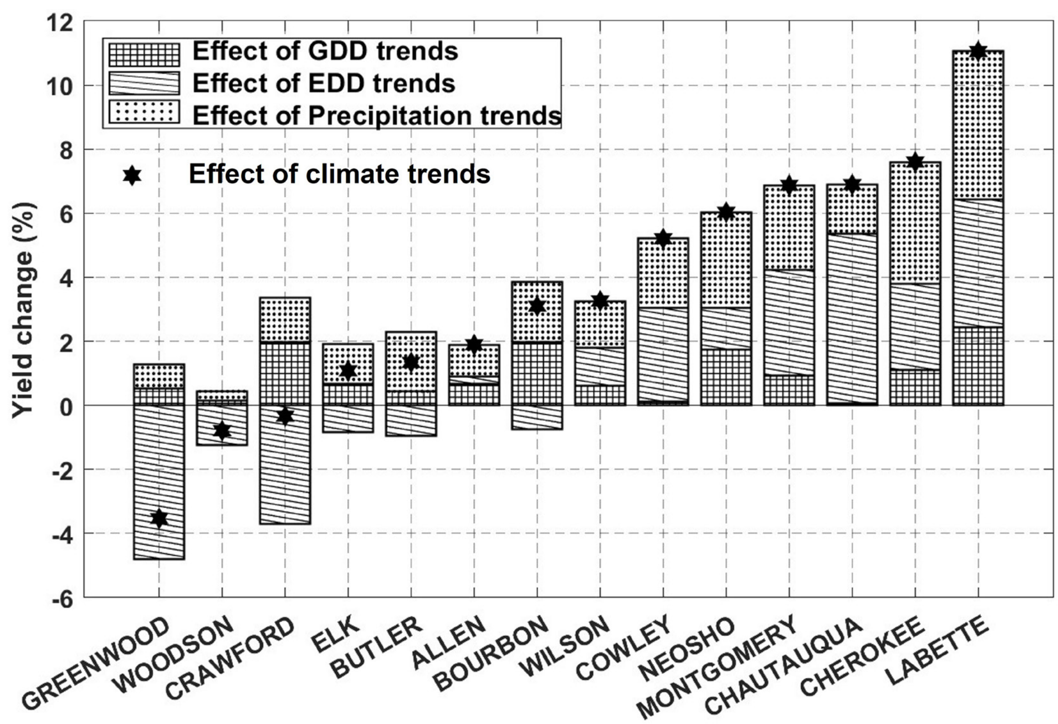

Figure 2. The impact of growing degree days (GDD), extreme degree days (EDD), and precipitation changes on corn yield from 1981 to 2019 per county.

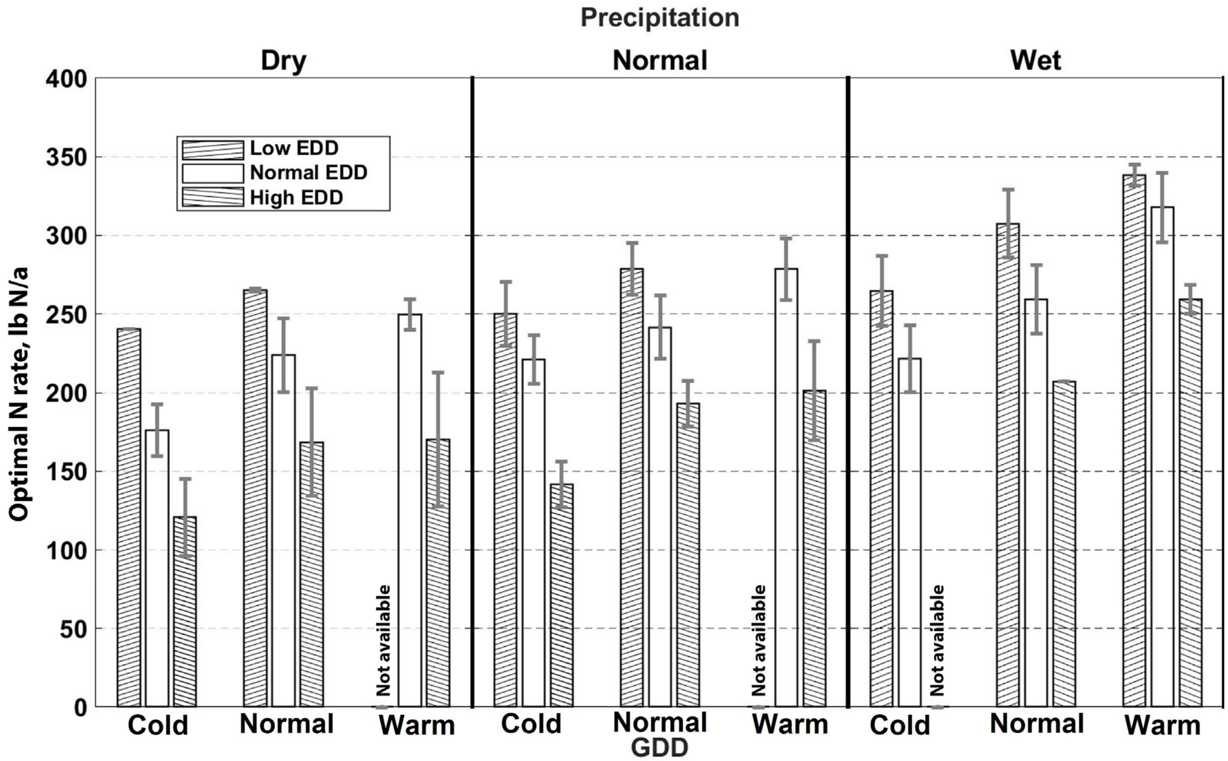

Figure 3. The optimal N fertilizer rate under different combinations of growing degree days (GDD), extreme degree days (EDD), and precipitation.

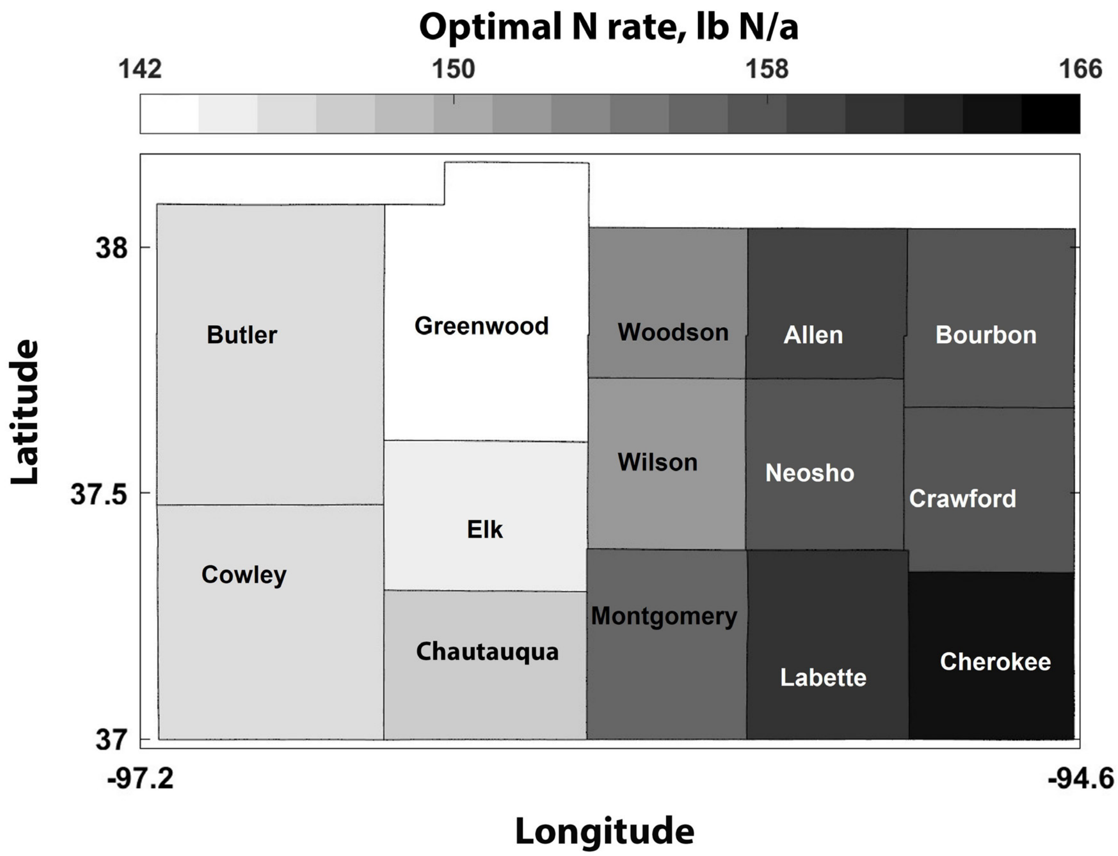

Figure 4. The optimal N fertilizer rate under average growing degree days (GDD), extreme degree days (EDD), and precipitation from 1981 to 2020 for the 14 counties in southeastern Kansas.

Impact of Lime, Phosphorus, and Potassium on Yield and Forage Quality on Native Hay Meadows in Southeast Kansas

J.I. Yasuoka, W. Powell,[1] W. Fick,[2] and B.C. Pedreira

Summary

Native meadows are frequently harvested for hay in southeast Kansas to produce forage for winter use. However, the low soil fertility associated with nutrient removal has resulted in limited yield potential and broomsedge infestation. This study evaluated the effect of phosphorus, potassium, and lime on the forage yield and quality in a native meadow. Our results indicated that P and K fertilization contributes to improving yield and quality on native meadows in southeast Kansas. This study will be repeated in 2023, including broomsedge measurements.

Introduction

In Kansas, native meadows are widely utilized for hay or grazing, especially in areas with shallow soils and/or hills. Native plants have low yield potential and low forage quality. The native meadows are commonly harvested once a year, but fertilizers or lime have not been traditionally applied to replace the soil nutrients. After decades of utilization, some farmers have taken note of the lowering yield and the presence of broomsedge (*Andropogon virginicus*) and bluestem (*Bothriochloa* spp.).

Thus, recognizing the need to replenish nutrients that would improve yield and quality, even knowing the limited response of native species, this study aims to evaluate the combinations of phosphorus (P), potassium (K), and lime (L) on yield and forage quality in native meadows in southeast Kansas.

Experimental Procedures

The trial was conducted at the Southeast Research and Extension Center in Parsons, KS, in a native meadow, which has been harvested and baled annually for more than 30 years. The soil is a Parsons silt loam. Soil samples were taken on September 28, 2021, resulting in pH = 5.6, P = 0.3 ppm, and K = 69 ppm.

The experimental design was a randomized complete block in a split-plot arrangement, with three replications. The plots (30 × 40 ft) were P rates, and the sub-plots (10 × 30 ft) were the application of K, L, K+L, and a control. Phosphorus rates were 0, 50, and 100% (0, 25, and 50 lb P_2O_5/a; P0, P25, and P50, respectively). The K rate was 100% (20 lb K_2O/a) of the soil test recommendation based on the K-State Research and Extension publication Soil Test Interpretations and Fertilizer Recommendations (*bookstore.ksre.ksu.edu/pubs/mf2586.pdf*). As the spreadsheet has no native species listed, it was set for tall fescue with a 1 ton/a yield goal. The lime rate was 2200 lb/a, half applied on October 18, 2021, and another half on April 25, 2022. On May 6, 2022, P and K were applied in the respective treatments.

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On July 6, 2022, the plots were harvested using a flail harvester (Carter) where a 3 × 25 ft area was sampled at 3-in. stubble height to determine forage yield. The collected forage was weighed, dried in a forced-air dryer at 130°F for three days, and weighed. To evaluate forage quality, dry samples were sent to the laboratory for crude protein (CP) and total digestible nutrients (TDN) analyses. Crude protein yield (CPY) was calculated by multiplying yield and CP. In 2022, the broomsedge population was not evaluated, but it will be in the fall of 2023.

Results and Discussion

When no P was applied, L, K, or L+K had little effect on yield. However, at the 25 and 50 lb P_2O_5/a rates, K and L+K increased the yield, mainly at the P25 level which was, on average, 43% greater than when no P, K, and lime were applied (Figure 1). Lime application increased the forage yield only when combined with 50 lb P_2O_5/a.

Another interesting result, regardless of the P rate, the forage yield was similar among K and K+L. These results indicate that K can be applied without lime and is associated with at least 25 lb P_2O_5/a. The strategy based on the soil test report contributes to reducing costs and increasing hay production on native meadows.

All combinations among P rates and lime, K, and L+K application resulted in CP values below 7%, considered the minimum to keep ruminal animals healthy. Treatments had little effect on TDN, with values ranging from 37.0 to 40.6%. Both CP and TDN values are much lower than commonly reported for tamed forage species. Our results, therefore, highlight that native meadows produce forage with low quality (protein and energy) even with P and K fertilization or lime application. For this reason, energy and protein supplementations are essential to sustain animal nutrient requirements when cattle are fed with native hay.

Comparing the P rates without any other addition (control), the application of 25 or 50 lb P_2O_5/a only increased CPY by 8% when compared to P0. It means that P fertilization by itself has little effect on CPY. On the other hand, the greater forage yield in the P25 combined with K and L+K and the highest CP values for P50 with L, K, and L+K resulted in better CPY results. These results support the use of P associated with L, K, and L+K if there is a need to improve CPY in a livestock system.

Conclusions

In the first year of this study, P (25 lb P_2O_5/a) and K (20 lb K_2O/a) fertilization increased native meadows' forage yield and CPY, based on the soil test requirement. In addition, lime had little effect in the year of application. Regardless of the P, K, and lime application, CP and TDN values were low, therefore, energy and protein supplementation are crucial to reach animals' nutrient requirements. Thus, P and K fertilization contributes to improving yield and quality on native meadows in southeast Kansas. The trial will be repeated in 2023 and broomsedge will be also evaluated.

Acknowledgments

This work was supported by the Kansas State University Spring 2022 University Small Research Grant; the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1003478.

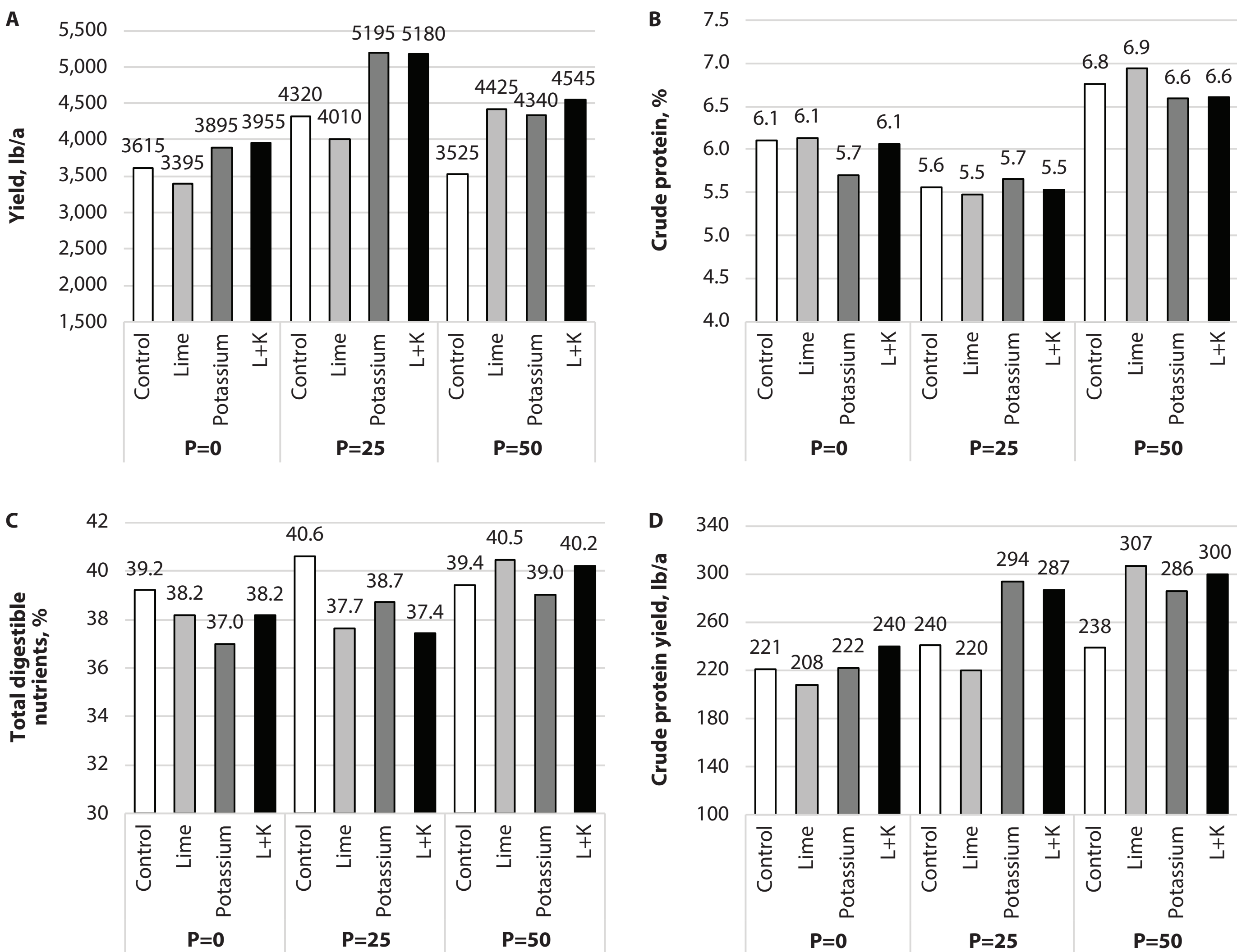

Figure 1. Forage yield (a), crude protein content (b), total digestible nutrients (c), and crude protein yield (d) on a native meadow in Parsons, KS.

Yield and Forage Quality on Native Meadows as Affected by Burn and Fertilization Management

J.I. Yasuoka, D. Helwig,[1] W. Fick,[2] and B.C. Pedreira

Summary

Native meadows are widely used by producers in southeast Kansas. However, there are few studies about management practices to improve agronomic performance in southeast Kansas. This study evaluated the spring burn effect combined with the application of lime, nitrogen, phosphorus, and potassium on yield and forage quality in native meadows. Yield and forage quality on native meadows were not affected by lime application, or P and K fertilization in the first year of the study. However, N fertilization increased yield, crude protein, and total digestible nutrients when associated with spring burn.

Introduction

In southeast Kansas, native meadows are an important forage source (hay or grazing) in livestock systems. However, native species are known for low yield potential and forage quality due to soil and plant limitations. An alternative to improve production and, especially, forage quality is to burn the pasture in the spring to remove old plant materials and stimulate a new flush of tillers. Combining prescribed spring burning with lime or fertilizers applications may contribute to improving soil fertility, resulting in greater forage production to feed cattle.

This research studied combinations among spring burn, lime application, and N, P, and K fertilization aiming to improve yield and forage quality on native meadows.

Experimental Procedures

The study was conducted at the Southeast Research and Extension Center in Parsons, KS. The native meadow soil is a Parsons silt loam with pH = 5.2, P = 2.4 ppm, and K = 61.0 ppm.

The experimental design was a randomized complete block with a split-plot arrangement. In the plots (30 × 40 ft), treatments were combinations between prescribed spring burn or not; and 0 or 30 lb/a of N (N0 and N30); and in the sub-plots (10 × 30 ft), lime, P, K, and a control (without any application). The lime rate was 2200 lb/a, and P and K were 30 lb/a. On October 18, 2021, half of the lime rate (1100 lb/a) was applied. On April 19, 2022, prescribed spring burn plots were burned, and on April 25, 2022, the rest of the lime (1100 lb/a) was applied. On May 6, 2022, N, P, and K were applied in their respective subplots.

To measure forage yield, on July 8, 2022, a flail harvester (Carter) was used to sample a 3 × 25 ft area in each subplot. All collected forage was weighed fresh, and a 1-lb

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subsample was taken, dried at 130°F in a forced-air drying oven to constant weight, and weighed. The dried sub-samples were sent to the laboratory for crude protein (CP) and total digestible nutrients (TDN) analyses. Forage yield was multiplied with CP to calculate crude protein yield (CPY).

Results and Discussion

The application of lime, P, and K did not increase forage yield when compared to the control (Figure 1a). Similarly, lime, P, and K did not improve forage quality (CP and TDN) in native meadows (Figures 1b and 1c) and, consequently, CPY was similar among treatments (Figure 1d).

On the other hand, N fertilization and burning affected the yield and forage quality. When the meadow was burned in the spring, all plant materials were eliminated, and new tissues were grown. For this reason, the forage yield was lower than when the meadow was not burned (Figure 2a). Forage yield was 31 and 20% higher in the no burn/N0 and no burn/N30, respectively, when compared with the burned meadows.

Although the yield was higher when the meadow was burned, the forage quality in these treatments was lower, mainly with no N fertilization. The CP and TDN were 10 and 14% higher in the N0/spring burn, respectively (Figures 2a and 2b). Thus, it is important to understand the trade-off between yield and forage quality to decide if the goal is to produce high-yield or high-quality hay.

The N input increased forage yield, but this effect was greater in the burned meadows. When the meadow was not burned, the fertilization with 30 lb N/a increased by 325 lb/a while in the burned meadows, the yield was increased by 555 lb/a (Figure 2a). This difference occurred because the new tillers that would most benefit from N were shaded by the old tillers when the meadow was not burned. Thus, spring burning can reduce or eliminate the accumulated dead plant material as well as the weeds, favoring the use of N by the new tillers, mainly warm-season grasses. Therefore, the N response will be greater when combined with spring burning on native meadows.

Nitrogen also affected forage quality, improving CP and TDN concentrations (Figures 2b and 2c). Because of the increased yield and CP, the CPY was also enhanced by N fertilization. The fertilization of 30 lb N/a increased CPY by 44 or 73 lb/a more than the CPY when the meadow was burned or not, respectively (Figure 2d).

Conclusions

In the first year of this study, the application of lime, P, and K does not improve yield and forage quality on native meadows. Nitrogen fertilization improves yield, CP, and TDN when associated with spring burning. The no-burn meadow produces higher yield but TDN and CP are lower. Therefore, the decision regarding the spring burn depends on whether the goal is to improve tonnage or quality in the native meadow. The trial will be repeated in 2023.

Acknowledgments

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

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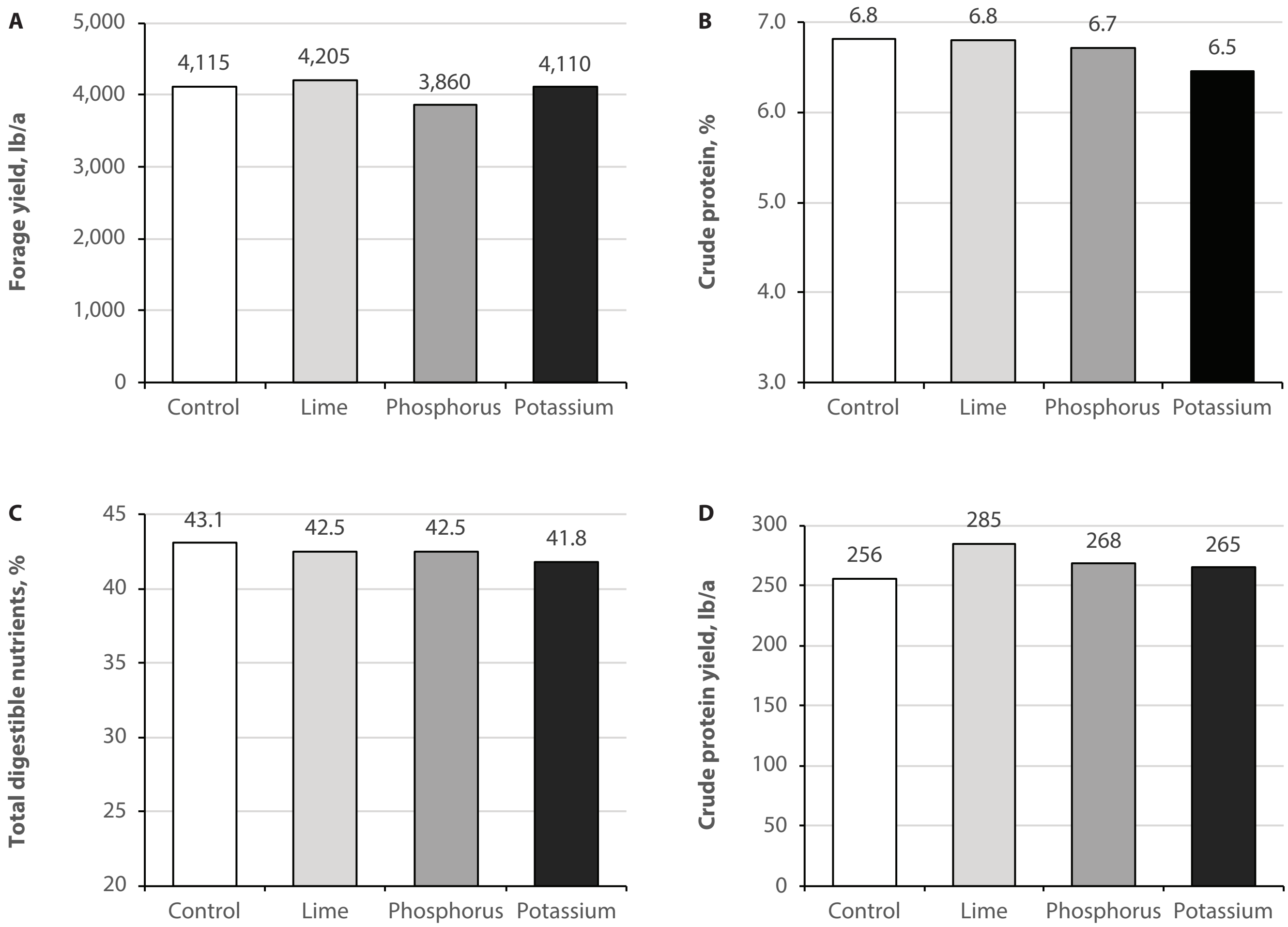

Figure 1. Lime application, phosphorus, and potassium fertilization effects on forage yield (a), crude protein (b), total digestible nutrients (c), and crude protein yield (d) on native meadows in Parsons, KS.

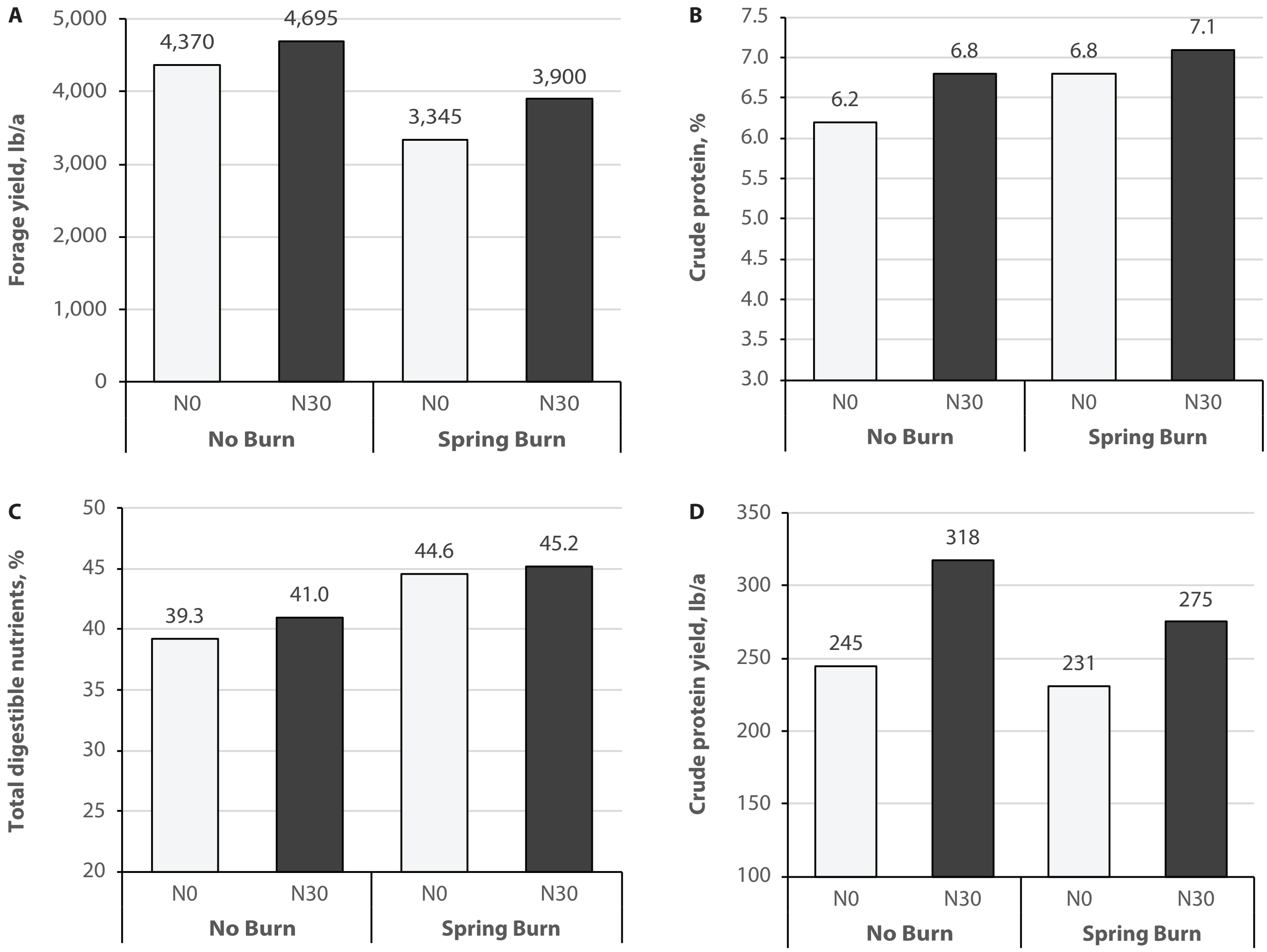

Figure 2. Nitrogen fertilization and spring burn effects on forage yield (a), crude protein (b), total digestible nutrients (c), and crude protein yield (d) on native meadows in Parsons, KS.

Impact of Stubble Heights on Native Hay Meadows in Southeast Kansas

J.I. Yasuoka, W. Powell,[1] W. Fick,[2] and B.C. Pedreira

Summary
Management practices affect hay production in native meadows. The objective of this study was to evaluate how stubble heights affect forage yield and quality in a native meadow. Prescribed spring burns contribute to improving forage quality. Setting the stubble height at 3 inches resulted in high forage quality and had a low impact on yield.

Introduction
In eastern Kansas, livestock production is mostly forage-based; cattle rely on pastures during the growing season but are highly dependent on hay or silage during the winter months. For that reason, harvesting hay is a very common practice in native meadows. Conversely, farmers need to consider nutrient replenishment and stubble heights to assure regrowth. In the last few decades, the lack of nutrient replenishment associated with the new mowers that can mow closer to the ground has led to overall yield reductions and weed problems.

Prescribed fire is also a common practice on native meadows, a low-cost way to control weeds and improve forage quality. Burning removes old plant material and stimulates production of new tissues, improving forage quality.

This study aims to evaluate stubble height effects on native meadows in southeast Kansas, with or without prescribed fire.

Experimental Procedures
The three sites selected for this study were native meadows at the Southeast Research and Extension Center in Parsons, and in two farms located in Coyville and Caney. The soil's chemical analyses are shown in Table 1.

In Parsons, the experimental design was a randomized complete block in a split-plot arrangement with three replications. The plots (30 × 40 ft) were burned or unburned, and the sub-plots (10 × 30 ft) were four stubble heights (1, 3, 5, and 7 inches). The spring burn plots were burned on April 19, 2022, and all plots were harvested on July 8, 2022, to determine yield and quality. In each sub-plot, forage inside two quadrats (1.6 × 3.3 ft) was sampled at their respective stubble heights. These samples were dried in a forced-air drying oven to constant weight at 130°F and weighed. Dried samples were sent to a laboratory for quality analyses of crude protein (CP) and total digestible nutrients (TDN). The CP concentration (%) was multiplied by forage yield to calculate crude protein yield (CPY).

In Coyville and Caney, a randomized complete block with three replications was used. The treatments applied in the plots (10 × 30 ft) were the same four stubble heights

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applied in Parsons (1, 3, 5, and 7 inches), but the native meadow was not burned. On July 5, 2022, the forage yield, CP, TDN, and CPY were evaluated by the same procedure used in Parsons.

Results and Discussion

Forage yield was lower in the burned native meadow than in the unburned, mainly when the stubble heights were 1, 3, and 5 inches (Figure 1a). This result occurred because all of the old material was removed from the last year's growth. However, the new tissues usually have higher CP and TDN than the old tissues (Figures 1b and 1c). The higher forage yield in the unburned plots also resulted in higher CPY (Figure 1d).

The forage yield was lower with higher stubble heights in all locations (Figures 1a, 2a, and 3a). This result was expected because stubble height will directly affect the amount of harvested forage. At shorter stubble heights, most of the dead tissues located at the bottom of the canopy were collected. Dead material has low quality, and, consequently, CP and TDN were reduced in forage harvested with shorter stubble heights. On the other hand, when the stubble height was taller, forage was predominantly composed of young leaves with higher CP and TDN (Figures 1b, 1c, 2b, 2c, 3b, and 3c). Nonetheless, even with the higher CP in the taller stubble heights management, the CPY increased as stubble height was reduced (Figures 1d, 2d, and 3d) following the same trend of the forage yield.

Based on our results, 3-inch stubble height resulted in satisfactory yield quality in all sites evaluated. Also, mowing and leaving only 1-inch stubble height is always a challenge for the plant because regrowth is delayed and as long-term management can reduce plant vigor, weed infestation can increase.

Conclusions

The forage yield and CPY are higher when native meadows are not burned. However, on the burned meadows, forage quality is higher. Harvesting with a 3-inch stubble height resulted in great forage quality and a lower impact on yields.

Acknowledgments

This work was supported by Montgomery and Wilson County Conservation districts; the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1003478; and the K-State Research and Extension Wildcat Extension District.

Table 1. Soil chemical characteristics in the experimental area in three locations in southeast Kansas

Location	pH	Phosphorus, ppm	Potassium, ppm
Parsons	5.2	2.4	61.0
Coyville	5.8	1.1	25.9
Caney	5.8	2.1	26.6

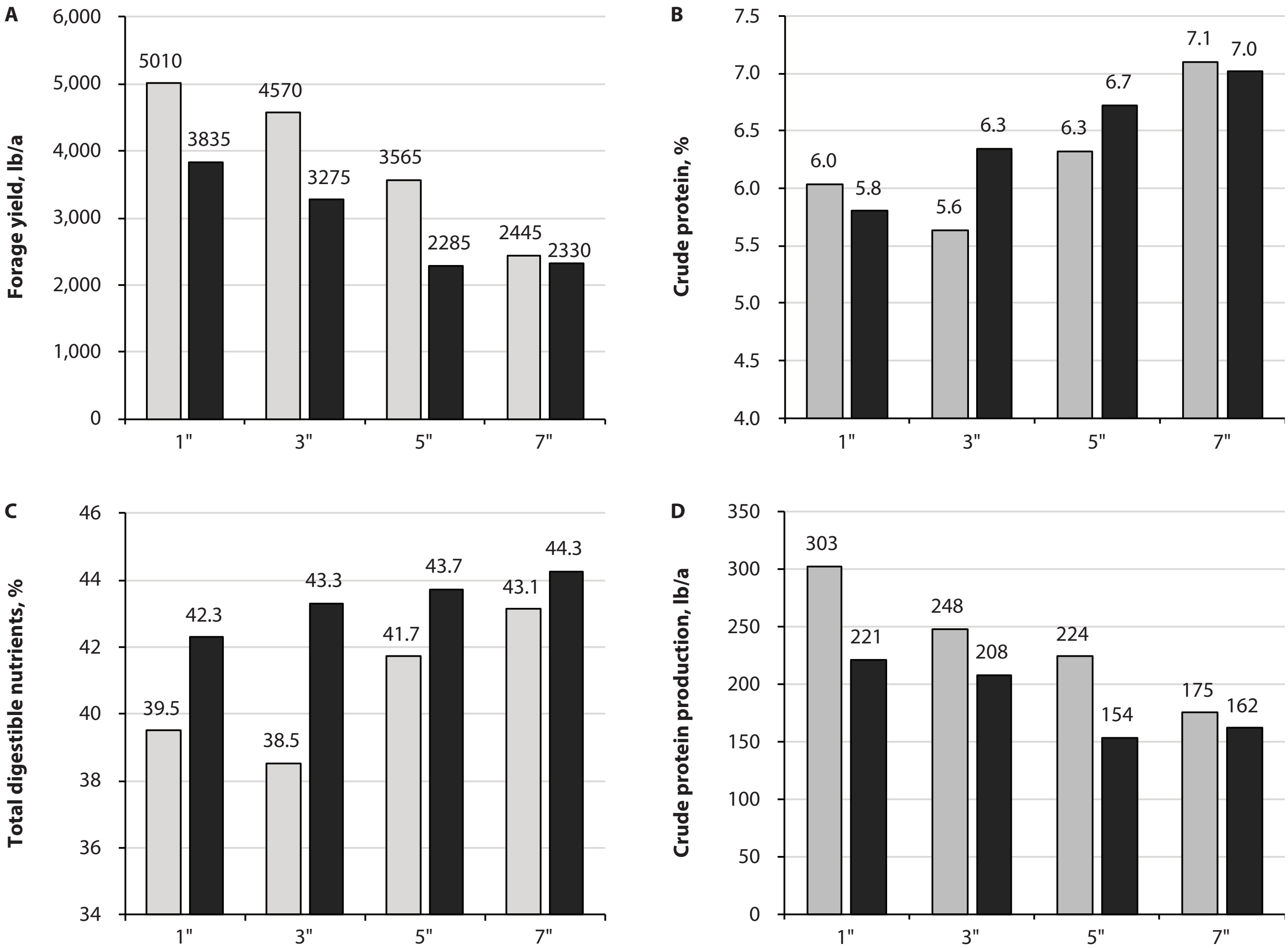

Figure 1. Spring burn and stubble height effects on forage yield (a), crude protein (b), total digestible nutrients (c), and crude protein yield (d) in native meadows in Parsons, KS.

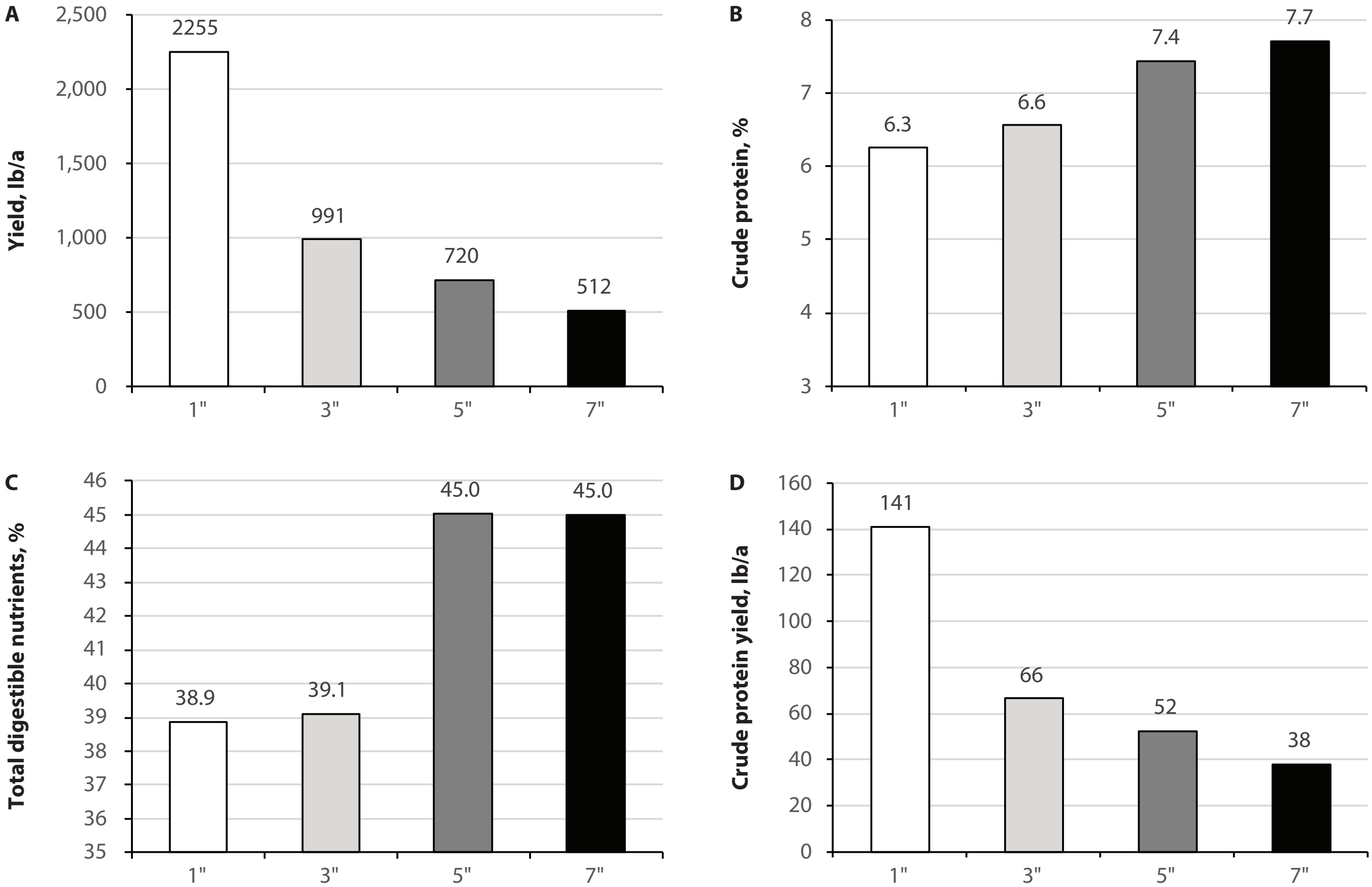

Figure 2. Stubble height effect on forage yield (a), crude protein (b), total digestible nutrients (c), and crude protein yield (d) in native meadows in Coyville, KS.

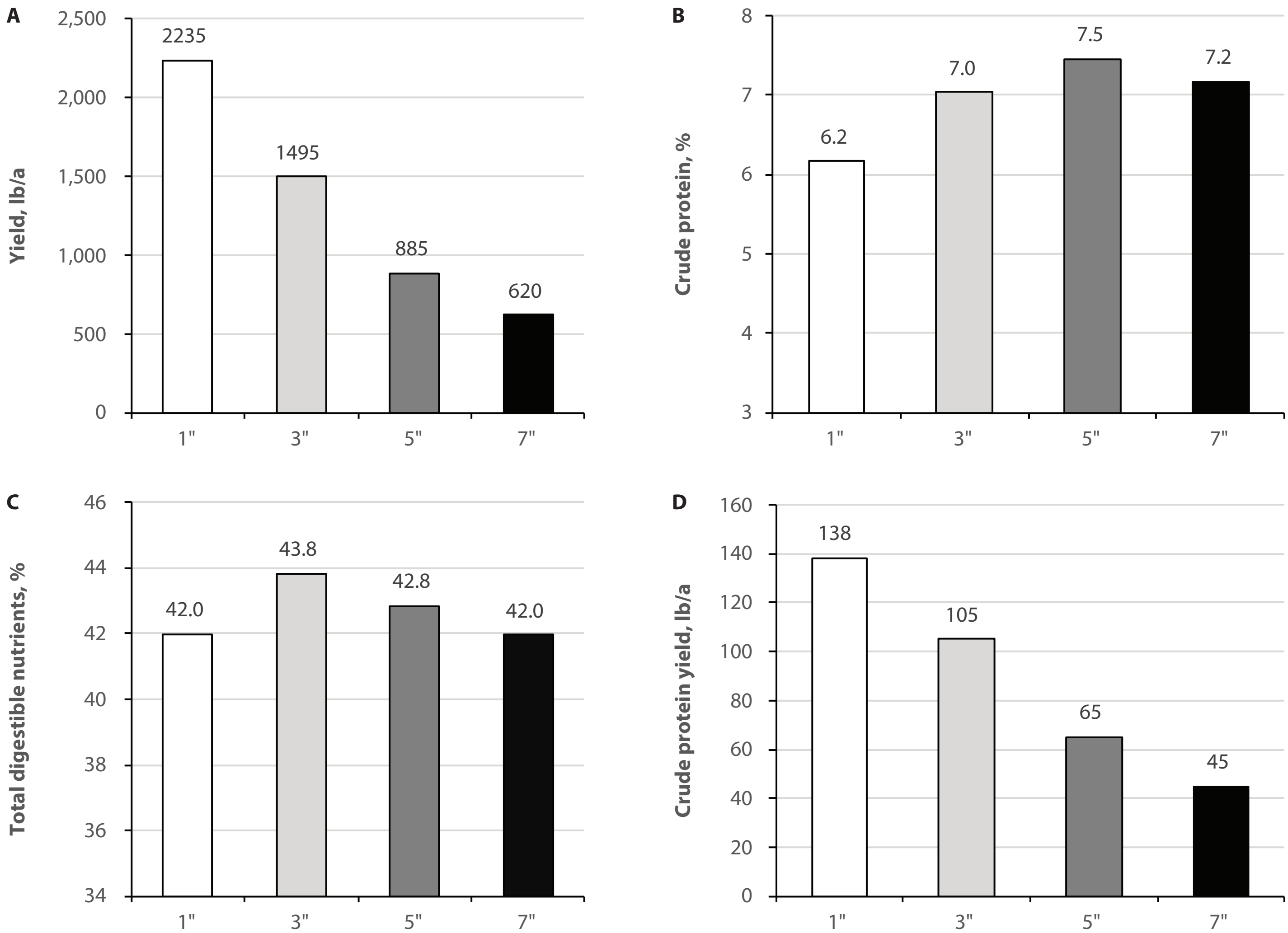

Figure 3. Stubble height effect on forage yield (a), crude protein (b), total digestible nutrients (c), and crude protein yield (d) in native meadows in Caney, KS.

Nutrient Management Strategies to Control Broomsedge Infestation and Improve Yield and Quality of Tall Fescue Hayfields

J.I. Yasuoka, D. Helwig,[1] W. Powell,[2] J.K. Farney, G.F. Sassenrath, and B.C. Pedreira

Summary
A study in tall fescue hayfields infested with broomsedge and bluestem was conducted at four locations in southeast Kansas. The purpose of this study was to evaluate how phosphorus, nitrogen, and potassium fertilization affect yield, forage quality, and broomsedge/bluestem control in tall fescue hayfields. This trial will be repeated in 2023.

Introduction
Tall fescue (*Lolium arundinaceum*) is a cool-season grass widely used to feed animals across the U.S. (Young et al., 2014) due to its high yield and quality. However, in the last few decades, tall fescue hayfields have been infested by weeds such as broomsedge (*Andropogon virginicus*).

Broomsedge is a perennial grass that provides low forage yield and quality, and for these reasons is not desirable for grazing or hay production. Even though broomsedge does not compete well with tall fescue, under limited soil fertility conditions (low P, K, and pH), it can slowly take over the hayfields. Blevins et al. (2018) in a 3-year study found that low P soil favored broomsedge on tall fescue pasture. Thus, establishing a soil fertility program based on sampling can be an alternative to increase tall fescue yield and forage quality, and simultaneously suppress the broomsedge population by competition.

Our objective was to evaluate the impact of nutrient management strategies on the forage yield and quality of 'Kentucky 31' tall fescue hayfields, and the broomsedge population in southeast Kansas.

Experimental Procedures
The project was carried out at four locations in Kansas: the Southeast Research and Extension Center in Parsons, the research field in Columbus, and two production farms located in Girard, and Altamont. 'Kentucky 31' tall fescue pastures infested by broomsedge were used in all locations. The soil in all areas was a Parsons silt loam. Before starting the study, soil samples were taken in all locations to identify nutrient deficiencies and develop nutrient management plans based on soil pH, P, and K (Table 1). At the research fields in Parsons and Columbus, a complete trial was established with 3 replicates, but in the production fields in Altamont and Girard, only one replicate was established (demonstration plots).

The experimental design for each trial was a randomized complete block under a split-plot arrangement. Treatments were: three phosphorus (P) rates (0, 100, and 125% of the soil test recommendation and from the K-State Research and Extension publication

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Soil Test Interpretations and Fertilizer Recommendations (*bookstore.ksre.ksu.edu/pubs/mf2586.pdf*) and nitrogen (N), potassium (K), N+K, and control (without fertilization) in the sub-plots. Plots were 30 × 40 ft and sub-plots were 10 × 30 ft. Phosphorus rates (plots) used were 0, 20, and 25 lb/a in Parsons; 0, 70, and 88 lb/a in Columbus; 0, 65, and 81 lb/a in Girard; and 0, 50, and 63 lb/a in Altamont. Nitrogen and K rates were 100 and 30 lb/a, 100 and 35 lb/a, 130 and 35 lb/a, and 140 and 15 lb/a for Parsons, Columbus, Girard, and Altamont, respectively. Nitrogen and K rates were determined based on soil test reports and K-State fertilization recommendations for each site.

In Girard, 2750 lb/a of lime ECC was applied in the total area on July 2, 2021; N, P, and K were applied on August 12, 2021, and forage yield and quality were measured on October 8, 2021. In Altamont, fertilizers were applied on June 28, 2021, and the yield was estimated on October 8, 2021. In Parsons, 1100 lb lime ECC/a was surface-applied on October 18, 2021; P and K were hand-applied on December 3, 2021; N was surface-applied on March 3, 2022, and forage yield was measured on May 19, 2022. In Columbus, 200 lb lime ECC/a was surface-applied on November 18, 2021; P and K were hand-applied on December 13, 2021; N was hand-applied on March 3, 2022, and forage yield was measured on May 31, 2022.

To measure forage yield, quadrats (1.6 × 3.3 ft) were placed within each sub-plot and all forage inside the quadrat was harvested to a 3-in. stubble height at each location. In Girard and Altamont, the collected samples were sorted into tall fescue and weeds (broomsedge). All samples were weighed, dried at 130°F in a forced-air dryer until constant weight, and reweighed. These dried samples (except Girard) were sent to a laboratory for quality analysis, which included crude protein (CP), and TDN. Crude protein yield (CPY) was calculated by multiplying forage yield by CP.

Results and Discussion

The addition of P representing 100 or 125% of the soil test recommendation without N and K did not affect the forage yield, except in Columbus (Figure 1). In Columbus, the yield in the control plots (only P applied) was 77 and 64% higher in the P70 (2270 lb/a) and P88 (2106 lb/a) compared to P0 (1285 lb/a), respectively (Figure 1b). This result highlights the P fertilization potential when soil P is very low (1.0 ppm; Table 1) and, for this reason, the P application was more effective compared to other locations that had higher initial soil P. Therefore, it demonstrates the importance of taking soil analysis before applying any P fertilizers.

In general, K by itself had little effect on forage yield, CP, TDN, and CPY (Figure 1 and Table 2). Conversely, application of N significantly impacted yield regardless of the P rate at all locations. The N input also increased TDN at all locations and CP at Altamont, achieving 14% CP when 50 lb P_2O_5/a was combined with 140 lb N/a. This is a high CP value for a tall fescue hayfield.

Even with the strong impact of N fertilization on forage yield, greater values were observed when N and K were applied together. In Altamont, for example, the N+K application produced 2315 lb/a more than when only N was applied, even with no P application (Figure 1d). This nutrient combination also resulted in higher CPY. These results support the importance of combining N and K fertilization when soil K is limited.

The broomsedge population was also reduced in the N+K treatments, especially when given with P fertilization (Figures 2a and 2b). As broomsedge infestation causes huge problems for producers, a fertilization package combining P, N, and K can be a powerful tool to suppress this weed while increasing tall fescue yield and quality.

Conclusions

The P application in tall fescue hayfields increases yield only when soil P is very low. Nitrogen application by itself increases yield, CP, TDN, and CPY. However, the N effect is enhanced if combined with K and P, resulting in higher forage yield, CP, CPY, and TDN, and better broomsedge suppression. The soil test is the most important tool to establish a fertilizer program for fescue hayfields. This study will be repeated in 2023.

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Blevins, D. G., Hamilton, E. J., Remley, M. A., Massie, M. D., Naumann, H. D., & Miles, R. J. (2018). Lime or phosphorus: which is best to limit broomsedge in tall fescue pastures? Crop, Forage & Turfgrass Management, 4(1), 1–5. *https://doi.org/10.2134/cftm2017.12.0090*

Young, C. A., Charlton, N. D., Takach, J. E., Swoboda, G. A., Trammell, M. A., Huhman, D. V., & Hopkins, A. A. (2014). Characterization of *Epichloë coenophiala* within the US: are all tall fescue endophytes created equal? Frontiers in Chemistry, 2(Nov), 1–11. *https://doi.org/10.3389/fchem.2014.00095*

Table 1. Initial soil chemical characteristics in the experimental areas in four locations in southeast Kansas

Local	pH	P	K
		ppm	
Parsons	5.3	14.2	76
Columbus	6.0	1.0	64
Girard	5.8	5.2	57
Altamont	6.7	1.7	103

Table 2. Crude protein level (CP), total digestible nutrients (TDN), and CP yield on tall fescue pastures infested by broomsedge in Parsons, Columbus, and Altamont

P rate, lb/a	N and K rates, lb/a	CP, %	TDN, %	CP yield, lb/a
	Parsons			
0	Control	11.0	46.3	73
	30K	11.2	46.5	116
	100N	11.2	49.7	239
	100N/30K	11.3	48.4	379
20	Control	10.9	49.6	83
	30K	11.1	47.8	90
	100N	11.2	50.7	365
	100N/30K	11.0	49.7	522
25	Control	11.2	46.5	88
	30K	11.3	48.4	91
	100N	11.3	51.2	323
	100N/30K	11.3	50.2	427
	Columbus			
0	Control	9.3	42.4	119
	35K	9.5	44.4	128
	100N	11.5	46.0	198
	100N/35K	9.5	44.4	128
70	Control	9.1	42.7	207
	35K	9.1	43.5	248
	100N	9.6	41.2	344
	100N/35K	9.9	41.5	410
88	Control	9.1	43.9	191
	35K	8.3	42.4	187
	100N	9.6	42.3	353
	100N/35K	9.9	43.9	388
	Altamont			
0	Control	8.2	47.4	189
	15K	9.2	51.6	154
	140N	12.9	51.8	357
	140N/15K	11.9	50.4	601
50	Control	10.2	52.7	299
	15K	8.4	49.1	149
	140N	14.0	55.5	457
	140N/15K	11.4	47.4	488
63	Control	8.6	51.1	197
	15K	7.9	44.8	216
	140N	11.5	50.7	357
	140N/15K	10.1	47.3	515

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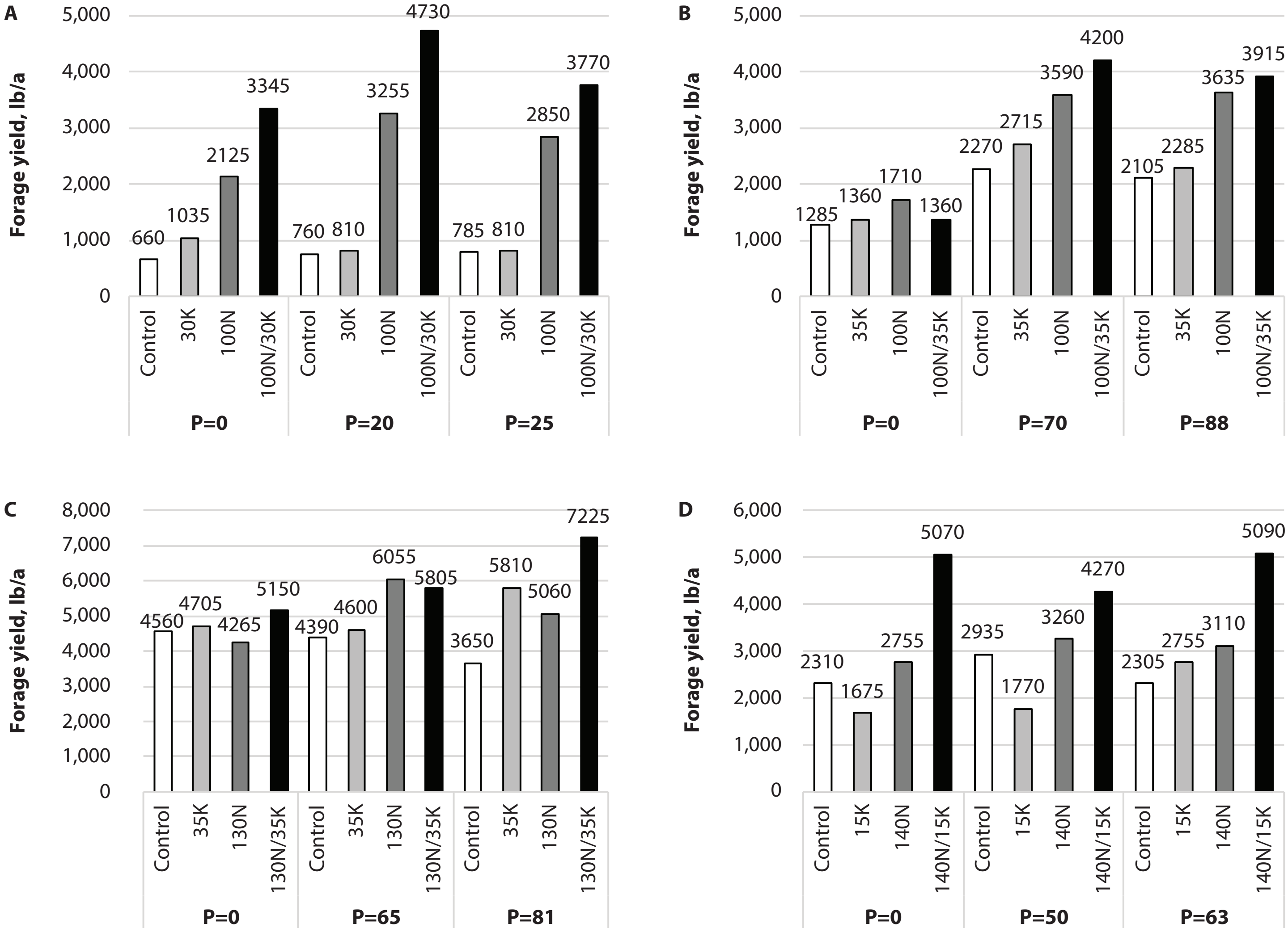


Figure 1. Forage yield on tall fescue pastures infested by broomsedge in (a) Parsons, (b) Columbus, (c) Girard, and (d) Altamont. Nutrient rates are given in lb/acre. Phosphorus rates were determined from initial soil test results based on 0%, 100%, and 125% of requirement.

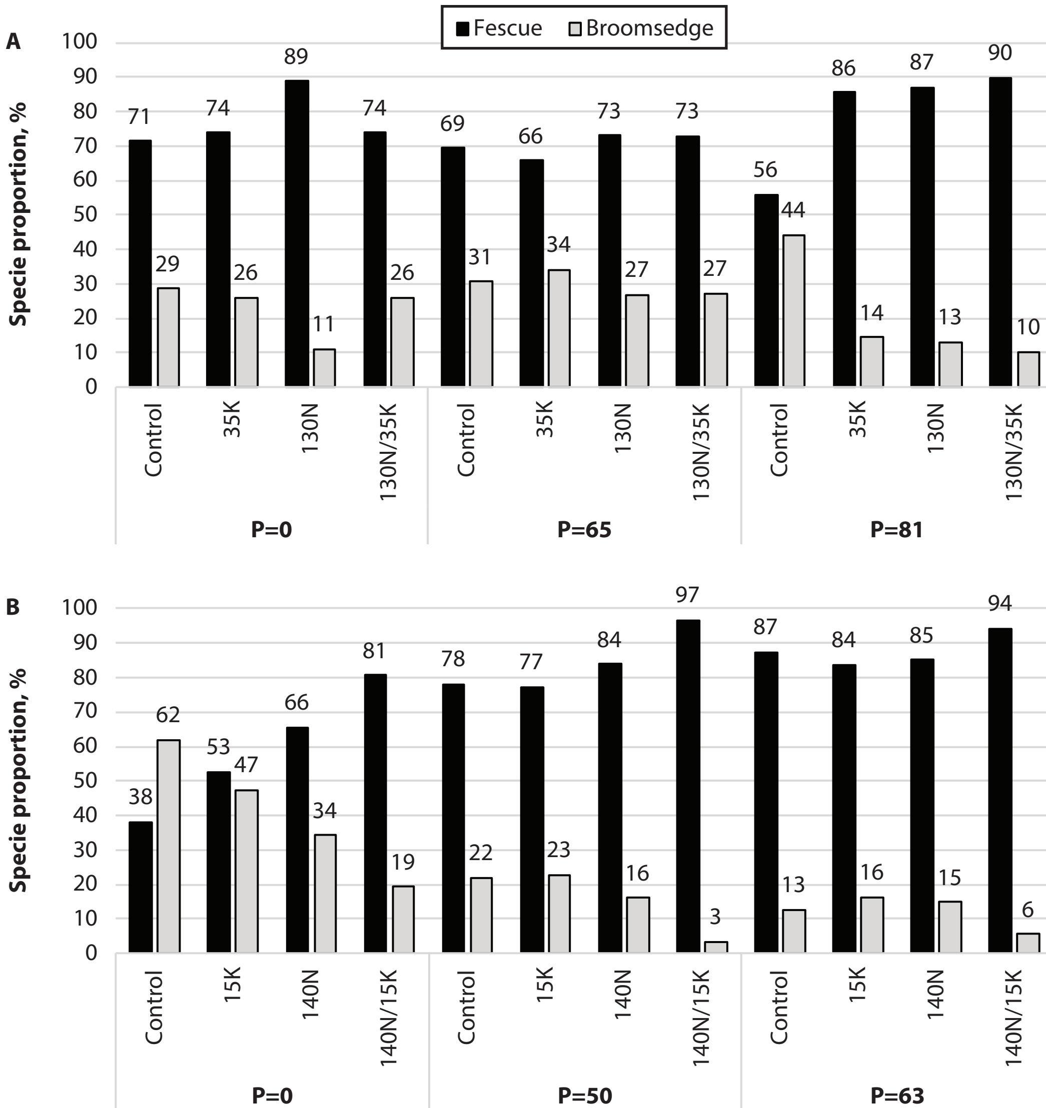


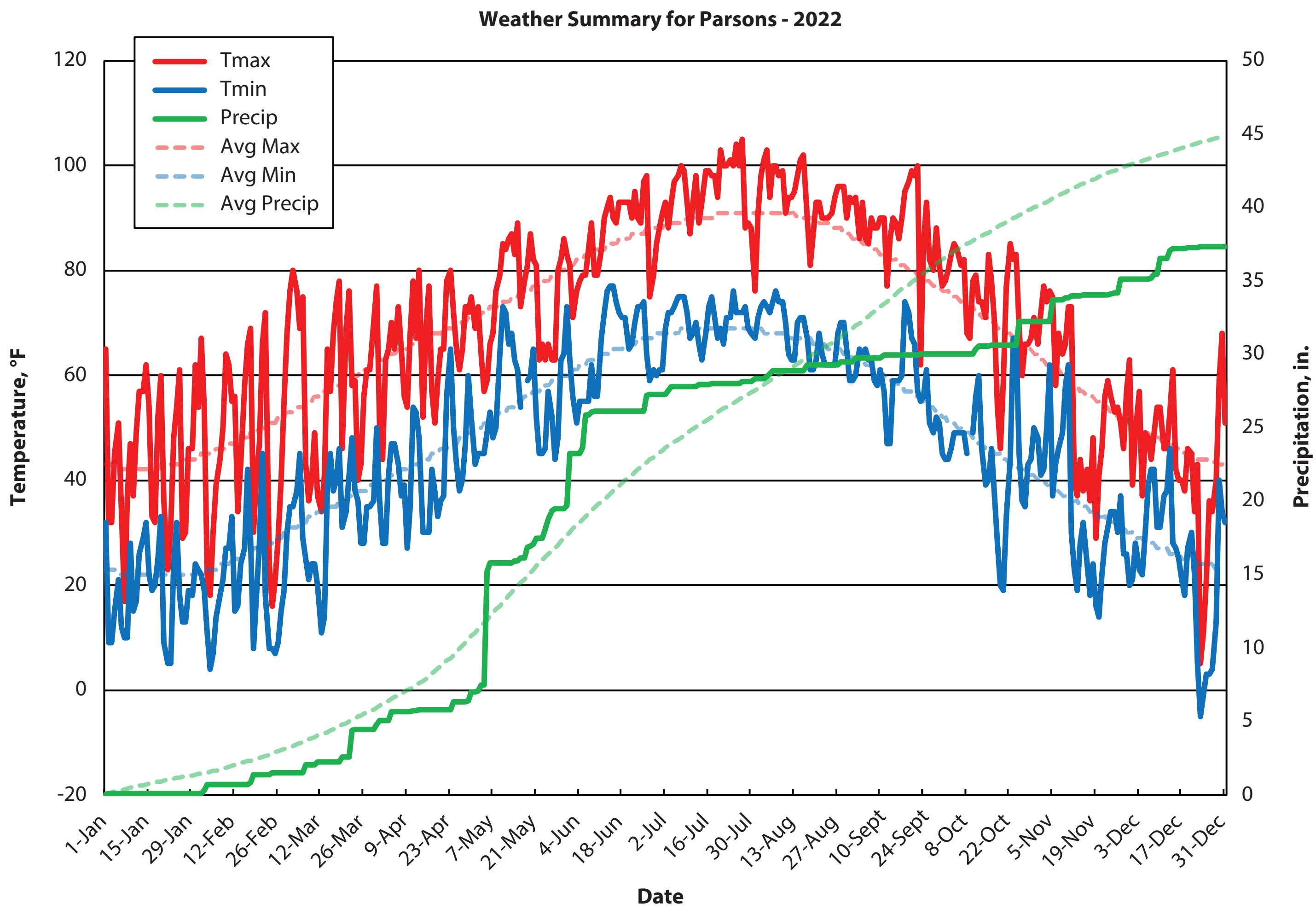
Figure 2. Effect of phosphorus (P), potassium (K), and nitrogen (N) in the tall fescue and broomsedge proportions at (a) Girard and (b) Altamont. Phosphorus rates were determined from initial soil test results based on 0%, 100%, and 125% of requirement.

Annual Summary of Weather Data for Parsons – 2022

	2022 Data												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Avg. Max	44.3	45.4	59.1	66.1	74.9	86.4	95.3	94.5	87.9	73.1	55.7	43.2	69.0
Avg. Min	18.9	19.3	33.4	41.8	55.7	64.9	70.3	67.6	58.7	44.2	33.5	24.4	44.5
Avg. Mean	31.6	32.3	46.2	54.0	65.3	75.7	82.8	81.1	73.3	58.7	44.6	33.8	56.7
Precip	0.13	1.39	3.52	2.00	12.63	7.61	1.09	1.13	0.51	2.22	2.86	2.27	37.36
Snow	0.3	1.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	5.7
Heat DD	1028	907	575	336	117	2	0	0	13	210	612	958	4758
Cool DD	0	0	0	12	132	330	558	504	271	30	7	0	1844
Rain Days	9	9	11	15	20	9	11	8	4	7	7	13	123
Min < 10	5	7	0	0	0	0	0	0	0	0	0	6	18
Min < 32	27	25	12	6	0	0	0	0	0	3	16	22	111
Max > 90	0	0	0	0	0	9	24	24	9	0	0	0	66

	Normal Values (1991-2020)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Avg. Max	42.7	48.1	57.6	67.1	75.6	85.0	90.1	89.7	81.4	70.1	56.8	46.1	67.5
Avg. Min	22.0	25.7	35.0	44.2	55.1	64.6	68.7	66.6	58.2	45.8	34.8	25.8	45.5
Avg. Mean	32.4	36.9	46.3	55.6	65.4	74.8	79.4	78.2	69.8	57.9	45.8	35.9	56.5
Precip	1.42	1.70	2.95	4.77	6.84	5.64	4.23	4.07	4.83	3.64	2.80	2.00	44.89
Snow	2.5	0.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.4	7.1
Heat DD	1012	787	583	299	94	6	0	1	42	253	578	900	4555
Cool DD	0	0	3	19	104	300	446	408	186	34	2	0	1502

	Departure from Normal												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Avg. Max	+1.6	-2.7	+1.5	-1.0	-0.7	+1.4	+5.2	+4.8	+6.5	+3.0	-1.1	-2.9	+1.5
Avg. Min	-3.1	-6.5	-1.6	-2.4	+0.6	+0.3	+1.6	+1.0	+0.5	-1.6	-1.3	-1.4	-1.0
Avg. Mean	-0.8	-4.6	-0.1	-1.6	-0.1	+0.9	+3.4	+2.9	+3.5	+0.8	-1.2	-2.1	+0.2
Precip	-1.29	-0.31	+0.57	-2.77	+5.79	+1.97	-3.14	-2.94	-4.32	-1.42	+0.06	+0.27	-7.53
Snow	-2.2	+1.0	+1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-1.3	-1.4
Heat DD	+16	+120	-8	+37	+23	-4	0	-1	-29	-43	+34	+58	+203
Cool DD	0	0	-3	-7	+28	+30	+112	+96	+85	-4	+5	0	+342


Weather Summary for Parsons - 2022
Tmax
Tmin
Precip
Avg Max
Avg Min
Avg Precip
Temperature, °F
Precipitation, in.
Date
120
100
80
60
40
20
0
-20
50
45
40
35
30
25
20
15
10
5
0
1-Jan
15-Jan
29-Jan
12-Feb
26-Feb
12-Mar
26-Mar
9-Apr
23-Apr
7-May
21-May
4-Jun
18-Jun
2-Jul
16-Jul
30-Jul
13-Aug
27-Aug
10-Sept
24-Sept
8-Oct
22-Oct
5-Nov
19-Nov
3-Dec
17-Dec
31-Dec

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Beason Farm, Elk City, KS

Columbus Chamber of Commerce, Columbus, KS

Corner Post Crop Insurance, Independence, KS

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