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Evaluation of Implants, Clover, and Fescue Variety on Stocker Steers

Z.T. Buessing[1] and J.K. Farney

Summary

Sixty-four growing steers were used in a split-plot experiment, where the whole plot was pasture, and the split-plot was implants. 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, Ralgro). Data collected were weights, hair coat scores, hair length, rectal temperature (every 28 days), and ultrasound carcass characteristics coming off grass. Steers on High Endophyte had the lowest average daily gain (ADG), longest hair, and highest temperature as compared to steers on all other fescue types. The gain differentiation was observed beginning at day 56 through the end of the study. Overall, ADG was not impacted by the addition of legume nor implant type. Steers that were not implanted had a longer hair length throughout many measurement dates. Steers grazing pastures with legumes tended to have a higher ultrasound-measured marbling score and less muscle depth. This study found that the best management strategy for fescue toxicity is to use non-endophyte or non-toxic varieties of fescue pasture. Contrary to previous research, the addition of implants and legumes for this project showed no improvement in cattle gains.

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 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 included fescue development, the addition of clover, or implants. The other fescue varieties have shown improvements to cattle gains, but 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.

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

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 endophyte 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 March 26, 2020, and grazed until November 4, 2020. Pastures were fertilized according to recommendations of soil test results in February 2020. Legumes were interseeded into pastures in 2014. Seedheads were clipped in all pastures June 2020.

On day zero of the trial, calves were implanted and wormed, and rectal temperature, hair coat length and score were recorded. Hair length was measured over the 10th rib in the upper 1/3 of the body using a hemming tape measure. Hair scoring was completed by three individual scorers about every 28 days and based on a scale of 1-5 where a value of 1 is a steer that is completely slick haired; 2 has 25% of body with long hair; 3 has 50% of body with long hair; 4 has 75% of body with long hair; and 5 has 100% of body with long hair coat. Steer weight, hair measurement, and rectal temperature was recorded every 28 days until the pastures no longer supported the steers.

At the end of the grazing period, steers were weighed off grass, scanned with ultrasound for body composition, hair scored and measured, and rectal temperature read. The steers were then placed into feedlot pens where they were implanted with a finishing implant (Revalor-XS) and fed a common finishing ration consisting of corn, corn silage, distillers grains, mineral pack, Rumensin, and Tylosin. For the first three weeks, hair coat scores were recorded by three independent evaluators to determine the rate of overcoming fescue toxicity. Steers were weighed every 28 days during the feedlot period until ~0.5-in. backfat was visually appraised and confirmed by ultrasound. Feedlot data and carcass measurements were not reported.

Results and Discussion

In this first year of data collection, there were no interactions between grass type and implant, thus only main effects have been reported.

Steer Performance Fescue Types

Fescue type had the greatest impact on the overall steer performance. Similar to past studies, High Endophyte Kentucky-31 Fescue resulted in the poorest performance by the steers. These steers had the lowest ADG, longest hair, and highest rectal temperature when compared to the steers grazing other types of fescue (Table 1). By 56 days on the fescue, the High Endophyte treatment steers had the lowest gain.

Hair length tended to have a little variation among Low Endophyte, Novel Endophyte, and Endophyte Free on which treatment produced the shortest hair length. One consistency among all measurement days for hair length is that High Endophyte always had the longest hair on the steers. When rectal temperatures were different, the calves on High Endophyte had the highest rectal temperature, yet that was not observed consistently through the measuring period.

Steer Performance Legumes

The addition of legumes did not present as great of an impact on the steers' performance as did the type of fescue. Legumes had no impact on the ADG of the steers throughout the course of the grazing period (Table 2). During the whole grazing period there were little to no individual weigh days that showed a significant difference between the two treatments of legume or no legume on the ADG. Steers that grazed legumes tended to have higher measured ultrasound marbling scores and less muscle depth (Table 2). The addition of legumes and effects on gain and mitigation of fescue toxicity may have been diluted as some of the high endophyte pastures with legumes had a very low stand count of legumes (< 5% of plant population was legume).

Steer Performance Implants

Implants proved to impact the hair length of the steers, where those that were not implanted had longer hair than those steers implanted throughout many of the measurement periods (Figure 1). Longer hair was consistently observed in those steers that did not receive an implant. The other three implant treatments proved to produce better results in minimizing the effects fescue toxicity had on the hair length of the steers. Implants did not have any effect on the steers' ADG (Table 3). Although there were different payout windows for each of the implants, a difference in ADG was not seen based on the results from this grazing period. There was some variability in ADG between implants, that were not statistically significant, and it will be interesting to see as the study continues for 2 more years with more replications.

This study found that the best management strategy for fescue toxicity is to use non-endophyte or non-toxic varieties of fescue pasture. Additionally, even though implants did not result in greater gains for the steers, the shorter hair coats may correspond to an economic incentive at marketing as calves that have the "look" of a fescue calf (long, rough hair coat), are reduced in price at market. Contrary to previous research, the addition of implants and legumes for this project showed no improvement in cattle gains.

Table 1. Steer performance measures based on fescue type

Item	Endophyte Free	Novel Endophyte	Low Endophyte	High Endophyte	SEM	*P*-value
Initial wt, lb	605	613	605	607	8.0	0.88
Final wt, lb	928	943	937	835	14.0	< 0.0001
Grazing ADG, lb/d	2.11	2.17	2.18	1.65	0.08	< 0.0001
Loin muscle depth, mm	50	49	51	49	1.2	0.53
Marbling score[1]	5.10	4.90	5.10	5.07	0.14	0.75
Backfat, in.	0.17	0.17	0.19	0.17	0.01	0.68

SEM = standard error of the mean. ADG = average daily gain.
[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	608	608	5.6	0.96
Final wt, lb	907	914	9.9	0.63
Grazing ADG, lb/d	2.03	2.02	0.05	0.93
Loin muscle depth, mm	49	51	0.9	0.09
Marbling score[1]	5.15	4.91	0.10	0.08
Backfat, in.	0.18	0.17	0.006	0.86

SEM = standard error of the mean. ADG = average daily gain. Legume = ladino clover seeded at 6 lb/acre.
[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	609	607	609	607	7.8	0.99
Final wt, lb	900	904	910	928	14.0	0.53
Grazing ADG, lb/d	1.96	1.99	2.00	2.15	0.08	0.30
Loin muscle depth, mm	51	49	50	50	1.2	0.67
Marbling score[5]	4.91	5.02	5.01	5.18	0.13	0.56
Backfat, in.	0.19	0.16	0.18	0.17	0.01	0.28

[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.
[5] 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*).

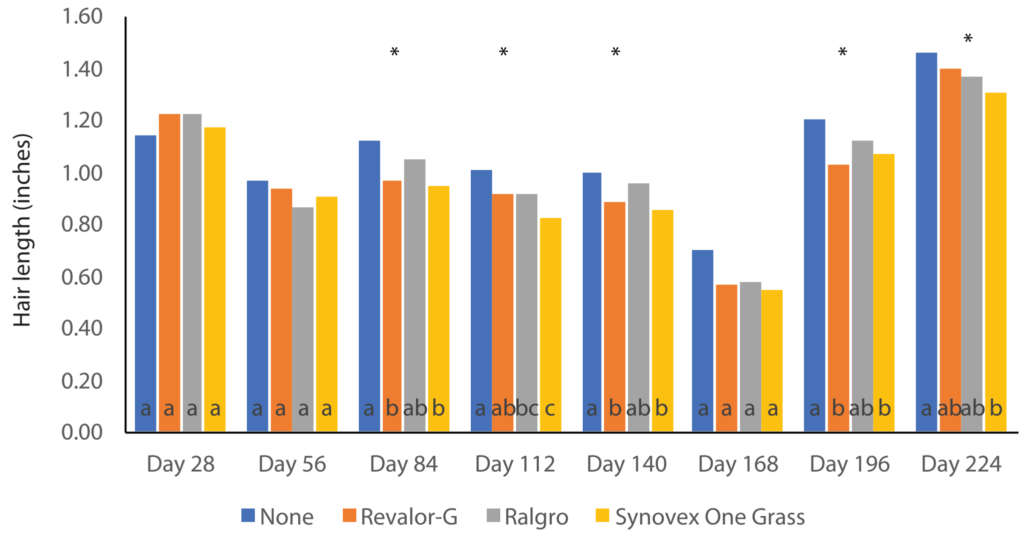

Figure 1. Effects of implant type on the hair length.

[abc] Different letters within day indicate differences at $P < 0.05$.

* Indicate $P < 0.05$ for day of measurement.

Form of Supplement and Addition of Ionophore Effects on Steer Performance while Grazing Bromegrass and Subsequent Effects in Feedlot and Carcass Measures

J.K. Farney and K. Malone[1]

Summary

Stocker steers were grazed on bromegrass from April to the end of August and were supplemented with several different forms of products. Treatment structure was a 2 × 2 + 2 factorial (six total treatments). Treatments evaluated included mineral only; free-choice supplementation in the form of liquid feed (MIX30) or block format (Mintrate); hand-fed supplement of corn:dried distillers grains at 0.25% of body weight on a dry matter basis offered three times per week; and ionophore (Rumensin) was included in one block and hand-fed supplement. Steers were weighed every 28 days while on grass and in the feedlot. Steers were ultrasounded prior to placement in the feedlot and harvested when they reached at least 0.4-in. backfat and scanned Choice at 115 days on feed. There was no difference in steer gains during the grazing phase or feedlot phase based on all treatments, or if ionophore was included. However, during the grazing period hand-fed steers had greater gain than self-fed supplemented steers and these steers also had more backfat coming off-grass than other supplemented steers. During the finishing phase the steers that were on the self-fed supplement while on grass compensated and had a greater average daily gain than hand-fed steers. Hand-fed supplemented steers tended to have a more backfat at harvest and subsequently higher (but still acceptable) yield grade. Steers that were supplemented with MIX30 tended to have a greater average daily gain (ADG) in the feedlot than hand-fed steers, with block supplemented steers being intermediate. Additionally, MIX30 steers had a heavier final weight prior to harvest than block supplemented steers, with hand-fed being intermediate. There was no difference in ADG or total gain for the entire system (grazing and feedlot period).

Introduction

Supplementation is important in cattle production because it could (1) fill the gap in 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 forage supply. Cattle management is different based on geographic location, access to labor, distance to cattle from feed source, forage types, and economic goals. A variety of supplements for grass cattle have been developed to meet operational objectives. Determining which supplement best fits an operation can be daunting.

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

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versus self-fed); (2) form of self-fed supplement; (3) addition of ionophore into the supplement; and (4) how supplementation strategy impacts performance in the feedlot and carcass characteristics.

Experimental Procedures

Eighteen brome pastures were used in a 2 × 2 + 2 factorial research project at the Southeast Research and Extension Center in Parsons, KS. The 2 × 2 factorial was evaluating supplement type and the addition of ionophore. The additional two treatments include MIX30 (liquid feed) and a negative control (no supplement except free choice mineral). Pastures were fertilized on March 4 and 5, 2020, based on recommendations from soil test for phosphorus and potassium and all pastures had 100 lb of nitrogen applied in 46-0-0 form.

Supplement Specifics

The hand-fed supplement (HAND) is a 50:50 blend of cracked corn:dried distillers grains (DDG) with or without Rumensin (138 g/ton; HANDRU) fed at 0.25% of body weight daily, offered 3 times a week on Monday, Wednesday, and Friday. The liquid feed supplement is a product called MIX30 (Agridyne, LLC; MIX30) fed in an open-topped tub. The block treatments were Mintrate 40 Red Block (ADM Alliance Nutrition; BLOCK) and the Mintrate Red RU (BLOCKRU). Blocks were fed free-choice to the steers and placed in bunks to contain all pieces of the block. The control (CON) treatment were steers that were fed a free-choice mineral (Farney, 2021).

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 feeding tubs was done with a paint stirrer.

Cattle Specifics

Weaned and vaccinated steers (540 ± 14.7 lb) were used and stocked at 4 head per pasture on 5-acre pastures. There were three pastures of each treatment. To manage for rumen fill effects, four days before turnout steers were fed a 50:50 diet of wheat middlings and DDG at 2% of body weight for three full days. On days -1 and 0 (day of turnout) steers were weighed on two consecutive days and placed on brome pastures (April 2, 2020). Steers were wormed prior to turnout with a white wormer (Valbazen, Zoetis Inc.). During May, insecticide ear tags were inserted.

Steers were ultrasounded (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 31, 2020; 151 days on grass). After scanning, steers were placed on a rumen fill equivalence diet for three days (50:50 blend of wheat middlings and DDG at 2% of body weight on DM basis) and weighed on two consecutive days before being placed in feedlot. Steers were placed in a feedlot at Mound Valley, KS; implanted with a terminal implant (Revalor XS), then placed on a step-up diet to reach a finishing diet. Steers were penned in feedlot by contemporary pasture group. The finishing diet (on DM basis) was 85% whole shelled corn, 10% corn silage, and 5% supplement (contains minerals, vitamins, urea, Tylan, and Rumensin). Steers were weighed every 28 days until ~0.4 inch of backfat then taken to commercial packing facility. Steers were harvested on January 7, 2021 (124 days on feed). Final weight was calculated from carcass weight divided by dressing percentage.

Results and Discussion

Grazing Period

Results are for year 1 of 3. During the study there was above average rainfall for the area through May, then much lower precipitation than usual. Due to weather, cattle were removed from the pasture nearly 2 months earlier than has traditionally been done with those pastures. There was no difference in grazing ADG when comparing all the treatments ($P = 0.36$; Table 1). However, grazing ADG was impacted by category of supplementation where hand-fed steers had a greater ADG than steers fed free-choice supplements ($P = 0.05$; Table 1). This advantage was observed after cattle had been on trial for 84 d and was maintained until steers reached the feedlot ($P < 0.05$; Table 1) and resulted in heavier final weight off-grass ($P = 0.04$; Table 1).

There was no difference in grazing ADG based on the addition of ionophore ($P = 0.43$), yet by 56 d into the study, calves with ionophore approached a tendency for improved gains as compared to non-ionophore feeds ($P = 0.12$). By d 112 of the study, steers fed ionophore did result in improved ADG ($P = 0.04$; Table 1). During the period of poorest quality forage (period between d 84 and 112) the ionophore did help improve gains over non-ionophore feeds ($P = 0.04$; Table 1).

There was no difference in ADG based on class of supplement up to d 84 on study ($P > 0.10$), yet based on cumulative gains from d 84 to 112, hand-fed steers gained more than steers supplemented with a block, and the liquid feed gains were intermediate ($P < 0.05$; Figure 1). For the entire grazing period there was no difference in gain based on supplement type ($P = 0.16$).

Ultrasound data at the end of the grazing period (d 150) indicated very few differences between the feeding systems. The only differences detected were that there was a tendency ($P = 0.09$) for backfat to be greater in hand-fed steers as compared to free-choice supplements and for marbling to be greater in control steers compared to any that were supplemented ($P = 0.09$; Table 1). Also, there was a tendency ($P = 0.11$) for hand-fed steers to have more backfat than liquid supplemented steers, with block supplemented steers being intermediate.

Feedlot Period

Average daily gain was greater in steers that were self-fed supplement during grazing period as compared to the hand-fed supplemented steers ($P = 0.07$; Table 1). The MIX30 steers had a greater ADG than hand-fed steers fed the supplement, with block being intermediate ($P = 0.06$; Table 2). Final weights were greater for MIX30 than steers fed the supplement block, with hand-fed being intermediate ($P = 0.09$; Table 2). No other gain measures were different during the feedlot period ($P > 0.15$; Table 1).

There were minimal differences in carcass characteristics based on form of supplement during the grazing period ($P > 0.15$; Tables 1 and 2). The only differences were a tendency for hand-fed supplemented steers to have more backfat than self-fed steers, and subsequently yield grade tended to be higher for hand-fed than self-fed ($P < 0.10$;

Table 1). Even though hand-fed steers were higher in yield grade, it was still at an acceptable grade value.

System Performance Effects

There were no differences in the whole system (grazing and feedlot phase) for any treatment, addition of ionophore, hand-fed vs. self-fed supplement, nor type of supplement (P > 0.20; Tables 1 and 2).

Supplement Intake on Grass

The hand-fed cattle intakes were more consistent than self-fed intakes for the cattle on supplements and intakes increased through the feeding period, as the calves were increasing in weight. The most variable intake was found with the MIX30 supplement (Figure 2A). The steers had a higher intake of MIX30 early in the grazing period and then a much lower intake towards the end. Average daily protein and energy intakes were fairly similar across the feeding period for HAND and HANDRU. BLOCK and BLOCKRU also had similar protein and energy intakes that were nearly the same throughout the entire grazing period (Figure 2B and Figure 2C). Forage crude protein decreased through the grazing period (Figure 2D). Average pasture protein values were similar between pastures for each respective month (1.3% to 2.4% difference in treatments), even though in July (corresponds to period between d 84 and 112) the control pastures had a higher crude protein and that was the time when CON steers gained quite a bit more than supplemented steers (Table 1). Since supplement intakes were not different when the forage was lower quality, overall protein and energy supplied to steers resulted in the low to negative gains from d 112 to the end of grazing period.

References

Farney, J.K., and M.E. Reeb. 2021. Stocker Steer Gains and Fly Numbers as Impacted by Burn Date and Type of Mineral on Tallgrass Native Range. *Kansas Agricultural Experiment Station Research Reports*: Vol. 7.

Table 1. Steer gain and carcass measures during the grazing, feedlot, and entire system

	Treatment							*P*-value			
Item	**CON[1]**	**MIX30**	**Block[2]**	**Block-RU[2]**	**Hand[3]**	**Hand-RU[3]**	**SEM[4]**	**Trt[5]**	**Hand vs. self[6]**	**Supple. vs. no[7]**	**Ion.[8]**
Start weight, lb	540	540	540	540	540	540	14.9	1.00	0.99	0.99	0.99
Final grazing weight, lb	810	793	792	794	825	834	19.2	0.50	0.04	0.92	0.77
Grazing ADG, lb/d	2.04	1.87	1.83	1.97	2.07	2.09	0.10	0.36	0.05	0.48	0.43
Final feedlot weight, lb	1341	1375	1321	1320	1350	1323	21.1	0.41	0.92	0.87	0.50
Feedlot ADG, lb/d	4.29	4.52	4.14	4.24	4.11	3.94	0.15	0.21	0.07	0.56	0.81
System ADG, lb/d	2.91	2.97	2.81	2.83	2.88	2.85	0.07	0.66	0.88	0.55	0.95
System gain, lb	801	816	774	780	791	783	18.5	0.66	0.88	0.55	0.95
Cumulative average daily gain (ADG) grazing period, lb/d											
d 28	4.34	4.10	3.74	4.33	3.97	3.99	0.22	0.40	0.69	0.21	0.19
d 56	3.57	3.75	3.27	3.66	3.53	3.74	0.18	0.48	0.66	0.90	0.12
d 84	2.85	2.93	2.55	2.77	3.06	3.09	0.17	0.28	0.05	0.89	0.47
d 112	2.35[ab]	2.13[bc]	1.95[c]	2.16[abc]	2.21[abc]	2.42[a]	0.10	0.05	0.02	0.10	0.04
d 140	1.99	1.83	1.79	1.91	2.06	2.06	0.11	0.36	0.05	0.60	0.57
Period ADG grazing period, lb/d											
d 56	2.79	3.41	2.80	3.00	3.09	3.50	0.28	0.39	0.39	0.25	0.29
d 84	1.43	1.28	1.11	1.00	2.12	1.78	0.35	0.26	0.02	0.95	0.53
d 112	0.84[a]	-0.24[cd]	0.16[bcd]	0.32[abc]	-0.36[d]	0.41[ab]	0.21	0.01	0.79	0.01	0.04
d 140	0.55	0.59	1.15	0.94	1.47	0.60	0.33	0.34	0.65	0.29	0.13
Ultrasound carcass measures: grazing phase											
Back fat, in	0.19	0.16	0.18	0.18	0.18	0.21	0.01	0.31	0.09	0.49	0.54
Marbling[9]	5.72	5.42	5.41	5.26	5.29	4.88	0.25	0.31	0.23	0.09	0.27
Loin depth, mm	50.0	50.1	49.1	51.0	52.0	47.2	1.67	0.44	0.75	0.98	0.38
Carcass measures											
Hot carcass wt, lb	793	805	787	779	809	789	12.9	0.62	0.48	0.98	0.30
Dressing, %	59.2	58.6	59.7	59.1	59.9	59.7	0.48	0.45	0.15	0.69	0.37
Marbling score[10]	473	466	448	467	461	487	30.1	0.96	0.63	0.81	0.47
Ribeye area, sq in.	12.9	13.0	12.8	13.3	12.9	12.6	0.35	0.84	0.45	0.95	0.91
Backfat, in.	0.42	0.40	0.44	0.42	0.52	0.47	0.05	0.52	0.09	0.60	0.49
Yield grade	2.85	2.84	2.89	2.66	3.16	3.10	0.20	0.56	0.10	0.69	0.49

[abcd]Values indicate treatment differences within row with $P < 0.05$.
[1]CON: control treatment received free choice mineral (Wildcat Feed, LLC).
[2]Block: Mintrate40 block (ADM Alliance Nutrition) and BlockRU: Mintrate RedRU block includes Rumensin at 300 g/ton (ADM Alliance Nutrition).
[3]Hand: 50:50 blend of dried distillers grains (DDG) and cracked corn offered at 0.25% of body weight, 3 times per week (Monday, Wednesday, and Friday) and HandRU: 50:50 blend of DDG and cracked corn with Rumensin as 139 g/ton offered at 0.25% of body weight, 3 times per week (Monday, Wednesday, and Friday).
[4]SEM: standard error of means.
[5]Trt: *P*-value comparison between all 6 treatments.
[6]Hand vs. Self: *P*-value comparison between free-choice treatments (MIX30, Block, BlockRU) and hand-fed treatments (Hand and HandRU).
[7]Supple. vs. No: *P*-value comparison non-supplemented (CON) and supplemented (MIX30, Block, BlockRU, Hand, and HandRU).
[8]Ion.: *P*-value comparison between treatments with ionophore (BlockRU and HandRU) or without ionophore (Block and Hand).
[9]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*).
[10]U.S. Department of Agriculture marbling scores: 300-399: Slight 0-90; 400-499: Small 0-90; and 500-599: Modest 0-90.

Table 2. Carcass measures based on category of supplementation (average ± standard error of means)

Item	Block[1]	Liquid[2]	Hand[3]	*P*-value
Gain measures				
Grass period ADG, lb/d	1.90 ± 0.1	1.87 ± 0.1	2.08 ± 0.1	0.16
Grass period final wt, lb	793 ± 13.3	793 ± 18.8	830 ± 13.3	0.11
Feedlot period ADG, lb/d	4.19 ± 0.1[ab]	4.52 ± 0.2[a]	4.02 ± 0.1[b]	0.06
Feedlot period final wt, lb	1320 ± 13.6[b]	1375 ± 20.6[a]	1335 ± 13.9[ab]	0.09
System ADG, lb/d	2.83 ± 0.04	2.97 ± 0.07	2.86 ± 0.04	0.21
Total system gain, lb	777 ± 12.2	816 ± 18.5	787 ± 12.5	0.21
Ultrasound measures off-grass				
Marbling score[4]	5.34 ± 0.15	5.41 ± 0.22	5.08 ± 0.15	0.36
Back fat, mm	4.52 ± 0.25[ab]	4.03 ± 0.37[b]	4.95 ± 0.25[a]	0.11
Loin depth, mm	50.1 ± 1.1	50.1 ± 1.6	49.6 ± 1.1	0.95
Carcass data				
Hot carcass wt, lb	783.4 ± 8.7	805.4 ± 13.2	798.5 ± 8.9	0.30
Dressing, %	59.4 ± 0.3	58.6 ± 0.5	59.8 ± 0.3	0.15
Marbling score[5]	457.4 ± 20.0	466.1 ± 29.4	474.5 ± 20.2	0.84
Ribeye area, sq in.	13.0 ± 0.2	13.0 ± 0.4	12.8 ± 0.2	0.67
Backfat, in.	0.43 ± 0.03	0.40 ± 0.05	0.50 ± 0.03	0.17
Yield grade	2.77 ± 0.14	2.84 ± 0.21	3.13 ± 0.14	0.23

[1]Block: averages from Mintrate40 block and MintrateRU block (ADM Alliance Nutrition) treatments.
[2]Liquid: Mix 30 (Agridyne, LLC).
[3]Hand: Average gains from hand feeding (without and with Rumensin) 50:50 blend of dried distillers grains and cracked corn at 0.25% of body weight, 3 times per week.
[4]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*).
[5]U.S. Department of Agriculture marbling scores: USDA – 300-399: Slight 0-90; 400-499: Small 0-90; and 500-599: Modest 0-90.
ADG = average daily gain.

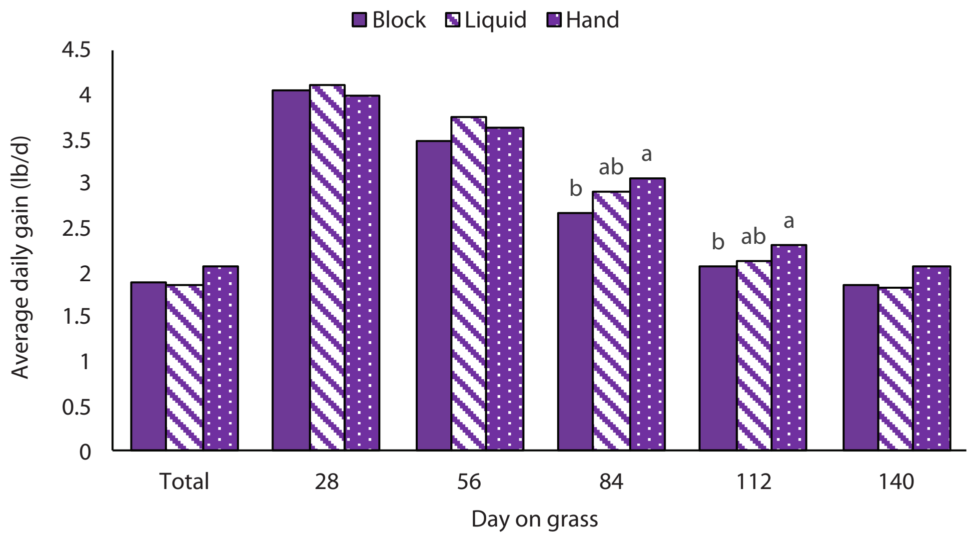

Figure 1. Cumulative average daily gains measured every 28 days, based on supplement category.

Block: Average gains of Mintrate Red40 and Mintrate RedRU blocks.

Liquid: Average daily gains on MIX30 liquid supplement.

Hand: Average gains from hand feeding (without and with Rumensin) 50:50 blend of dried distillers grains and cracked corn at 0.25% of body weight, 3 times per week.

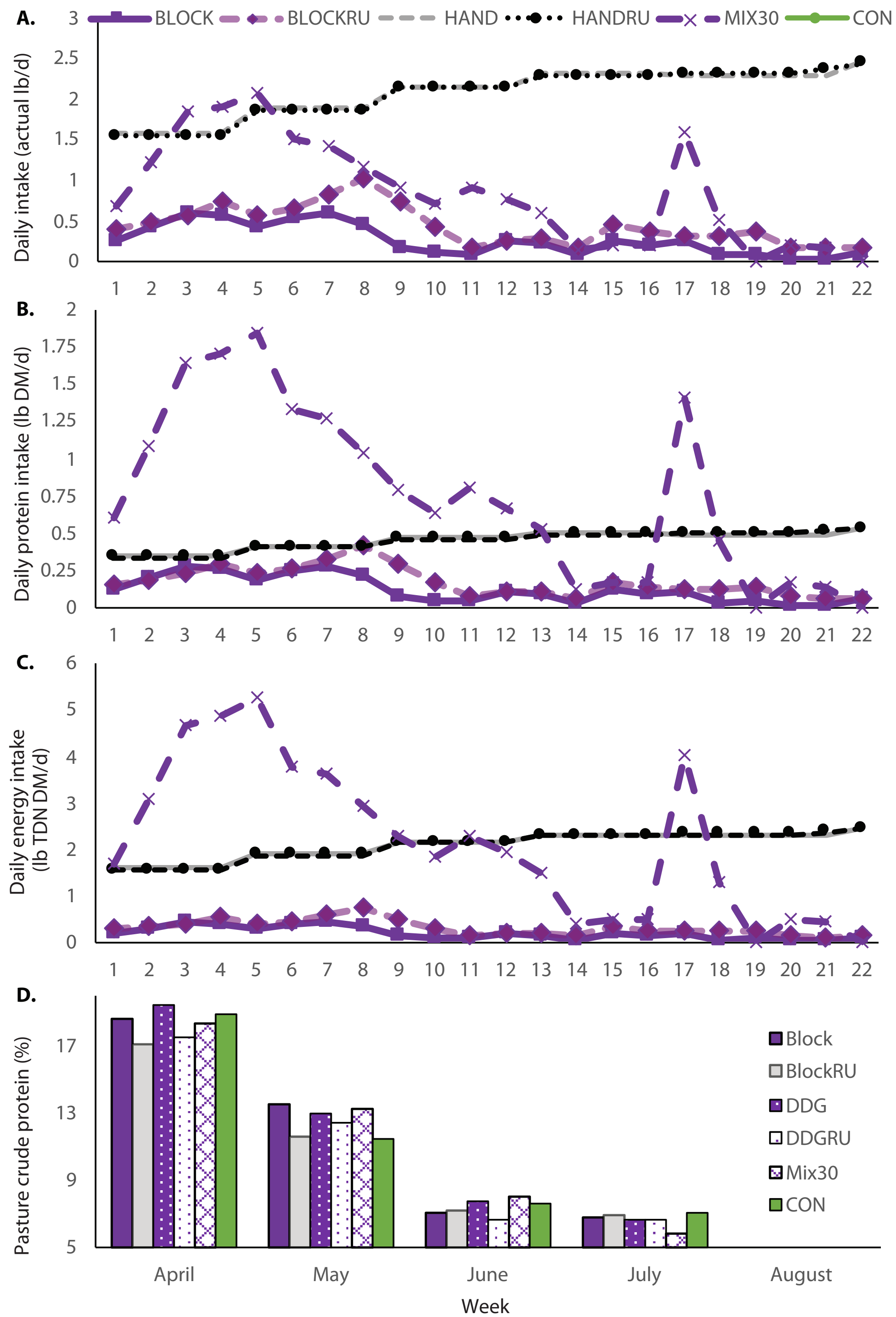

Figure 2. Daily intake of supplements (as-is), protein and energy (DM basis), and average pasture crude protein over grazing period. See Table 1 for the treatment definitions listed in this figure.
DM = dry matter. TDN = total digestible nutrients.

Evaluation of Grazing Options During Summer for Growing Heifers

J.K. Farney

Summary

Developing methods to provide high quality forage through a majority 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) were used in a completely randomized design and stocked with growing heifers (n = 47; initial wt 419 ± 20 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 grazed FES/SS-FES pastures April to November (213 d) or CRAB and BERM May through September (131 d). Heifers on FES were continuously grazed. All other pastures were rotationally grazed. Average daily gain for the entire grazing period was greater for heifers on SS-FES as compared to all other grass treatments ($P = 0.001$). Between April and May, FES heifers had greater average daily gain (ADG) than SS-FES pastures ($P = 0.001$); yet, the heavier stocking rate resulted in similar gain per acre ($P = 0.16$). May to July ADG and gain per acre was greatest for BERM, followed by CRAB, with FES and SS-FES having the lowest gains ($P < 0.001$). From July through September, ADG was greater for SS-FES and CRAB as compared to FES, with BERM intermediate ($P = 0.03$) while gain per acre was lowest for FES ($P = 0.10$). The ADG and gain per acre were greater for SS-FES than FES ($P = 0.001$) from late September to November. As a summer grazing option, warm season grass alternatives, either as the sole source of pasture or interseeded into fescue, are better options for gain as compared to fescue alone.

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 have designated warm-season pastures and cool-season pastures and rotate cattle between the two during their respective growing season. However, that requires at least double the acreage or reduction of 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.

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 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 (April through November – 213 days of grazing) 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 6 head per pasture from April to July and 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 May, the paddock that was just grazed 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 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. Heifers on FES and SS-FES were placed on pasture on April 2, 2020. Heifers on BERM and CRAB were placed on pasture May 14, 2020. All heifers were weighed July 7, 2020 and September 22, 2020 (CRAB and BERM were removed from pasture). Heifers in the FES and SS-FES pastures were removed from pasture November 5, 2020, and weighed.

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

Results and Discussion

Total grazing season average daily gain was the greatest for heifers on SS-FES pastures (Figure 1). However, these heifers did not have the greatest average daily gain throughout each of the grazing periods. While grazing March through April, heifers on FES had a greater ADG and total gain than SS-FES heifers (Figures 1 and 2). While grazing May through June, heifers on FES and SS-FES had similar ADG that was lower than heifers on CRAB, and BERM and heifers on BERM had the greatest gains (Figures 1 and 2). Once the sorghum-sudan began growing, heifers that grazed SS-FES had similar ADG and gain as heifers on CRAB, with BERM being intermediate, and FES having the lowest ADG (Figures 1 and 2). Grazing September through November resulted in heifers grazing SS-FES that had greater ADG and gain than heifers grazing on FES (Figures 1 and 2).

Gain per acre was not different for the heifers grazing FES or SS-FES from May through April (Figure 3). Even though ADG was greater for heifers on FES, gain per acre was the same. In most studies, heavier stocking rate and rotational grazing resulted in lowered individual animal ADG but greater gain per acre. This was observed while grazing FES and SS-FES from Mary through April. Gain per acre from May through June was greatest for BERM, then CRAB, with FES and SS-FES being the lowest (Figure 3). While grazing May through June, the heifers on SS-FES were only grazing fescue as the sorghum-sudan had not started growing because of low moisture immediately after planting. Once the sorghum-sudan started growing in the grazing period from July through September, gain per acre was the same for heifers on SS-FES, BERM, and CRAB pastures when the lowest gain per acre was with FES (Figure 3). Heifers grazing SS-FES pastures had a greater gain/acre while grazing from September to November (Figure 3). Pasture forage quality was not reported, however, pastures that were SS-FES remained vegetative and bright green through the entire summer, until the end of the summer, which may be one reason heifers on SS-FES had greater total gain through the entire summer grazing season.

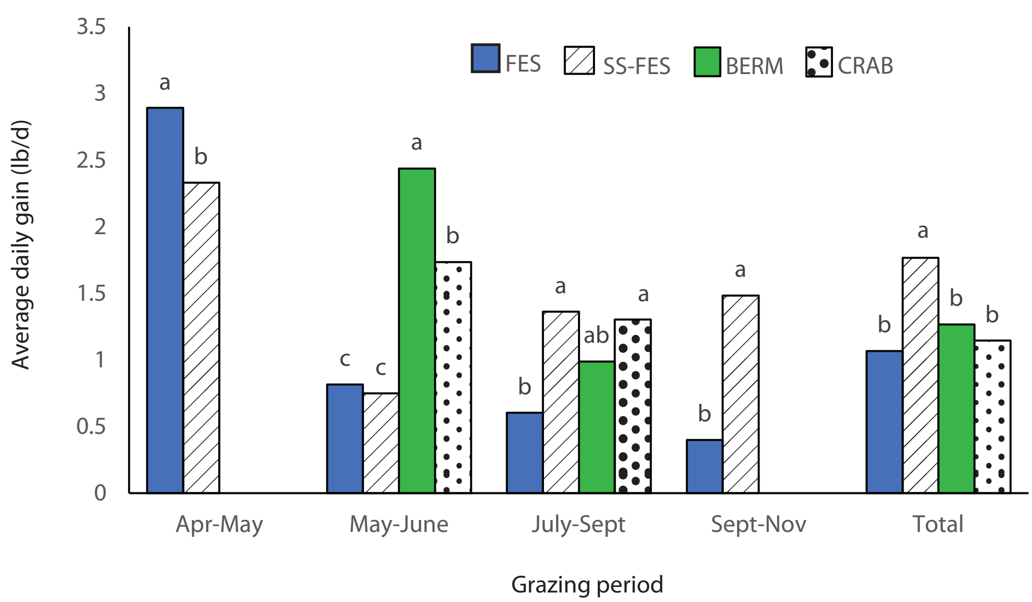

Figure 1. Average daily gain of heifers based on grazing period.
[abc] Within grazing periods letters that are different indicate differences in pasture type. FES: fescue grazing treatment; SS-FES: sorghum-sudan interseeded into fescue; BERM: bermudagrass pasture; CRAB: crabgrass pastures. Grazing periods were Apr-May: April 2 through May 15, 2020; May-June: May 15 to July 7, 2020; July-Sept: July 7 to September 25, 2020; Sept-Nov: September 25 to November 5, 2020.

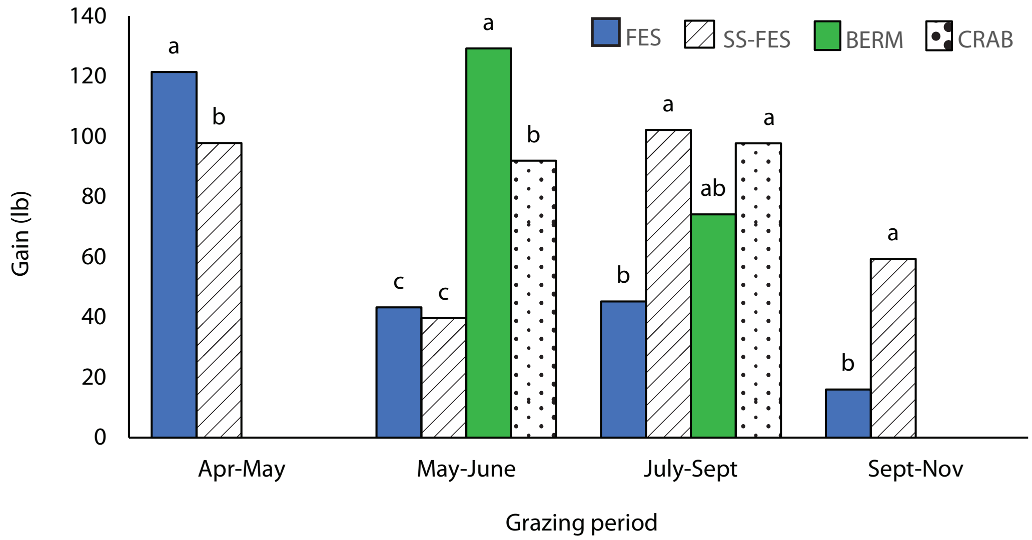

Figure 2. Gain per grazing period.
[abc] Within grazing periods letters that are different indicate differences in pasture type. FES: fescue grazing treatment; SS-FES: sorghum-sudan interseeded into fescue; BERM: bermudagrass pasture; CRAB: crabgrass pastures. Grazing periods were Apr-May: April 2 through May 15, 2020; May-June: May 15 to July 7, 2020; July-Sept: July 7 to September 25, 2020; Sept-Nov: September 25 to November 5, 2020.

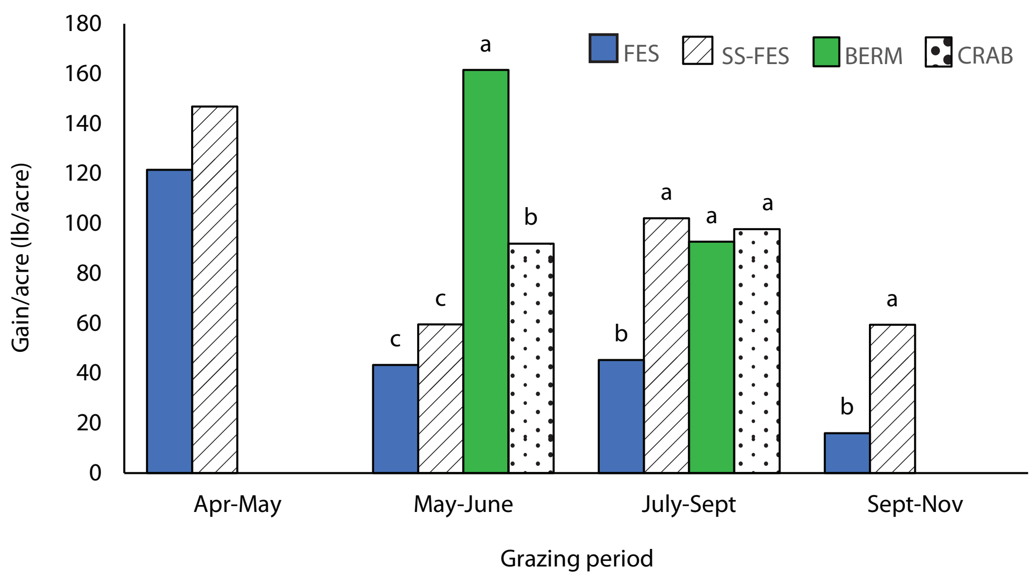

Figure 3. Gain per acre based on each grazing period.
[abc] Within grazing periods letters that are different indicate differences in pasture type. FES: fescue grazing treatment; SS-FES: sorghum-sudan interseeded into fescue; BERM: bermudagrass pasture; CRAB: crabgrass pastures. Grazing periods were Apr-May: April 2 through May 15, 2020; May-June: May 15 to July 7, 2020; July-Sept: July 7 to September 25, 2020; Sept-Nov: September 25 to November 5, 2020.

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

J.K. Farney and M.E. Reeb[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 612 ± 57 lb) were used in a 2 × 2 factorial treatment structure. Steers were weighed individually, randomly assigned to treatment, and grazed for 85 days. Weekly, 33% of steers were photographed to count flies and evaluated for hair coat score. Cattle on the APR-SPICE treatment had a greater average daily gain (ADG) than MAR-SPICE and APR-CON with MAR-CON intermediate. Cattle on SPICE were 10 lb heavier than cattle consuming CON mineral. In general, APR-SPICE steers had a greater number of flies on weeks 8, 10, and 11, corresponding to a time when mineral intake averaged 72% of the formulated intake. Additionally, steers on SPICE had a greater number of flies than CON steers. In year 2 of 4 for this study, there was minimal difference in gain based on burn date, primarily because burn dates were only 12 days apart. The use of spices increased weight in cattle but resulted in more flies than control steers. The addition of these spices added $0.02/hd/day to cost of production and the improved gains resulted in a positive return on investment.

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 handfeeding (Beck et al., 2017). However, other studies at Kansas State University have found that the feeding 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 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 gains and plant population changes are not too different when burning in March instead of April, it would provide the opportunity to develop a smoke management plan that allows for an increased burning season to dilute a single month's smoke.

[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 include evaluating timing of burning, addition of spices in a complete free-choice mineral, and determining if the effects 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 27, 2020, while the April burned pastures were burned on April 9, 2020.

The free-choice mineral supplementation strategies evaluated 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 (612 ± 657 lb) were weighed individually on April 23, 2020, and assigned to pasture randomly based on order through the chute. Cattle were weighed at the end of the study on July 16, 2020, for a total of 87 days of grazing. Four head were not weighed on the final weigh date so only 277 head were included in the analyses. 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 counted (Figure 1). 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

Burn date did not alter steer gain (Table 2). This result is in contrast to most other studies that showed that APR burning results in greater gain than MAR burning. In these same pastures in 2019, steers grazing pasture burned in April gained 29 pounds more than steers grazing pasture burned in March (Farney, 2020b). With the 2020 data, there were only 12 days between burned dates, instead of a full month like in 2019. The 2020 March burn was moved later than originally planned as rains in the beginning of March prevented fire success.

Similarly to 2019, steers on the spice mineral were heavier coming off-grass than steers on the control mineral (Table 2). There was an interaction in burn date and mineral for ADG, total gain, and final weight (Table 2). Steers on the APR-SPICE treatment had the greatest gain, with MAR-SPICE and APR-CON having the lowest gains and MAR-CON being intermediate. In 2019, even though there was no statistical difference in gains, the greatest gains were still observed in the APR-SPICE treatment with the lowest gain in MAR-CON. The MAR-CON cattle had greater gains than anticipated; gains may have been affected by the fly numbers, which will be discussed. One of the MAR-SPICE treatment pastures had a heavy infestation of *Serecia lespedeza*, which may have hampered gains due to this weed's unpalatability for cattle, and its competition with more desirable plant species.

Fly Counts

Flies increased through the summer and by week 9 all treatments had more than 200 flies on steers (Figure 2). Two hundred total flies is the economic threshold where cattle start having reductions in performance enough to negatively impact economic returns. The MAR-CON steers had one extra week (Week 8) where they had fly numbers less than the economic threshold. This one week worth of lower fly counts may have contributed to the cattle having a greater gain than APR-CON and MAR-SPICE treatments. The hypothesis is that the MAR-CON cattle should have the lowest gain of all the treatments, yet with the second highest gains in 2020, the fly numbers may have been a contributing factor to the greater than hypothesized gain for MAR-CON.

Interestingly, the steers on the SPICE treatment had a greater number of flies than steers consuming the CON mineral. This was in opposition of what was hypothesized—that the spices would have some deterrent capabilities towards the flies. Some studies that have found that consumption of the spices does not have fly repellency, whereas spraying the spices on the animals does lead to reductions in fly populations (summarized in Showler, 2017). The APR-SPICE steers had more flies than all other treatments during weeks 8, 10, and 11 (Figure 2). Outside of week 8, those weeks were times when SPICE mineral intake was 72% of formulated intake amount. This may have been part of the reason these steers had an elevated fly population. As with most free-choice options, there is a wide range of intakes through the season and within animal groups. With the apparent trend of low SPICE mineral intake and corresponding high numbers of flies, this may indicate that the evaluated SPICE products do not have a long systemic life in the animal, thus a more consistent intake is needed if there is a fly repellency effect of the spices.

Hair Coat Scores

The addition of SPICE in mineral resulted in steers with a slicker hair coat through the entire grazing season (average hair coat score 2.08 for SPICE vs. 2.39 for CON). The highest gaining steers (APR-SPICE) also were the slickest hair coated steers, with the APR-CON steers have the longest hair of all the treatments (Table 2). The importance of hair coat comes into effect when it is marketing time for the steers. Cattle that have a long hair coat are discounted at sale as they are perceived to either have been on fescue, sick at one point, or overall be poorly performing, unthrifty animals. The SPICE addition in the mineral helped the steers to slick up and this may also have played a role in temperature control as long haired calves during the summer have increased panting, spend more time in water and shade, and less time grazing—all of which decrease gains. A reduction in a combination of several of those behaviors may have occurred that led to the highest gains being observed with APR-SPICE steers.

Economics

The SPICE adds $0.02/head/day to mineral cost. Over the entire grazing period, the cost of the mineral was $1.74/head. The steers on SPICE were 10 pounds heavier coming off-grass and netted $9.80 more than CON steers. This resulted in a 5.6× return on investment of the spice in the mineral.

References

Araujo, R. C., D. R. Daley, S. R. Goodall, S. Jalali, O. A. G. Bisneto, A. M. Budde, J. J. Wagner, and T. E. Engle. 2019. Effects of a microencapsulated blend of essential oils supplemented alone or in combination with monensin on performance and carcass characteristics of growing and finishing beef steers. App. Anim. Sci. 35:177-184.

Beck, P. A., M. S. Gadberry, C. B. Stewart, H. C. Gray, T. J. Wistuba, M. D. Cravey, and S. A. Gunter. 2017. Effects of blended garlic and cinnamon essential oil extract with and without monensium sodium on the performance of grazing steers. Prof. Anim. Sci. 33:176-185.

Elcoso, G., B. Zweifel, and A. Bach. 2019. Effects of blend of essential oils on milk yield and feed efficiency of lactating dairy cows. App. Anim. Sci. 35:304-311.

Farney, J. K. 2020a. Spices fed to growing heifers on bromegrass result in increased gains with some effects on tick populations. Kansas Ag. Exp. Stat. Res. Report. Vol. 6: Issue 4. *https://doi.org/10.4148/2378-5977.7907*.

Farney, J. K. 2020b. Evaluating stocker steer gains on tallgrass native range with two burn dates and spices in mineral. Kansas Ag. Exp. Stat. Res. Report. Vol 6: Iss. 2. *https://doi.org/10.4148/2378-5977.7885*.

Massariol, P.B., C. J. Olivo, N. Richards, C. A. Agnolin, G. R. Meinerz, J. F. Both, L. Faccio, F. Hohenreuther, and S. Martinelli. 2009. Ectoparasite load alteration in Holstein cows fed with different garlic (*Allium sativum* L.) levels. Revista Brasileira de Plantas Medicinais. 11:37-42.

Ownesby, C. 2010. Managing Kansas Flint Hills grasslands. Symphony in the Flint Hills Field Journal. *https://newprairiepress.org/sfh/2010/nature/4*. Accessed 9/13/19.

Showler, A. T. 2017. Botanically based repellent and insecticidal effects against horn flies and stable flies (Diptera: Muscidae). J. Int. Pest Manage. 8:11.

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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	619	623	600	606	7.8	0.06	0.53	0.88
Out wt., lb	824[a]	815[ab]	802[b]	829[a]	6.7	0.58	0.10	< 0.01
Gain, lb	209[ab]	200[b]	193[b]	218[a]	5.8	0.88	0.22	< 0.01
ADG, lb/d	2.46[ab]	2.34[b]	2.27[b]	2.56[a]	0.07	0.88	0.22	< 0.01
Fly counts, n	141	133	127	172	19	0.80	< 0.01	0.97
Score coat score	2.25[b]	2.19[b]	2.53[a]	1.98[c]	0.07	0.67	< 0.0001	< 0.001

SEM = standard error of the mean. ADG = average daily gain.

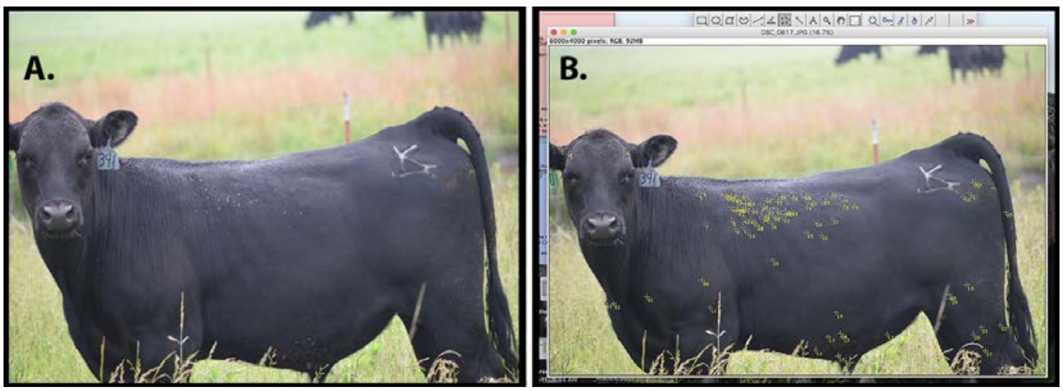

Figure 1. Illustration of the photos taken and fly count method.
A. Original photo taken with Nikon camera with 300 mm zoom lens.
B. Same image in ImageJ with flies highlighted in yellow.

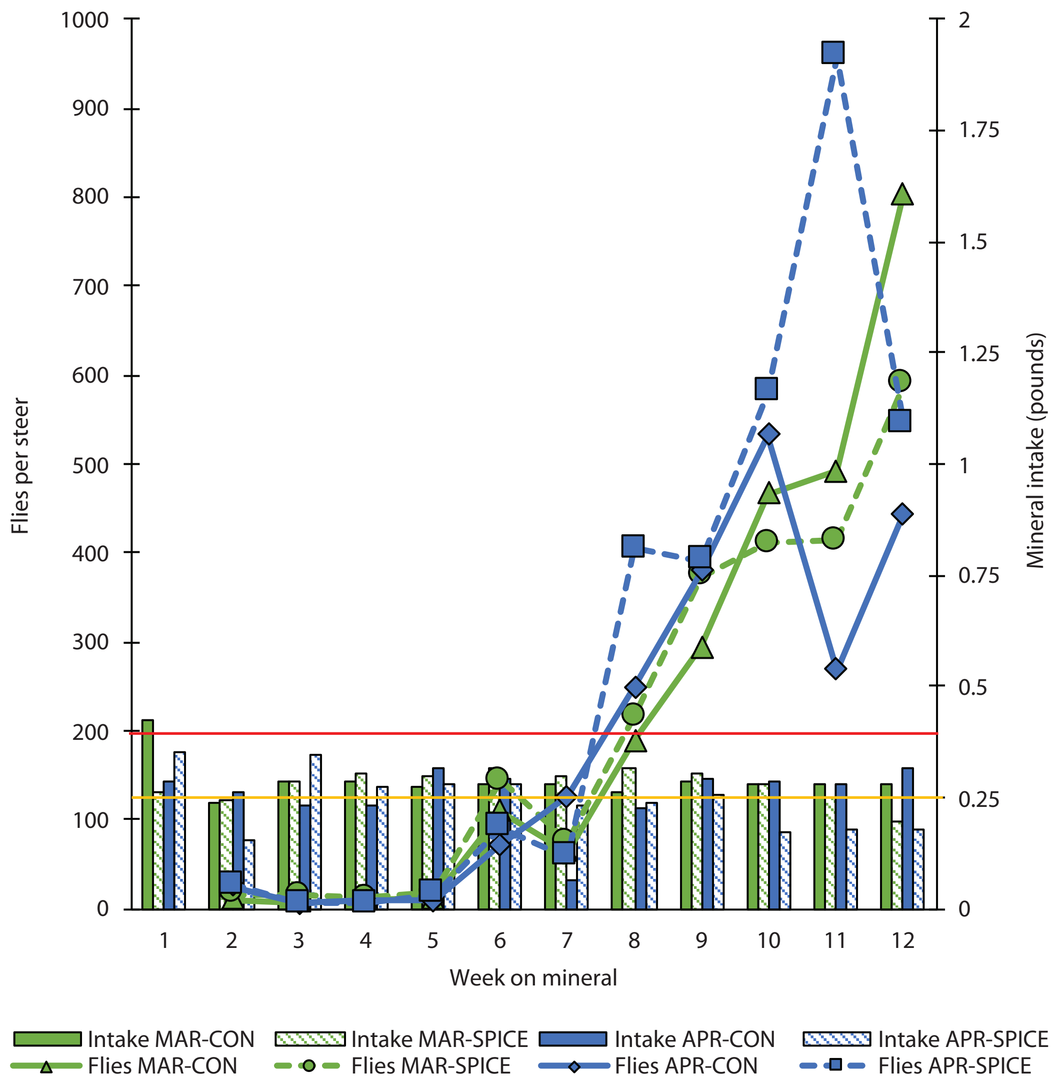

Figure 2. Average number of flies per steer per week and average weekly intake of mineral by treatments.

Average number of flies per steer per week ($P < 0.001$) are represented in the line chart while weekly average mineral intake is the bar charts. Red line at 200 indicates economic threshold for horn flies. Yellow line at 0.25 indicates the formulated mineral intake of 4 oz/head/day.

MAR-CON: Fly numbers are represented in green solid line with triangle markers. Mineral intake is represented by solid green bars.

MAR-SPICE: Fly numbers are in dashed green line with circle markers. Mineral intake is represented by green striped bars.

APR-CON: Fly numbers are in solid blue line with diamond markers. Mineral intake is represented by solid blue bars.

APR-SPICE: Fly numbers are in dashed blue line with square marker. Mineral intake is represented by blue striped bars.

Evaluation of Warm Season Annual Forages for Livestock: Biomass and Cost of Production

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Summary

Seventeen warm season annual forage options were evaluated as livestock feed to be grazed, hayed, ensiled, or left as a cover crop. Treatments were planted in mid-May and terminated in late September with one harvest for silage, two hay cuttings, and three grazing rotations. One additional treatment was unharvested to serve as a cover crop. Biomass production and cost to produce final outputs were determined. Even with restricted rainfall during the summer months in 2020, the growth for the chosen forage options was at least 1,500 lb of dry matter (DM) per acre, with the exception of sunflowers that had the lowest biomass production. Biomass production was the greatest for the forages that were left in the field as cover crop, followed by hay, then grazed, with the lowest biomass measured for the silage harvest. Monocultures of grass and sunn hemp produced as much biomass as multi-species blends that included grass or sunn hemp. Adding a high-producing grass species to sunflower and cowpeas increased biomass production compared to the respective monoculture. Regardless of harvest method, monocultures of cowpea and the blend of pearl millet + cowpea cost the most per unit of production. The lowest costs per unit of production for all harvest methods were found in three treatments: a monoculture of sorghum-sudan, the low seeding rate of pearl millet, and the blend of sorghum-sudan + sunn hemp.

Introduction

Forage systems are important components of livestock production. When pasture is not available, harvested forage serves as a timely and important animal nutrient supplement. Adequate production of forages requires careful attention to detail to provide an optimal feedstock for cattle.

There are two broad categories of alternative forage systems: monocultures and multi-species forages. Monocultures are a single species of plant that is planted for a specific purpose. Multi-species forage systems include a diverse population of plants that have been selected to match producer objectives. The thought is that multi-species blends offer benefits to the production system and more accurately mimic native pasture ranges. However, from the perspective of biomass production and forage quality, there have been varying responses to whether one plant species or multiple species result in a more desirable forage harvest.

Therefore, the purpose of this study was to evaluate the biomass production of single and multi-species summer forages as harvested in multiple methods for cattle producers and determine the cost of production for outputs.

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Experimental Procedures

The study was conducted at the Southeast Research and Extension Center in Parsons, KS. Seventeen treatments were planted in 10- × 95-ft strips in a split-plot design where the whole plot was the seventeen forage treatment options and the split-plot was four harvesting methods of grazed (GRAZE), hay (HAY), silage (SILAGE), or traditional cover crop with no harvest or grazing (COVER). The seventeen forage options are described in Table 1. Treatments were planted May 18, 2020, with a 5-ft drill and fertilized with 50 lb N as 46-0-0. The first grazing event occurred when the grass species were at least 2-ft tall and were "grazed" to 8-inch stubble every time the grass species reached that height, in a simulated grazing system. Grazing harvest dates occurred on July 7, 2020; August 5, 2020; and September 24, 2020. Hay was harvested on July 22, 2020, and September 24, 2020. Silage harvest occurred on August 5, 2020. The unharvested treatment was sampled for biomass on September 24, 2020. Samples were harvested using a Carter flail forage harvester which harvested an area of 3 ft × 20 ft and harvested area was weighed for a wet biomass yield. Grab samples from the harvested samples were collected and dried in forced-air oven to determine DM and then total yield on DM basis was determined by taking the total wet collection amount and multiplying by DM.

Cost per unit of production was determined using actual seed costs from 2020 (Table 1), estimated harvesting costs as reported in Kansas Custom Rates 2020 report, silage bagging costs from the 2020 Nebraska Farm Custom Rate report (McClure and Jansen, 2020), and cattle care estimates from 2019 Bluestem Report. All other costs associated with the analysis are described in Table 2.

Data were analyzed for treatment and harvest effects. Pre-planned contrasts comparing single species versus multiple species; low seeding rate and high seeding rate of pearl millet; grass and legume specie differences; and categorization of forage (i.e. grass only, grass+broadleaf, grass+legume, etc.) were completed.

Results and Discussion

Annual Forage Production Based on Forage Treatment Options

The forages evaluated offered impressive amounts of biomass production, with the exception of sunflower, even in a low moisture late summer such as 2020. On average, all treatments other than sunflowers, had a minimum of 1,500 lb DM per acre of production (Table 2). The greatest biomass yield was for the COVER harvest (5,936 lb DM/acre), followed by HAY (3,826 lb DM/acre), then GRAZE (3,097 lb DM/acre), and finally SILAGE (2,603 lb DM/acre) with the lowest biomass yield.

Sorghum-sudan yielded on average 1,337 lb DM/acre more than pearl millet ($P < 0.001$) and for all harvest methods sorghum-sudan out-yielded pearl millet ($P < 0.001$). Both of the legumes evaluated had similar biomass production whether alone or in mixtures ($P = 0.18$); with the exception of the COVER harvest when sunn hemp had a greater biomass than forages with cowpeas ($P = 0.001$; Table 2).

The addition of a broadleaf or legume into a stand with either sorghum-sudan or pearl millet did not affect biomass production ($P > 0.50$). Adding a legume has been suggested to complement the grass and result in improvements in quantity and quality; however, this was not found in this study. The forage quality is still being analyzed. There is a wide range of seeding rates for pearl millet. No differences in biomass yield were observed between the highest versus lowest seeding rates ($P = 0.69$).

Similar to other research projects, the low biomass-producing plants of sunflower and cowpea, when mixed with a high biomass-producing grass such as sorghum-sudan or pearl millet, significantly increase yield above single species mixtures ($P < 0.02$).

Forage Production Based on Harvest Intervals

The second cutting for HAY resulted in more biomass produced than the first harvest ($P < 0.01$; 2,051 lb DM/acre vs. 1,759 lb DM/acre, respectively). Monoculture of sorghum-sudan had a greater biomass in the 1st cutting than 2nd cutting ($P < 0.01$; Figure 2A). This was probably driven by a severe lack of moisture between the two cutting events. In contrast, the monocultures of sunn hemp and cowpea, and the multi-species blend of sorghum-sudan + sunflower + sunn hemp had greater biomass in the second cutting than in the first ($P < 0.05$; Figure 2A).

For GRAZE, the greatest tonnage occurred with the first grazing event, followed by the second, with the lowest re-growth/biomass in the third grazing event ($P < 0.001$). For many of the warm-season annual forages, the best management practice is to allow the plant to reach at least 2 feet tall before grazing to minimize the chance of prussic acid poisoning in cattle. Generally, if weather is favorable, it takes about 28 days to allow a warm-season annual to reach that 2 feet height. In the summer of 2020, there were three grazing events. Several of the sorghum-sudan treatments showed a decrease in biomass production with a greater number of "grazing" events ($P < 0.001$; Figure 2B). Conversely, sunn hemp biomass increased with more grazing events. Sunn hemp increases branching with more frequent harvests, as has been shown elsewhere, potentially accounting for the greater biomass with increased grazing events.

Annual Forage Production Based on Classification of Forage

An increase in biomass production was observed in two- or five-plant mixtures compared to monocultures; three-plant species mixtures produced intermediate biomass amounts ($P < 0.01$). However, the low-producing monocultures of sunflower and cowpea lowered the average biomass production of the monocultures evaluated. When differentiating biomass production based on single species of grass, legume, broadleaf, and the blends of these plant categories, the grass species in a monoculture produced the same biomass yield as multi-species, legumes were intermediate, and the broadleaf (sunflower) was the lowest (Figure 1).

Costs of Annual Forage Production Based on Potential Forage Usage

For producers interested in annual forage for grazing, there is a wide range of costs per grazing day (Table 2). Regardless of grazing with growing, stocker calves, or cow-calf pairs, the most expensive options are a monoculture of cowpeas or pearl millet + cowpea. The intermediate cost range, based on production values, includes monocultures of sunflower, sunn hemp, the high seeding rate of pearl millet, and the multi-species blend of sorghum-sudan + sunflower + cowpea. All other forage options evaluated result in similar costs per unit of production and are lower in cost. The cost per grazing day ranged from \$0.51 to \$1.81 for stocker calves and \$0.97 to \$3.49 for cow-calf pairs. The cost estimates determined in this study consider several averages for cattle intake, pasture utilization, and costs associated with fence, labor, and water to generate values. Specific operational costs may vary.

The monoculture of cowpea and the multi-species blend of pearl millet + cowpea was the most expensive to produce a ton of hay, but the monoculture of sunflowers also had the same expensive price tag on a per unit of production basis. The lowest cost per ton of hay produced was for the monocultures of sorghum-sudan and sunn hemp, sorghum-sudan + sunflower or sunn hemp, low seeding rate of pearl millet, sorghum-sudan + sunflower + sunn hemp, and the everything blend (Table 2). In general, the base grass that included sorghum-sudan resulted in a low cost of production. The cost per ton of hay produced ranged from $28.27 to $35.92.

The most expensive silage to produce was the monocultures of sunflower and cowpea; pearl millet + cowpea; and pearl millet + sunn hemp (Table 2). The lowest cost per ton of silage produced was sorghum-sudan; sorghum-sudan + sunn hemp; and low seeding rate of pearl millet. Costs per ton of silage produced ranged from $22.78 to $40.87.

References

Bluestem Pasture Report. 2019. *https://www.agmanager.info/sites/default/files/pdf/Bluestem_2019_Report_FINAL.pdf*. Accessed 2/9/2021.

Drewnoski, M. E., N. Muller, R. Saner, P. Jasa, G. Zoubek, J. Rees, K. Pekarek, R. Elmore, D. Redfern, and G. Lesoing (2015). "Cover crop survey of Nebraska farmers." UNL Crop Watch. Retrieved August 4, 2017, from *http://cropwatch.unl.edu/image/CW_News/2015/UNL-2015-Cover-Crop-Survey-Summary-2.pdf*.

Kansas Custom Rates. 2020. *https://www.agmanager.info/machinery/papers/2016-rates-paid-kansas-farmers-custom-work*. Accessed 2/9/2021.

Kaye., J. P. and M. Quemada. 2017. Using cover crops to mitigate and adapt to climate change. A review. Ag. Sust. Devel. 37:4. doi:10.1007/s13593-016-0410-x.

McClure, G. A. and J. A. Jansen. 2020. Nebraska Farm Custom Rates. *https://extension.unl.edu/statewide/kearney/2020-Nebraska-Farm-Custom-Rates.pdf*. Accessed 2/9/2021.

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Table 1. Annual forage treatments, seeding rates (lb/acre), and seed price/acre

Forage treatments	Abbreviation	SS	PM	SF	SH	CP	$/acre
Sorghum-sudan[1]	SS	20					$30.00
Pearl millet[2]	PM		20				$32.00
Pearl millet, low rate	PM low		6				$9.60
Sunflower[3]	SF			10			$7.00
Sunn hemp[4]	SH				20		$27.40
Cowpea[5]	CP					60	$58.20
Sorghum-sudan + sunflower	SS-SF	10		10			$22.00
Sorghum sudan + sunn hemp	SS-SH	10			10		$28.70
Sorghum-sudan + cowpea	SS-CP	10				40	$53.80
Pearl millet + sunflower	PM-SF		10	10			$23.00
Pearl millet+ sunn hemp	PM-SH		10		10		$29.70
Pearl millet + cowpea	PM-CP		10			40	$54.80
Sorghum-sudan + sunflower + sunn hemp	SS-SF-SH	8		7.5	8		$28.21
Sorghum-sudan + sunflower + cowpea	SS-SF-CP	8		7.5		20	$36.65
Pearl millet + sunflower + sunn hemp	PM-SF-SH		8	7.5	8		$29.01
Pearl millet + sunflower + cowpea	PM-SF-CP		8	7.5		20	$37.45
Everything[6]	SS-PM-SF-SH-CP	5	5	5	5	10	$34.20

[1] Multi Leaf BMR sorghum-sudan, $1.50/lb.
[2] Graze King BMR Pearl Millet, $1.60/lb.
[3] Peredovik oilseed sunflower, $0.70/lb.
[4] Sunn hemp, $1.37/lb.
[5] Red Ripper cowpea, $0.97/lb.
[6] Everything treatment: sorghum-sudan + pearl millet + sunflower + sunn hemp + cowpea.

Table 2. Yields in both dry matter and actual (as-is) of all forage treatments and harvest methods

	Dry matter, lb/acre				As is, ton/acre		Cost/unit production			
Forage	**Graze**	**Hay**	**Silage**	**Cover**	**Hay**	**Silage**	**Hay[1]**	**Silage[2]**	**Stocker[3]**	**Cow[4]**
Sorghum-sudan[3]	3,915	4,554	3,678	8,355	9.02	7.24	$29.36	$23.65	$0.61	$1.17
Pearl millet[4]	2,463	3,272	2,149	5,129	5.59	4.30	$33.72	$29.51	$0.97	$1.87
Pearl millet, low rate	2,927	3,190	2,320	3,349	5.88	4.56	$29.45	$23.87	$0.51	$0.97
Sunflower[5]	1,025	1,385	962	1,169	3.12	4.30	$34.71	$32.67	$1.21	$2.33
Sunn hemp[6]	2,079	4,170	1,765	7,514	8.25	2.31	$29.54	$29.61	$1.21	$2.34
Cowpea[7]	2,068	3,078	1,306	3,518	6.88	3.71	$35.92	$40.87	$1.81	$3.49
Sorghum-sudan + sunflower	3,369	4,832	3,085	8,140	9.69	3.60	$28.27	$26.86	$0.69	$1.32
Sorghum-sudan + sunn hemp	4,552	4,982	4,015	10,130	10.67	6.72	$28.29	$22.78	$0.53	$1.01
Sorghum-sudan + cowpea	4,415	5,112	3,671	7,594	10.13	8.16	$31.34	$26.29	$0.78	$1.50
Pearl millet + sunflower	3,190	3,188	2,812	4,462	6.04	7.94	$31.63	$25.22	$0.64	$1.23
Pearl millet+ sunn hemp	3,154	3,671	2,292	6,317	6.86	5.67	$31.40	$32.26	$0.74	$1.42
Pearl millet + cowpea	2,632	3,630	2,180	4,257	6.82	4.56	$35.92	$34.01	$1.42	$2.74
Sorghum-sudan + sunflower + sunn hemp	3,146	4,344	3,409	5,676	8.81	4.58	$29.14	$24.45	$0.74	$1.43
Sorghum-sudan + sunflower + cowpea	3,283	3,963	2,254	6,242	8.62	7.13	$30.89	$31.05	$0.85	$1.63
Pearl millet + sunflower + sunn hemp	3,435	3,674	2,922	6,482	7.09	4.95	$30.96	$25.04	$0.67	$1.29
Pearl millet + sunflower + cowpea	3,340	3,390	2,457	4,148	6.72	5.85	$32.10	$27.98	$0.81	$1.55
Everything[8]	3,661	4,618	2,984	8,436	9.41	5.15	$30.24	$26.68	$0.72	$1.39

[1] Hay unit of production is by the ton. Costs included seed cost (Table 1); fertilizer at $18.75/acre; custom rate to cut, condition, and rake hay at $12.00/acre; and large round baling (<1500-lb bale) with net wrap at $13.24/bale; and custom hauling at $4.54/bale (Kansas Custom Rates 2020).

[2] Silage unit of production is as-received tonnage. Costs include seed cost (Table 1); fertilizer at $18.75/acre; custom rate to chop and haul at $8.76/ton (Kansas Custom Rates 2020); and cost to bag at $8/ton (UNL 2020 Nebraska Farm Custom Rates).

[3] Stocker calf unit cost of production is the cost per grazing day on one acre for an average weight 700-lb stocker steer over a grazing period (estimated intake 2.5% of body weight on DM basis with 40% pasture utilization). Costs include seed (Table 1); fertilizer at $18.75/acre; fencing fee ($0.03/foot single wire electric for 80 acres amortized over 5 years); water ($1.50 per 1000 gallon with $25 per 1000 gallon hauling charge with average estimated intake of 10 gallon/day); care based on equivalent grazing days for class of livestock reported in 2019 Bluestem Pasture report ($6 per head per acre for full summer season).

[4] Cow unit cost of production is the cost per grazing day on one acre for a spring calving cow-calf pair with dam average weight 1,350 lb (estimated intake 2.2% of body weight on DM basis with 35% pasture utilization). Costs include seed (Table 1); fertilizer at $18.75/acre; fencing fee ($0.03/foot single wire electric for 80 acres amortized over 5 years); water ($1.50 per 1000 gallon with $25 per 1000 gallon hauling charge with average estimated intake of 25 gallon/day); care based on equivalent grazing days for class of livestock reported in 2019 Bluestem Pasture report ($6.38 per head per acre for full summer season).

[3] Multi Leaf BMR Sorghum-sudan.

[4] Graze King BMR Pearl Millet.

[5] Peredovik sunflower.

[6] Sunn hemp.

[7] Red Ripper cowpea.

[8] Everything treatment is sorghum-sudan + pearl millet + sunflower + sunn hemp + cowpea.

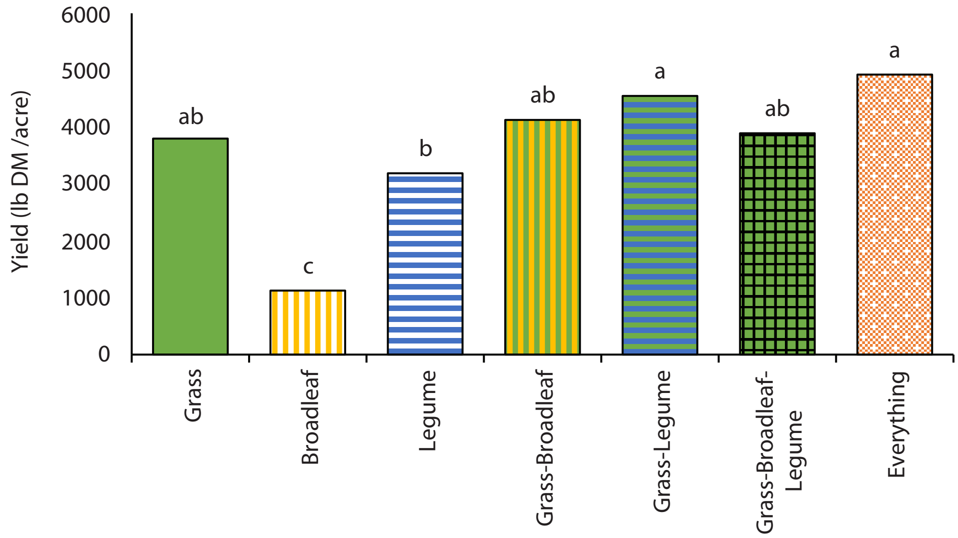

Figure 1. Biomass yield based on forage classification.
[ab] Different superscripts indicate biomass yield difference at $P < 0.05$. DM = dry matter.

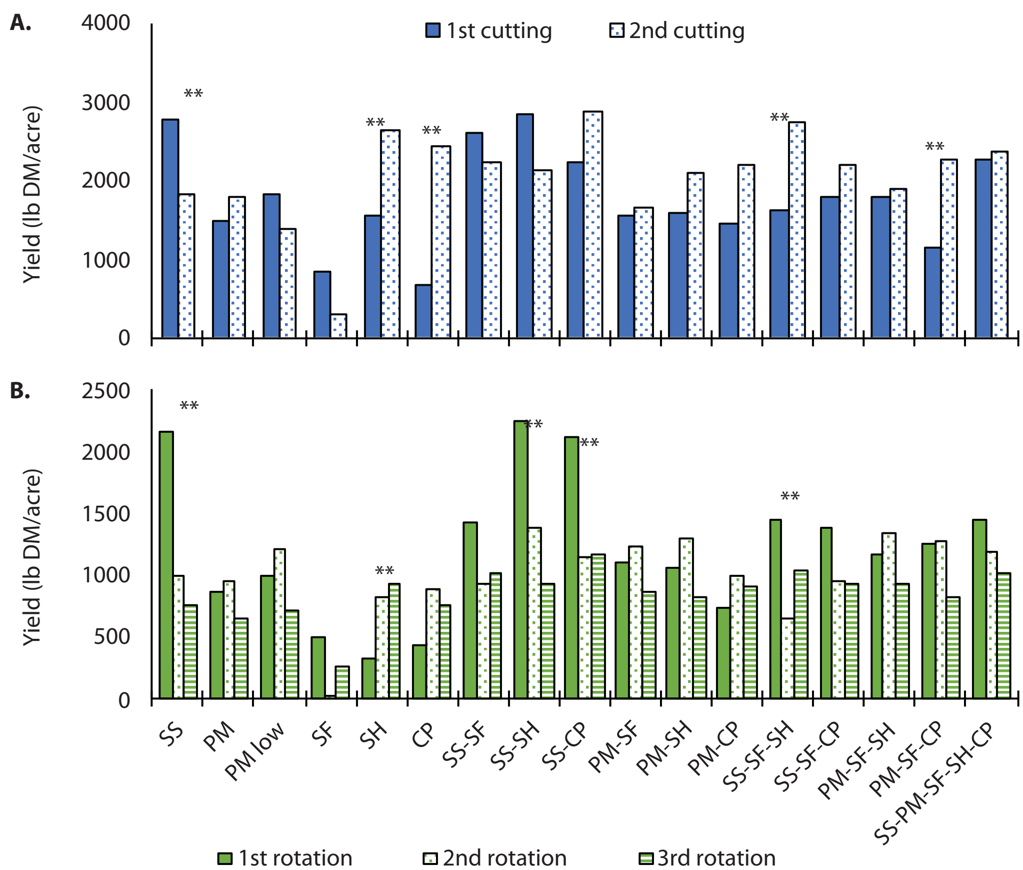

Figure 2. Biomass yields for the hay and grazing harvests based on the number of cuttings or grazing events. See Table 2 for the forage type per abbreviations in this figure.
DM = dry matter. ** Indicate that there is a difference in biomass yield for that forage treatment at $P < 0.05$.

Bermudagrass Fertility Trial in Southeast Kansas, 2020

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Summary
In 2020 a bermudagrass fertility study was conducted at the K-State Research and Extension experiment station outside of Columbus, KS. The purpose of the study was to simulate forage producer practices of managing bermudagrass and determine how each practice affects forage production and quality. Addition of fertilizer, and mowing were tested to determine the impact on forage biomass production and quality. Fertilizer increased both biomass production and forage quality. However, greater improvements in forage quality were observed by mowing the bermudagrass.

Introduction
Bermudagrass is a high yielding summer perennial and an efficient nitrogen (N) user. Under high fertility and ideal growing conditions, bermudagrass is capable of producing large amounts of high-quality forage that can be harvested multiple times a year. Producers take different approaches to forage production, ranging from no fertilizer, differing amounts of fertilizer, and frequency of fertilizer application. Another main difference in management is whether the producer allows the forage to grow during the season or if the producer harvests the forage, returning the grass to a vegetative state.

This study compared different fertilizer rates, timing, and harvesting scenarios corresponding with how producers manage their own fields to determine forage quality and production.

Experimental Procedures
The site selected for the trial was a bermudagrass stand at the Southeast Research and Extension Center field outside of Columbus, KS, that has been established for more than 15 years. Plots were 60 × 30 ft and replicated 3 times. The soil at the field is a Parsons silt loam soil. Lack of management had allowed other grasses to enter the stand. Before the bermudagrass broke dormancy in March, the stand was sprayed with glyphosate at the rate of 32 oz per acre to eliminate many of the cool season grasses that had encroached on the stand.

Treatments included addition of nitrogen fertilizer and mowing (Table 1). Control plots (treatments 1 and 2) received no fertilizer. Treatments 3 and 4 received 150 lb of N early in the spring (April 23, 2019). Treatment 5 received 150 units of N in the spring, and 100 lb N after each harvest (August 20 and October 9, 2020). Treatments 2, 4, and 5 were harvested by mowing on June 11, August 20, and October 9 after biomass sampling. This simulated harvesting of the forage for hay and encouraged regrowth. From April 23 to June 11, rainfall totaled 10.52 inches as recorded by the Mesonet station in Columbus, located 6 miles from the field (*https://mesonet.k-state.edu/weather/historical/*). However, from June 11 until August 20, rainfall only totaled

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3.2 inches with 2.03 inches from July 27 to August 16. June and most of July were extremely dry, stunting the growth of the grass.

All plots were sampled for biomass production and forage quality on June 11, August 20 and October 9, 2020, using a 3-ft Carter Harvester and samples were collected in bags. The entire sample was weighed for fresh weight determination on an area basis. Hand samples were taken from the plot sample to determine moisture, dry weight, and quality and converted to area basis based on total harvested weight. Biomass was determined after drying samples at 120°F for 3 days. Forage quality analysis was performed at SDK Labs, Hutchinson, KS. Total protein produced was calculated by multiplying crude protein (CP; %) by biomass (lb/acre).

Results and Discussion

Bermudagrass is a forage that responds well to nitrogen fertilization. By June 11, 2020, the control plot with no fertilizer only produced 1325 lb of dry matter (DM) per acre compared to the fertilized plots that each produced greater than 2330 lb of dry matter per acre (Table 2). Total DM production increased 1191 lb DM/acre for the unmowed plots with the addition of fertilizer (treatments 1 and 3) to 1628 DM/acre for the mowed treatments (2 and 4). Under adequate rainfall conditions, bermudagrass should have produced significantly more, but the dry weather stunted production. Under more favorable moisture conditions from August 20–October 9, treatment 5 produced an additional 2621 lb of dry matter per acre while treatment 4 only produced 1525 lb of DM by October 9. Dry matter production continued to increase in all plots but was much greater in the fertilized plots by the final harvest, with total DM of just over 3400 lb/acre for the unfertilized plots compared to more than 4600 lb/acre DM for the fertilized plots. The additional 100 units of N per acre in treatment 5 after mowing on June 11 and August 20 resulted in greater dry matter production at both subsequent harvests (August 20 and October 9; Table 2). Treatment 5, which received a total of 350 lb of N, produced a total of 6198 lb DM/acre.

Mowing reduced dry matter production of bermudagrass in the subsequent harvests. Moreover, total DM production was increased with mowing only for those plots that were fertilized (Table 2). The additional fertilizer applied to Treatment 5 further increased DM production.

Forage quality was also improved with increased fertility and mowing. Crude protein levels were greater in fertilized than in unfertilized plots in June, with CP at 8% in unfertilized plots, and from 9.7% CP to 10.1% CP in the fertilized plots (Table 3). This increase in CP% continued throughout the season, with much higher total %CP/acre in the fertilized plots. The additional fertilizer added to treatment 5 increased the crude protein level to 11% and 16.4% compared to only 8.7% and 9.9% CP in treatment 4 at the August 20 and October 9 harvest dates, respectively.

Nitrogen fertilizer increased total crude protein and %CP of the forage, from an average across all harvest dates of 7.5% CP to 8.6% CP for unmowed, and 8.3% CP to 9.6% CP for mowed, in unfertilized versus fertilized, respectively. Interestingly, treatment 2, which did not receive N but was mowed, had a higher crude protein content at the August 20 and October 9 sampling times than was observed in either treatment 1 or 3

(Table 3). This highlights the importance of the harvest management to enhance forage quality. In treatment 1, with no fertility or mowing, the crude protein level was only 6.9% on August 20 and 7.6% on October 9. Treatment 3 received 150 lb of N but was not mowed and had crude protein levels of 7.4% and 8.7% on August 20 and October 9, which were slightly higher than treatment 1 but less than treatment 2. Treatment 2 had no added fertilizer, but was mowed and had 7.9% and 9.1% CP (August 20 and October 9, respectively) demonstrating that mowing plays a role in forage quality. Interestingly, mowing also increased CP% (7.5% vs. 8.3%, unfertilized; 8.6% vs. 9.6% fertilized, across all harvest dates). The change in CP during the growing season was also influenced by mowing. Treatment 5 had a crude protein level of 16.4% at final harvest, while treatment 4 only had 9.9% CP. Observations of the forage indicated a darker green in treatment 5 than in all other treatments, showing the effects of the nitrogen. Treatment 5 did have a significant amount of cool season grass in the plots, which could have affected the crude protein levels.

Total protein produced in treatment 1 was 262.9 lb/acre compared to the mowed treatment 2 of 283 lb/acre, an increase of 7.6%. Treatment 3 produced 408 lb CP/acre compared to the mowed treatment 4 that produced 492 lb/acre, an increase of 20.5%. By increasing fertility and mowing, crude protein production increased to 799 pounds per acre (treatment 5), 62% more protein than treatment 4.

Mowing impacted total digestible nutrient levels (TDN) in the forage. The %TDN was higher in all fertilized treatments than in unfertilized treatments (Table 3). Mowing increased the %TDN, but only in the fertilized plots (compare Treatments 3 to 4 and Treatments 1 to 2). At the final harvest, the TDN level measured in treatment 4 was 56.8% while treatment 3, which received the same fertility, was 50.5%. Only a slight increase in %TDN was observed between the unfertilized treatments (compare 1 vs. 2). Treatment 5, with higher levels of N and mowing, had the highest reported %TDN (59.5%).

Recommendations

Though fertility is beneficial to pasture production and quality, mowing may play a larger role in forage quality than fertility. Mowing the grass after it reaches maturity resets the plant to a vegetative state and improves quality and the amount of protein produced per acre. After bermudagrass reaches maturity, it will continue to produce biomass, but nutrient values will decrease unless it is harvested and returned to a vegetative state. The continued increase in %CP with the addition of fertilizer in treatment 5 demonstrates the importance of continually fertilizing bermudagrass after every harvest to boost quality.

In bermudagrass pastures, harvest management along with fertility will provide the highest production and quality of bermudagrass forage. Mowing bermudagrass when it heads out or matures to reset it to a vegetative state will increase forage quality regardless of the addition of nitrogen. Adding nitrogen and mowing the grass throughout the year will give the best results for bermudagrass production and quality.

If bermudagrass is used for summer grazing, once it matures it needs to return to a vegetative state. If not, the forage will fail to meet the animal's nutritional requirements.

Nitrogen application will also enhance dry matter production and protein value of the forage to help meet the animal's nutritional needs.

Acknowledgments

We gratefully acknowledge the support from Farmers Coop of Columbus and Baxter Springs, KS, for providing the fertilizer for the experiment.

Table 1. Timeline of fertility and mowing treatments

	Fertilizer			Mowing		
Treatment	**April 23**	**June 11**	**August 21**	**April 23**	**June 19**	**August 21**
1	none	none	none	none	none	none
2	none	none	none	full	full	full
3	150 lb N	none	none	none	none	none
4	150 lb N	none	none	full	full	full
5	150 lb N	100 lb N	100 lb N	full	full	full

Table 2. Bermudagrass biomass production

	Dry matter, lb/acre			
Treatment	**June 11**	**August 20**	**October 9**	**Total**
1	1325	2010	3477	3477
2	1325	995	1088	3408
3	2408	2699	4668	4668
4	2663	847	1526	5036
5	2330	1247	2621	6198

Table 3. Bermudagrass forage quality

	Crude protein, %				Total digestible nutrients, %		
Treatment	**June 11**	**August 20**	**October 9**	**Total, lb CP/acre**	**June 11**	**August 20**	**October 9**
1	8	6.9	7.6	262.9	51.6	50.2	50
2	8	7.9	9.1	283.0	51.6	55.7	50.9
3	9.7	7.4	8.7	407.9	54.3	50.8	50.5
4	10.1	8.7	9.9	492.2	53.2	55.3	56.8
5	10	11	16.4	799.0	54.6	58.7	59.5

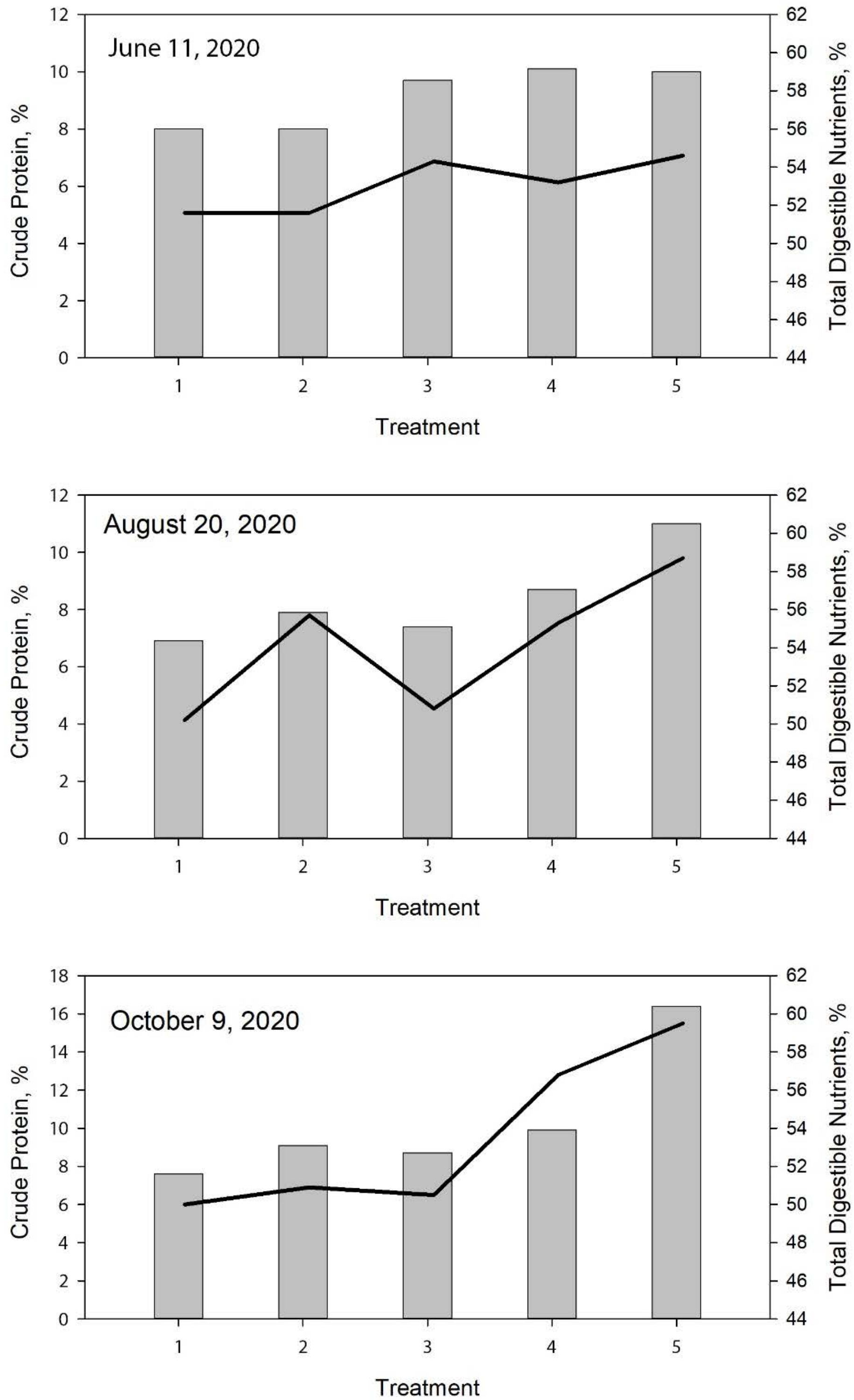

Figure 1. Crude protein (CP) percent (bars, left axis) and total digestible nutrients percent (line, right axis) for bermudagrass plots with different fertility and mowing treatments at three sampling times. Note change in scale for %CP on October 9.

Impact of Fertility and Mowing on Crabgrass Quantity and Quality for Hay Production in Southeast Kansas

D. Helwig,[1] M. Haywood,[1] J. Farney, B.C. Pedreira, and G.F. Sassenrath

Summary
A crabgrass variety trial comparing Quick-N-Big and MoJo crabgrasses was conducted during the summer of 2020 at the K-State Research and Extension experiment station near Columbus, Kansas. The trial evaluated quantity and quality of forage produced under different nitrogen fertility scenarios and mowing management techniques. MoJo produced more biomass than Quick-N-Big. Addition of nitrogen fertilizer increased biomass production and forage protein content. Mowing was also found to enhance forage quality.

Introduction
Forage is a major component of the agronomic production system in southeast Kansas. Forage can be grazed or harvested as hay to supplement cattle feed during the winter. Crabgrass is a high yielding summer annual that complements cool season forages or can be used as a cover crop for summer forage. Productivity and quality of two crabgrass varieties were compared: MoJo and Quick-N-Big. MoJo is a blended seed variety with a large portion of the blend derived from Impact Crabgrass from the Samuel Roberts Noble Foundation. Quick-N-Big is a commonly planted variety that has been shown to grow successfully in southeast Kansas and was chosen as a comparison.

The second research goal was to determine how management practices affected production and quality of forage. The experiment was designed to simulate how management practices, including fertility and mowing, would increase or decrease forage production and quality for the two varieties. Producers have many different management approaches to forage production, ranging from no fertilizer, to different amounts and frequency of fertilization. The main difference between these management methods is whether the producer allows the forage to grow during the season or if the producer harvests the forage during the summer, putting the forage back in a vegetative state due to mowing. The treatments in the research trial were fertilizer rates, timing, and harvesting scenarios corresponding with common production choices.

Experimental Procedures
Plots were established in a field at the Southeast Research and Extension Center near Columbus, KS. Plots were 60 × 10 ft and replicated 3 times in a Parsons silt loam soil. Prior to planting, the field was disked and field cultivated. A cultipacker was used to provide a firm seedbed. The seed was planted using a Brillion seeder that dropped the seed in front of packing wheels to a scant ¼ inch deep at a rate of 6 pounds per acre. Planting occurred on May 21, 2020, and plots were fertilized on June 19. Nitrogen (N)

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[1] Cherokee County K-State Research and Extension, Columbus, KS.

was broadcast by hand as urea at the rate of 100 lb N/acre as defined by the treatment. Treatments were the combination of mowing and fertilization (Table 1).

Treatments 2, 4, and 5 were completely mowed on August 20 after forage sampling. This simulated harvesting of the forage for hay and encouraged regrowth. The remaining treatments were allowed to grow without mowing until the final harvest in October.

Plots were sampled for biomass production and forage quality on August 20 and October 9, 2020, using a 3-ft Carter Harvester and samples were collected in bags. The entire sample was weighed for fresh weight determination on an area basis. Hand samples were taken from the plot sample to determine moisture, dry weight, and quality, and converted to an area basis based on total harvested weight. Forage mass was determined after drying samples at 120°F for 3 days. Samples were sent to SDK Labs, Hutchinson, KS, for quality analysis.

Weather during the growing season was recorded at the Mesonet station in Columbus, located 6 miles from the field (*https://mesonet.k-state.edu/weather/historical/*). Soil moisture was good at time of planting (5/21/2020). It rained shortly after planting and continued raining for several days. In total, 3.97 inches of rain were reported from 5/22/2020 to 5/30/2020, making soils very wet and muddy. However, after 5/31/2020, there were only 1.63 inches of rain for the next 61 days, causing soil moisture to be depleted and soils to dry out very quickly. Because of the lack of moisture, soil absorption of fertilizer and plant uptake may have been hampered. The original research plan was to harvest the plots every 30-45 days, but because of the dry weather, grass growth was slowed and harvest was delayed until August 20. Growing conditions were favorable after the first harvest, which allowed for a second harvest on October 9, 2020.

Results and Discussion

The MoJo seed was a coated seed and moved easily through the drill. It was heavier and flowed well. The Quick-N-Big seed was uncoated and required planting the field twice to obtain the desired planting population. With the drastic change in moisture conditions shortly after planting, weeds and other grasses became established in the grass plots. Barnyardgrass and pigweed were prominent in the MoJo stand. No herbicide or weed management program was implemented.

MoJo out-performed Quick-N-Big by 23% dry matter in the unfertilized plots and by 59% or greater in the other treatments (Figure 1) at the first sampling on August 20, 2020. The MoJo rebounded quickly from the initial harvest and weeds and other grasses did not return. In the treatments with no fertilizer (1 and 2), the MoJo produced an additional 1500 pounds of forage dry matter per acre while the Quick-N-Big only produced an additional 466 pounds of forage at the second sampling on October 9. In treatments 4 and 5, MoJo produced twice as much forage as the Quick-N-Big.

A key component of this trial was to show how management affects the quality of the grasses. Ideally, crude protein (CP) levels in hay should fall between 9% for dry cows and 12% for lactating cows. Crude protein values across all treatments and varieties varied from 6.9% to 10.0% at the August 20 sampling date, as the grass was well past maturity at the time of harvest (Figure 2). Fertilized plots did have slightly higher

CP% than the control plots except for treatment 4 of the MoJo. That may be due to other weeds and grasses in the MoJo plot. Crude protein values fell from 7% and 8% in August to 4% CP in October in the unfertilized, unmowed plots (Treatment 1; Figure 2). Conversely, the unfertilized, mowed plots (Treatment 2) had crude protein values that remained around 7% at the October sampling date. Similarly, the fertilized plots that were mowed (Treatments 4 and 5) had higher crude protein values in October than the fertilized plot that was not mowed (Treatment 3). Protein values for treatment 4 and 5 ranged from 10 to 12.9% in October, compared to approximately 7% crude protein in both varieties in treatment 3. This demonstrates that putting the plant back to a vegetative state, creating new tissue, by mowing enhances protein production in the forage.

Crude protein was greater in most of the fertilized plots at both sampling times than in the unfertilized treatments, confirming that adding nitrogen does affect protein value of the forage. There were two notable exceptions to this. The MoJo plots in August had low crude protein, potentially due to higher weeds contaminating the plots. The fertilized, unmowed treatment 3 also had crude protein percent much lower than the other two fertilized plots, and more similar to the unfertilized but mowed treatment 2. Treatment 5 that received additional N after the first harvest in August showed a protein value 2% higher than treatment 4.

Total digestible nutrients (TDN) is a measure of the energy content in the feed, and ranges from 40-50% for low quality hay to 50–60% for higher quality hay. Total digestible nutrients in the MoJo variety was higher than the Quick-N-Big variety for all treatments and all sampling times except the fertilized, mowed plots sampled on October 9 (Figure 3). The TDN values with the MoJo treatments ranged from 51% to 56%, while Quick-N-Big TDN values ranged from 47% to 49% at the August 20 sampling time. Mowed plots showed slightly greater TDN than in the unmowed plots. Fertility did not strongly influence TDN.

Recommendations

If crabgrass is used for summer grazing, once it matures it needs to return to a vegetative state to maintain the forage quality. If not, the forage will fail to meet the animal's nutritional requirements and the need for additional supplements will increase production costs. After crabgrass reaches maturity, it will continue to increase in forage accumulation, but protein values will decrease unless it is harvested and returned to a vegetative state. Though forage may be plentiful for an animal to eat, livestock fed on forage that is 6% CP or less will not gain even at a rate of 1 lb/day. Mowing encourages new growth and increases CP and TDN. Nitrogen application will also enhance dry matter production and protein value of the forage to help meet the animal's nutritional needs.

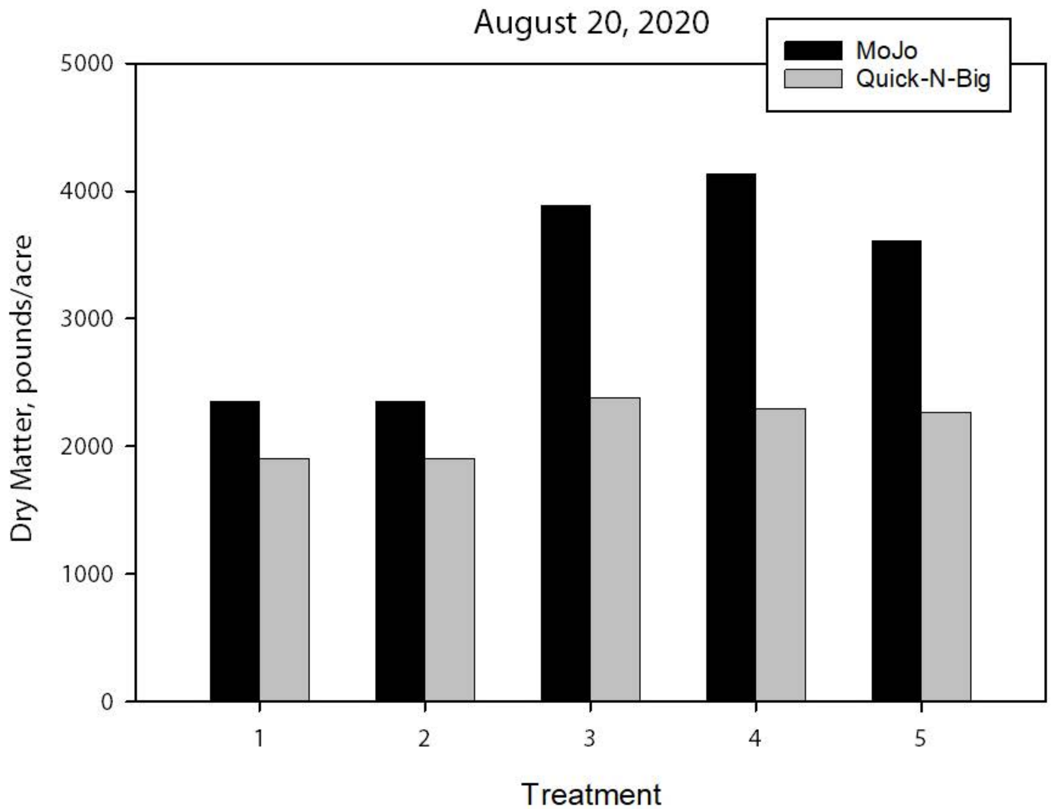
MoJo crabgrass out-performed Quick-N-Big in total dry matter production in both the August and October harvest. MoJo recovered faster after mowing than Quick-N-Big.

Acknowledgments

We gratefully acknowledge the assistance of Farmers Coop of Columbus and Baxter Springs, KS, for providing the fertilizer and MoJo seed for the experiment.

Table 1. Fertility and mowing treatments

Treatment	Mowing		Fertilizer (June 19)	Fertilizer (August 21)
1		October 21	None	None
2	August 21	October 21	None	None
3		October 21	100 lb N	None
4	August 21	October 21	100 lb N	None
5	August 21	October 21	100 lb N	100 lb N



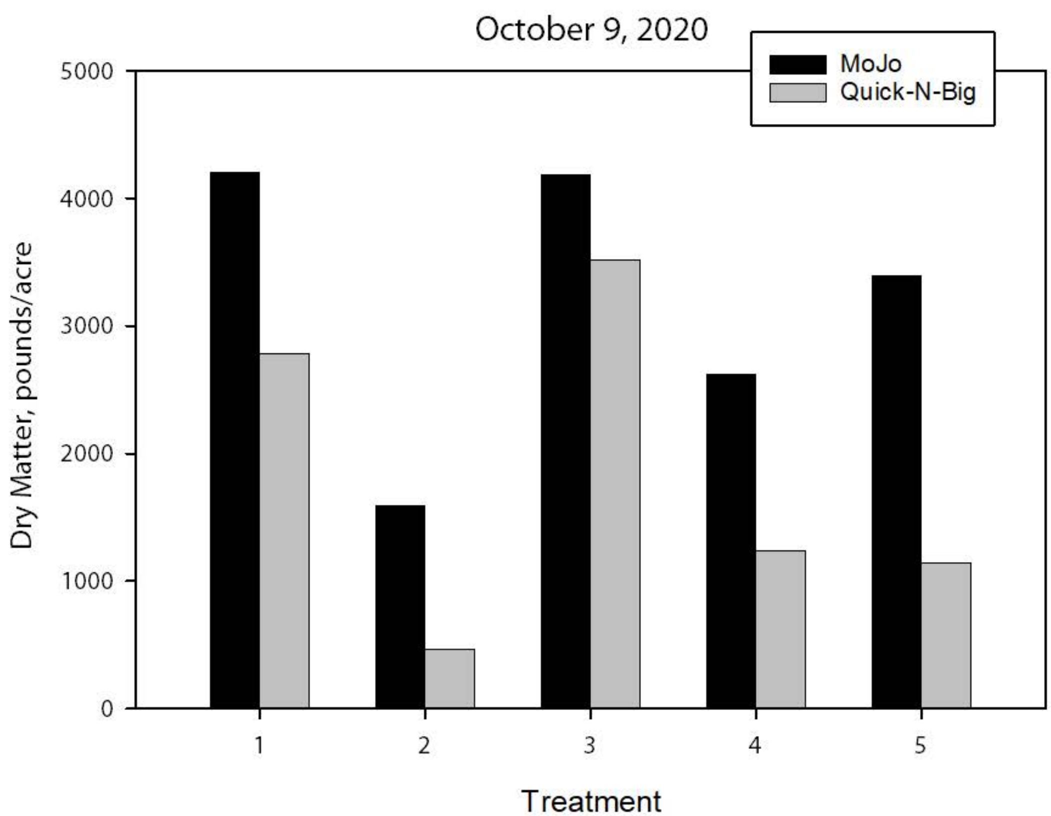


Figure 1. Dry matter production for MoJo (black bars) and Quick-N-Big (grey bars) crabgrass harvested August 21 (upper) and October 9 (lower). Averages are given for treatments as outlined in Table 1.

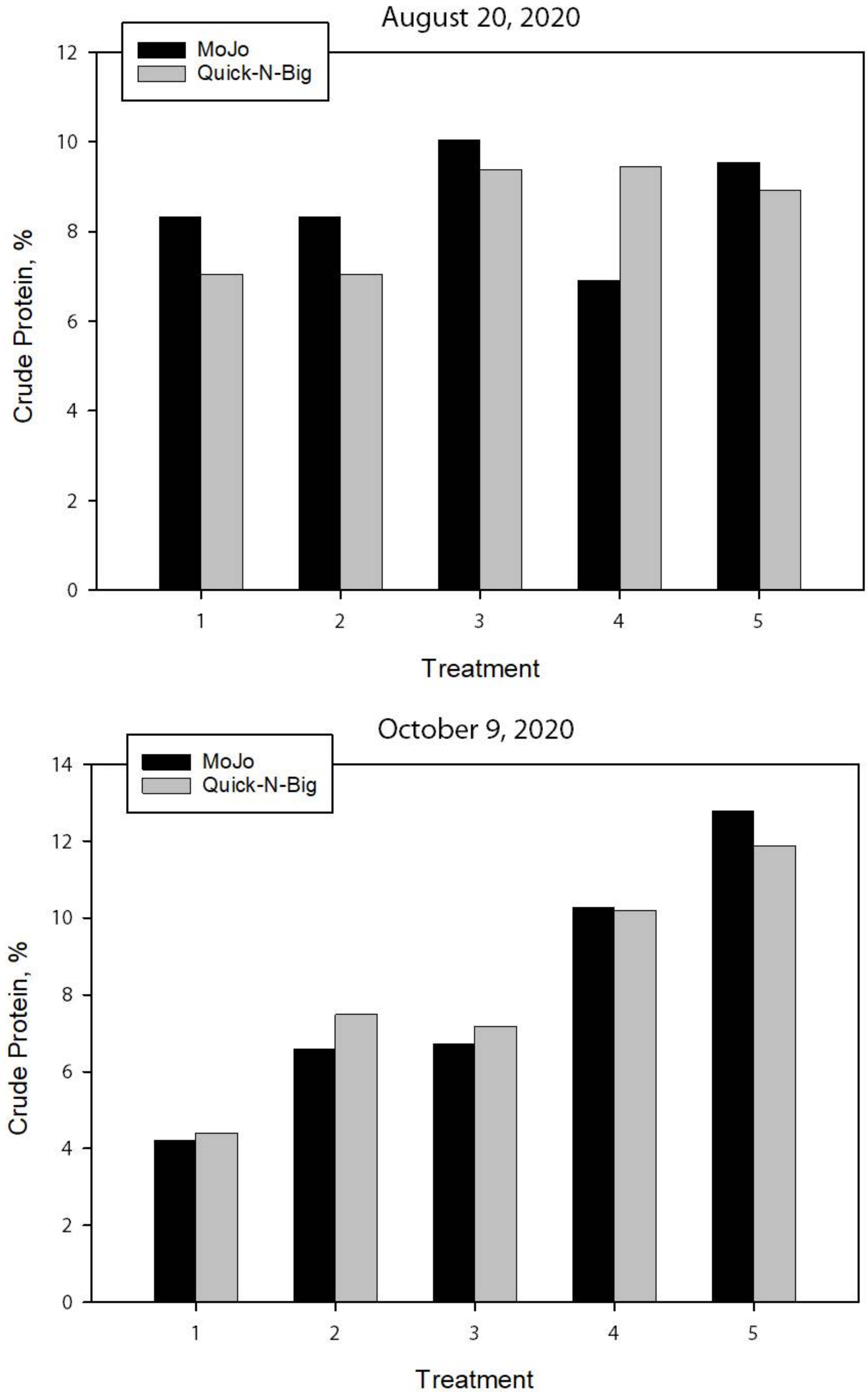
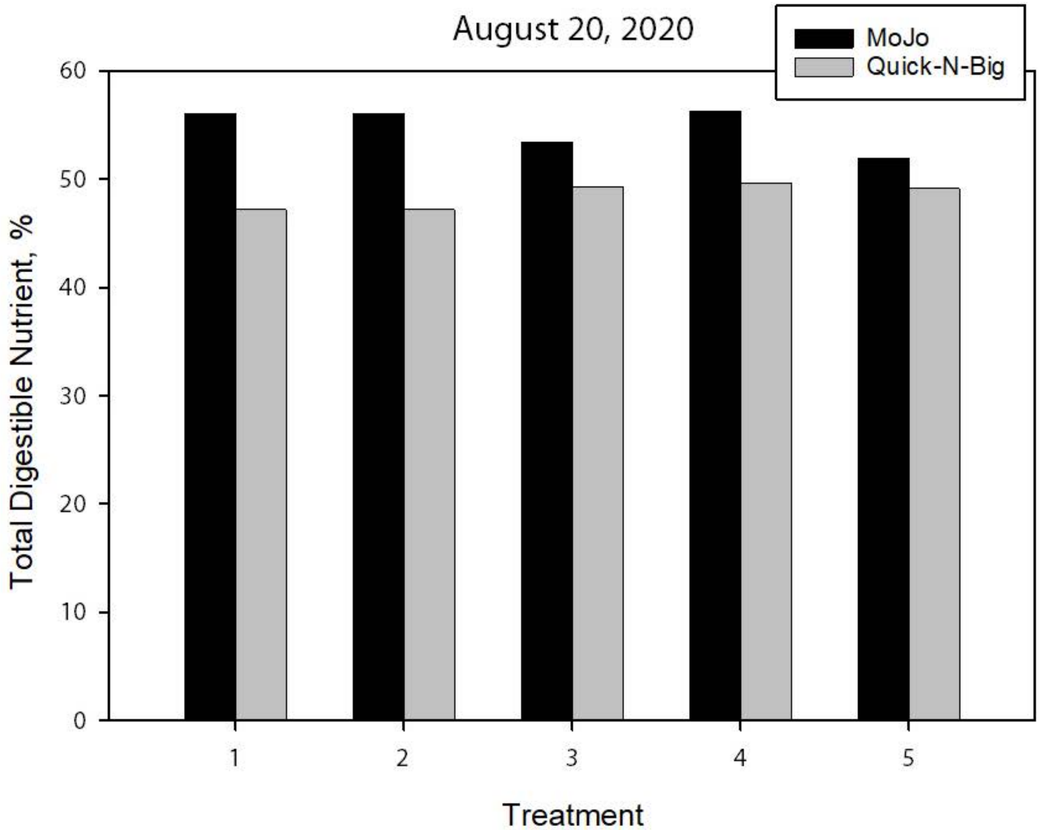


Figure 2. Crude protein percent for MoJo (black bars) and Quick-N-Big (grey bars) crabgrass harvested August 21 (upper) and October 9 (lower). Averages are given for treatments as outlined in Table 1.



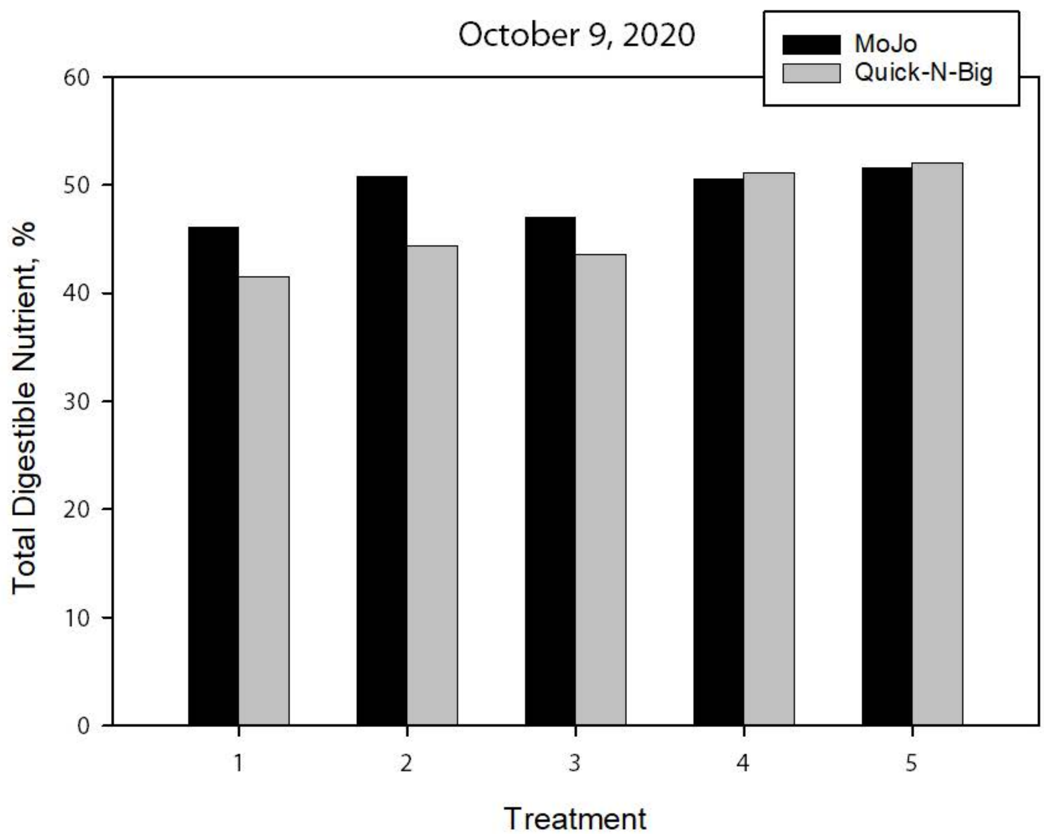


Figure 3. Total digestible nutrients percent for MoJo (black bars) and Quick-N-Big (grey bars) crabgrass harvested August 21 (upper) and October 9 (lower). Averages are given for treatments as outlined in Table 1.

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

D.W. Sweeney, J.K. Farney, J.L. Moyer, and D.A. Ruiz Diaz[1]

Summary
Tall fescue production was measured during the third production year of a study with locations started in fall of 2016 and fall of 2017. Phosphorus (P) fertilization rate affected spring harvest yield at Site 1, but not at Site 2. Applying nitrogen (N) in late fall or late winter resulted in greater spring yields than applying N in spring or not applying N. However, fall harvest yields at Site 1 were greater with spring N application, but not at Site 2. The third-year tall fescue total yield rank as affected by N fertilizer timing was late winter>late fall=spring>no N at Site 1 and late winter=late fall>spring>no N at Site 2.

Introduction
Tall fescue is the major cool-season grass in southeastern Kansas. Perennial grass crops, as with annual row crops, rely on proper fertilization for optimum production; however, meadows and pastures are often under-fertilized and produce low quantities of low-quality forage. The objective of this study was to determine the effect of N fertilizer timing and P and potassium (K) fertilization rates on tall fescue yields.

Experimental Procedures
The experiment was conducted on two adjacent sites of established endophyte-free tall fescue beginning in the fall of 2016 (Site 1) and 2017 (Site 2) at the Parsons Unit of the Kansas State University Southeast Research and Extension Center. The soil at both sites was a Parsons silt loam. The experimental design was a split-plot arrangement of a randomized complete block. The six whole plots received combinations of P_2O_5 and K_2O fertilizer rates allowing for two separate analyses: 1) four rates of P_2O_5 consisting of 0, 25, and 50 lb/a each year and a fourth treatment of 100 lb/a only applied at the beginning of the study; and 2) a 2 × 2 factorial combination of two rates of P_2O_5 (0 and 50 lb/a) and two levels of K_2O (0 and 40 lb/a). Subplots were four application timings of N fertilization consisting of none, late fall, late winter, and spring (E2 growth stage). Phosphorus and K fertilizers were broadcast applied in the fall as 0-46-0 (triple superphosphate) and 0-0-60 (potassium chloride). Nitrogen, as 46-0-0 (urea) solid at 120 lb N/a, was broadcast applied to appropriate plots on December 4, 2018, March 18, 2019, and April 25, 2019, at Site 1. Nitrogen was applied on December 5, 2019, March 3, 2020, and April 15, 2020, at Site 2. Third-year harvest dates from each site were as follows: (1) spring yield was measured at R4 (half bloom) on May 17, 2019, at Site 1 and at R5 (post anthesis) on May 17, 2020, at Site 2; (2) fall harvest was taken on September 10, 2019, at Site 1 and on October 22, 2020, at Site 2.

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Results and Discussion

In the third year of the study at Site 1 in 2019, spring harvest and total yield of tall fescue was increased by P fertilization, but was unaffected by rate (Table 1). Spring harvest yield was greatest when N was applied either in late fall or late winter. Even though applying N fertilizer at the E2 growth stage in spring resulted in greater yield compared with no N, delaying N application resulted in about a 35% reduction in spring yield compared with the more traditional timings of either late fall or late winter. However, fall harvest tall fescue yield increased with more recent N applications. Average annual total tall fescue yield was approximately doubled by applying N. Late winter application resulted in greatest total yield than with either fall or spring (E2) fertilization.

Third-year tall fescue spring harvest, fall harvest, or total yields in 2020 at Site 2 were unaffected by P fertilization (Table 2). As for the third year at Site 1 (Table 1), spring tall fescue yield was greatest with late fall or late winter N fertilization compared with N fertilizer applied at the E2 growth stage or with no N (Table 2). In contrast to results from Site 1 (Table 1), there were no differences in fall yield as affected by N fertilizer treatments (Table 2). Third-year tall fescue total yield mirrored spring yields.

Potassium fertilization resulted in inconsistent and small third-year yield responses in different harvests at the two sites (data not shown). Adding 40 lb K_2O/a resulted in less than 0.40 ton/a increase in yield in the fall harvest at Site 1 in 2019 and in the R4 harvest at Site 2 in 2020.

Acknowledgment

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

Table 1. Third-year yield of established tall fescue in the spring (R4-half bloom) and fall 2019 as affected by P_2O_5 fertilization rates and nitrogen (N) application timing at Site 1

Treatment	Spring harvest	Fall harvest	Total harvest (R4 + Fall)
P_2O_5 (lb/a)	---------------- ton/a, 12% moisture ----------------		
0	1.26	1.79	3.05
25	2.04	1.64	3.68
50	2.18	1.60	3.77
100[1]	1.92	1.46	3.38
LSD (0.05)	0.35	NS	0.40
N application timing			
None	0.77	1.28	2.05
Late fall	2.50	1.43	3.92
Late winter	2.53	1.73	4.25
Spring	1.61	2.05	3.66
LSD (0.05)	0.22	0.13	0.27

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

Table 2. Third-year yield of established tall fescue in the spring (R4-half bloom) and fall 2020 as affected by P_2O_5 fertilization rates and nitrogen (N) application timing at Site 2

Treatment	Spring harvest	Fall harvest	Total harvest (R4 + Fall)
P_2O_5 (lb/a)	---------------- ton/a, 12% moisture ----------------		
0	2.00	0.98	2.98
25	2.24	0.99	3.23
50	2.53	1.05	3.59
100[1]	2.34	1.07	3.41
LSD (0.05)	NS	NS	NS
N application timing			
None	1.04	1.06	2.09
Late fall	2.93	1.04	3.97
Late winter	3.01	1.01	4.00
Spring	2.13	0.99	3.14
LSD (0.05)	0.22	NS	0.31

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

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

D.W. Sweeney, D.R. Presley,[1] and D.A. Ruiz Diaz[1]

Summary
Double-cropping soybeans after wheat is common in southeastern Kansas and yields of double-crop soybean during the three years of this study were not affected by management of previous wheat straw practices such as burning or tillage done before planting. However, in the second and third year of the study, subsequent wheat yields were increased by 30% or more when the wheat residue had been burned the previous year.

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

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

Results and Discussion
In 2017, 2018, and 2019, burning versus not burning the wheat straw or tillage options prior to planting had no significant effect on double-crop soybean yields. In 2018, after one year of a continuous wheat-double-crop soybean rotation, subsequent wheat yields were unaffected by the residual of burn or tillage treatments. However, in both 2019 and 2020 wheat yields were increased by 30% or more where the wheat residue had been burned in the previous year, even though wheat yields were unaffected by using reduced-, strip-, or no-tillage to plant the previous double-crop soybeans.

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

[1] Department of Agronomy, College of Agriculture, Kansas State University, Manhattan, KS.

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

Residue management[1]	Double-crop soybean yields			Wheat yields		
	2017	2018	2019	2018	2019	2020
	---------- bu/a ----------					
Burn						
Yes	36.4	33.5	40.7	55.4	48.5	32.1
No	38.2	38.0	44.7	55.4	34.3	24.7
LSD (0.10)	NS	NS	NS	NS	6.9	7.4
Tillage						
Reduced-till	38.3	33.5	42.4	55.2	42.4	28.3
Strip-till	36.1	36.6	42.2	56.9	40.6	28.3
No-till	37.4	37.2	43.6	54.2	41.2	28.6
LSD (0.10)	NS	NS	NS	NS	NS	NS

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

Southeast Kansas Wheat Variety Test Results - 2020

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

Summary
This is a summary of the winter wheat production conditions in southeast Kansas in 2019-2020 and the results of the variety testing. Fifteen hard red and ten soft red winter wheat varieties were compared for yield and test weight. High spring rainfall increased disease pressure; cultivars were rated for Fusarium head blight and stripe rust. Average yield of hard red wheat varieties was above average at 81.1 bu/acre across all varieties. Soft red wheat yield was 102.4 bu/acre across all varieties. For comparison, previous variety yield results are reported from 2016, 2017, and 2018.

Introduction
Crop production is dependent on many factors including cultivar selection, environmental conditions, soil, and management practices. This report summarizes the environmental conditions during the 2019-2020 winter wheat growing season in comparison to previous years and the historical averages. Fifteen hard red and ten soft 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 a Parsons silt loam soil (fine, mixed, active, thermic Mollic Albaqualfs) at the Southeast Research and Extension Center in Parsons. All crop variety trials are managed with conventional tillage. Individual variety results are available at the K-State Crop Performance Test web page (*http://www.agronomy.k-state.edu/services/crop-performance-tests/*).

Wheat was drilled in 7-in. rows at 1.2 million seed/acre (approximately 90 lb/acre) in conventional tillage with an Almaco plot drill on October 23, 2019 in Parsons and harvested June 18, 2020. 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 on February 7, 2020, for both hard red and soft red cultivars. No fungicide or herbicides were applied. Historical weather data from the Parsons and Columbus mesonet stations were used (*http://mesonet.k-state.edu/weather/historical/*) and are reported separately (Sassenrath et al., 2021).

Results and Discussion
Rainfall during the 2019-2020 water year (WY) was near record highs (Sassenrath et al., 2021). Beginning in early January, regular high rainfall events increased the cumulative rainfall to well above average. During April, the cumulative rainfall exceeded that received during the previous WY19. On May 15, 2020, Parsons received 4.7 in. of rain in one 24-hr period. After a very wet spring, however, the rain stopped; Parsons received only 1.18 in. of rain in all of June. This dry weather coincided perfectly with wheat

harvest. Wet conditions during wheat flowering contribute to fungal disease, in particular Fusarium head blight or scab (De Wolf et al., 2003). There was heavy infestation of scab in some cultivars and wheat fields (Table 1 and 2). The dry conditions at wheat maturity allowed timely harvesting, resulting in little dockage due to scab in 2020.

Winter wheat was planted on 6.6 million acres in Kansas in 2020. In the variety trials, heading notes were taken on individual varieties. Heading is defined as the date when 50% of the plot had heads emerged. Heading in the hard red varieties began April 25, 2020, and was complete by April 30. Heading in the soft red varieties occurred between April 28 and May 1, 2020. Yields in all varieties were very good in 2020 (Figures 1A and 2, and Table 1). The highest yield in the hard red wheat varieties was measured in WB4401 at 108.8 bu/acre. This is well above the 12-year average yield of 53.1 bu/acre in the variety trials, and the 12-year average yield of 40.7 bu/acre across the state.

Cultivars varied in their susceptibility to disease. High rainfall around flowering and heading increases disease pressure (De Wolf et al., 2003). Fungal disease ratings were measured in all varieties as the percent infection and the extent of infection, with 0 being no damage and 10 being the highest infection rate. Fusarium head blight (FHB) and stripe rust were both present in the variety trials and showed differences across the varieties (Figure 4B and C). Stripe rust showed greater infection rates than FHB. Varieties with higher yields tended to have better resistance to the fungal diseases.

Yields in soft red varieties were higher than the hard red varieties, as has been observed previously (Figures 1). No information on state-wide yields for soft red wheat is available, as soft red wheat production occurs primarily in the southeast region of the state, so hard red wheat variety yields are given for the KS state average. Soft red yield of 102.4 bu/acre across all varieties in 2020 was much higher than the 11-year average of 64 bu/acre for soft red wheats in the variety trials. The yields were similar to those harvested in soft red wheat in 2012 in the variety trials. The highest yield of 113.9 bu/acre was measured in AgriMaxx 503, but several other varieties had yields greater than 100 bu/acre (Table 2). One advantage of soft red wheat is greater resistance to disease. This was observed in the FHB and stripe rust disease ratings (Figure 5B and C). As with the hard red varieties, those varieties that had greater resistance to diseases tended to have higher yields.

Conclusions

Wheat produced exceptionally well in 2020. The planting conditions in the fall and relatively mild winter led to good plant stands. Notably, many plots were thinner than expected. However, ideal dry conditions during harvest made optimal and timely harvest possible. The high probability of rainfall around May 31 in Parsons often confounds wheat harvest, making fields inaccessible and increasing disease damage.

Comparing variety performance across different growing seasons gives an understanding of how a variety responds under different growing conditions. For ease of comparison, variety testing results from the previous 5 years are provided for hard red (Table 1) and soft red (Table 2) varieties at Parsons. Note, no data were available from 2019 due to poor plant stand.

No herbicides or fungicides are normally used in the variety trials to provide an equal comparison based only on genetics. However, timely application of fungicide has been shown to be especially important in high rainfall areas such as southeast Kansas in order to control fungal diseases (De Wolf et al., 2003). Application of appropriate fungicides around flowering is especially important to control FHB (Onofre and De Wolf, 2020).

Acknowledgments

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1018005. These data are part of the 2020 Kansas Performance Tests with Winter Wheat Varieties, SRP1158 (https://bookstore.ksre.ksu.edu/pubs/SRP1158.pdf).

References

De Wolf, E. D., Madden, L. V., and Lipps, P. E. (2003). Risk assessment models for wheat Fusarium head blight epidemics based on within-season weather data. Phytopathology, 93(4), 428-435.

Onofre, K.A., De Wolf, E.D. 2020. Foliar fungicide efficacy ratings for wheat disease management 2020. KSU Ag Exp Station and Coop Ext Serv. EP130. *https://bookstore.ksre.ksu.edu/pubs/EP130.pdf*

Sassenrath G.F., M. Knapp, X. Lin. 2021. Southeast Kansas Weather Summary – 2020. *Kansas Agricultural Experiment Station Research Reports:* Vol. 7.

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

Hard red wheat varieties, Parsons, KS		Year								
		2016	2017		2018		2020			
Company	Variety	Yield, bu/a	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
AgriMAXX	AM Cartwright						**82.9**	60.8	1	1
AgriMAXX	AM Eastwood		47.2	55.5	**56.8**	58.5	67.2	57.9	3	8
AgriMAXX	EXP HRW				**57.9**	57.1				
Syngenta AgriPro	SY Benefit		56.9	57.7	45.2	57.4	77.5	59.5	1	7
Syngenta AgriPro	SY Grit	61.9			50.0	56.5	65.1	57.5	3	3
Syngenta AgriPro	SY Wolf				52.1	59.0				
Syngenta AgriPro	SY Llano	61.8	36.5	57.5						
Syngenta AgriPro	Bob Dole				49.0	57.4				
Syngenta AgriPro	Jackpot	66.2								
AGSECO	AG Gallant	57.0	**69.5**	57.7	45.1	58.9				
AGSECO	AG Icon				47.4	57.2	80.5	60.0	2	4
AGSECO	AG Robust	56.9	52.6	57.5	47.5	58.6				
AGSECO	EXP 52-5						76.1	56.6	0	3
AGSECO	Hot Rod	**76.8**	**69.6**	56.9	**58.1**	57.6				
AGSECO	TAM 205						**83.5**	60.2	5	1
Croplan	EXP 26-16				**60.6**	58.8				
Croplan	EXP 69-16				53.9	57.9				
Dyna-Gro	Long Branch	56.9	55.6	56.0	41.4	57.8				
KWA Wildcat Genetics	Everest	70.5	60.5	58.1	48.6	59.3	78.9	60.8	1	8
KWA Wildcat Genetics	Zenda	66.0	60.7	58.4	43.5	59.7	**86.1**	60.8	1	2
Wildcat Genetics	KanMark	66.1								
KWA Wildcat Genetics	KS061193K-2		**63.8**	57.5						
KWA Wildcat Genetics	KS080448C*102		52.4	58.4						
KWA Wildcat Genetics	KS060143K-2 "Larry"	65.4	53.7	56.8						
Limagrain	LCS Chrome	71.9	55.4	58.7	**62.9**	57.5				

continued

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

Hard red wheat varieties, Parsons, KS		Year								
		2016	2017		2018		2020			
Company	Variety	Yield, bu/a	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
OGI	Doublestop CL+	66.1								
OGI	Gallagher	**72.8**		49.6	55.3					
OGI	Iba	**74.8**								
OGI	OK09915C-1	57.1								
OGI	OK13209		54.3	56.7						
OGI	Ruby Lee	64.1	58.5	57.8	**56.9**	58.9				
OGI	Smith's Gold						**84.5**	60.1	2	1
Polansky	Rock Star						79.2	58.3	3	2
Scott Seed	TAM 304	70	58.5	57						
Scott Seed	TAM 305	**75.8**	**62.8**	57.1						
WestBred	WB4269		55	57	48.5	58.9	**86.8**	60.3	2	3
WestBred	WB4303						67.2	55.4	4	6
WestBred	WB4401						**108.8**	61.5	1	1
WestBred	WB4458	62.2								
WestBred	WB4515		60.5	58.4	**59.7**	58.4				
WestBred	WB4699						**94.5**	58.7	2	2
WestBred	WB-Cedar	66	57.6	58	42.9	59.1				
WestBred	WB-Grainfield	**73.8**								
Overall average		66	57.1	57.4	51.7	58.1	81.1	59.2		

Yields above average are highlighted in bold. Test weights were not available for hard red wheat in 2016.

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

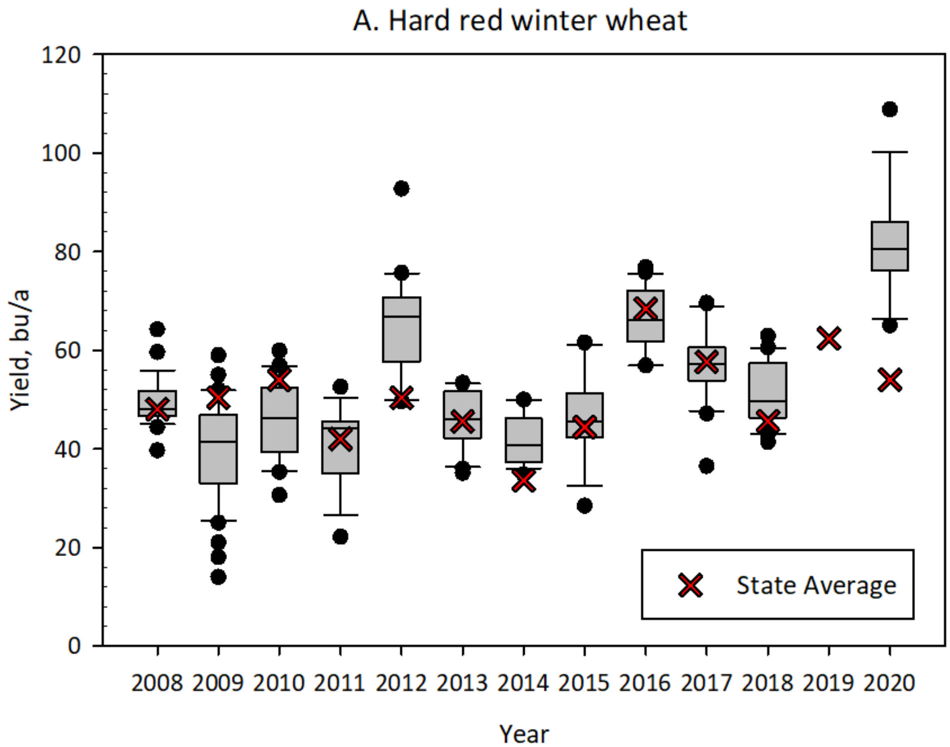
Soft red wheat varieties, Parsons, KS		Year									
		2016		2017		2018		2020			
Company	Variety	Yield, bu/a	Test weight, lb/bu	Yield, bu/a	Test weight lb/bu	Yield, bu/a	Test weight, lb/bu	Yield, bu/a	Test weight, lb/bu	Fusarium rating	Stripe rust rating
AgriMAXX	415	82.7	60.0	**91.9**	57.3	56.7	58.1	102.7	59.7	0	0
AgriMAXX	444	77.0	56.0	77.8	57.7	58.6	55.9				
AgriMAXX	454	56.6	54.0								
AgriMAXX	463			**81.6**	58.4	**62.5**	55.4				
AgriMAXX	473			**83.2**	57.9	**65.1**	57.5	**106.1**	59.0	0	1
AgriMAXX	475					56.4	57.3				
AgriMAXX	503							**113.9**	60.1	0	1
AgriMAXX	505							**112.2**	60.7	2	5
AgriMAXX	Exp 1663	**96.2**	57.0								
Croplan	9101	60.0	60.0								
Croplan	9201	52.8	63.0								
Croplan	9301	76.0	58.0								
Croplan	HRW 9415	72.9	65.0								
Croplan	HRW 9434	67.6	58.0								
Croplan	SRW 8550					**64.1**	56.9				
Croplan	SRW 9415					**64.7**	57.3				
Croplan	SRW 9606					55.9	55.7				
Pioneer	25R25	69.7	59.0								
DuPont Pioneer	25R40	82.5	59.0	79.5	56.8	**66.1**	56.7	**105.8**	58.1	3	1
DuPont Pioneer	25R46	56.3	54.0	70.4	57.1						
DuPont Pioneer	25R50					57.1	57.0	97.5	59.3	0	1
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
Dupont Pioneer	25R77	79.6	59.0	**84.4**	57.9	54.2	56.9	103.0	61.6	2	3

continued

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

Soft red wheat varieties, Parsons, KS		2016		2017		2018		2020			
Company	Variety	Yield, bu/a	Test weight, lb/bu	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
Frontier	Magnus 1069					**61.5**	55.8				
MFA	2166	63.3	57.0								
MFA	2250	80.9	60.0	60.9	56.5						
MFA	XP 2431	73.1	59.0								
MFA	2449	79.9	57.0	65.1	57.2	**63.8**	56.3				
MFA	XP 2474	83.2	61.0								
MFA	XP 2479	76.3	59.0								
MFA	XP 2538			75.8	57.6						
MFA	XP 2539			**84.6**	57.9						
MFA	XP 2542			**81.3**	57.6	**63.0**	58.6				
MFA	2622					58.3	57.8				
MFA	2633					59.7	56.7				
OGI	OCW03S580S-8WF							84.4	56.8	2	4.75
OGI	OK11311F	65.8	59.0								
OGI	OK11754WF	55.2	59.0								
Average		71.0	59.0	78.2	57.5	59.9	57.0	102.4	59.5		

Yields above average are highlighted in bold.



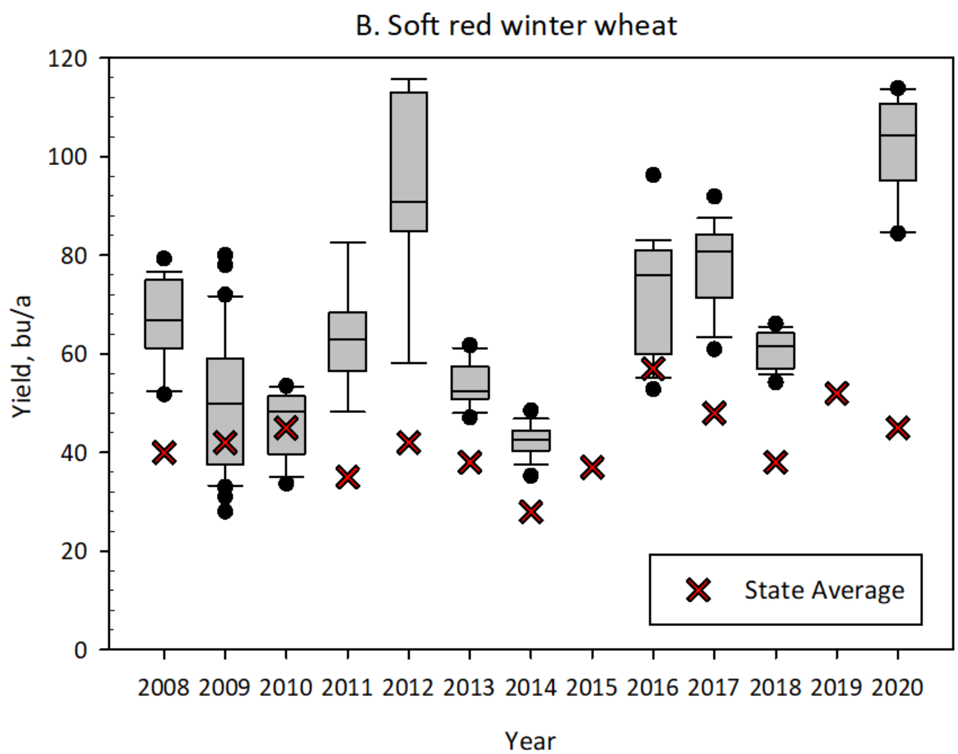


Figure 1. Winter wheat yield for (A) hard red wheat and (B) soft red wheat from variety trials in southeast and eastern Kansas from 2008 through 2020. In 2019, variety testing at both Ottawa and Parsons were abandoned due to flooding and poor stands. The line in the middle of the box plots is the median yield of all varieties. The upper and lower quartiles are given by the upper and lower edges of the boxes. The maximum and minimum values are given by the upper and lower "whiskers" extending from the box. Outliers are given as solid circles. For comparison, average reported state yields from Kansas are highlighted as a red X.

Impact of Fungicide on Wheat

G.F. Sassenrath, H. Zhao, and X. Lin

Summary
This is a report of research to test the impact of fungicide and management on wheat yield and quality. Fusarium head blight (FHB), or scab, is a persistent problem in wheat production, especially in high rainfall areas such as eastern Kansas. Two cultivars of winter wheat varying in FHB sensitivity (Everest, moderately resistant, and KanMark, susceptible) were tested for control of FHB using fungicide treatments made to the seed prior to planting or to the wheat plant at heading, in tilled or no-tilled management. The wet spring of 2020 resulted in high FHB pressure, but dry conditions at harvest reduced contamination. Tillage had a larger impact on yield improvement than fungicide applications in 2020. Tillage also impacted test weight and protein content.

Introduction
Fusarium head blight is particularly detrimental to wheat, resulting in significant reductions in yield. The most damaging aspect of FHB is the reduction in wheat quality caused by the mycotoxins (deoxynivalenol, DON) associated with the disease, rendering it unfit for human consumption in extreme cases. Wheat contaminated with FHB must be segregated from non-contaminated loads, and possibly is good enough to market as a feed grain.

Southeast Kansas has potentially challenging conditions for production of wheat. High humidity and rainfall during the spring can result in high fungal infection rate in wheat. Research has documented the potential to control FHB or scab through a management system that integrates cultivar selection, fungicide application, residue management, and crop rotations (Wegulo et al., 2011, 2013). This report summarizes the results of testing FHB control in two wheat cultivars varying in FHB disease susceptibility (Everest, moderately resistant, and KanMark, susceptible), four fungicide application treatments (no fungicide; seed treatment; in-season fungicide; and seed treatment + in-season fungicide), and residue management (tilled or no-till) after corn harvest.

Experimental Procedures
Two cultivars of hard red wheat varying in FHB sensitivity were planted in the fall in tilled or no-tilled replicated plots using a Great Plains grain drill at 7-in. row spacing. The cultivars included Everest (moderately resistant) and KanMark (susceptible). Fungicide treatments included: control (no fungicide); seed treatment; in-season (heading); and seed treatment + in-season. Treatments are listed in Table 1. Seed were treated with Apron XL (Syngenta, Inc.) at 0.5 oz/100 lb seed. The fungicide Prosaro (Bayer Crop Science, Inc.) was applied for the in-season treatment to the wheat near the time of heading (Feekes 10-10.1) at a rate of 6 oz/a. Plants were harvested at maturity on June 18, 2020. The harvested seed was tested at the Kansas Grain Inspection Service for test weight, protein content and DON contamination.

Results and Discussion

A very wet spring in 2020 (Sassenrath et al., 2021a) resulted in some FHB infection in the wheat. However, the dry conditions after May preserved the wheat quality and kept the scab damage to a minimum. Very low rates of DON were measured in the wheat samples, but results showed no consistent increase in DON with treatment.

Yields were higher in Everest than in KanMark across all treatments (Figure 1). Tillage was the factor that lead to the greatest improvement in yields for both cultivars and all treatments, potentially due to a decrease in soil moisture in tilled plots. Winter wheat tends to produce poorly in wet soil conditions. Tillage increased wheat yield in Everest by 11% and in KanMark by 21%, averaged across all treatments. Both seed and in-season fungicide treatments increased yields, but the effects were not additive. Seed fungicide treatment increased yield 2.6% in Everest and 4.9% in KanMark. In-season fungicide treatment alone or with seed treatment increased yields 4.3%. In-season fungicide treatment increased yields more in the treatments that did not receive seed treatment.

Seed quality was also affected by tillage. Test weight showed only a minor (1.2%) increase in KanMark with tillage, but did not change in Everest (Figure 2). However, protein was increased by 3% in Everest and 6.6% in KanMark with tillage across all fungicide treatments (Figure 3). Fungicide treatment did not consistently affect protein or test weight in any treatments or cultivars.

Conclusions

Selection of resistant cultivars is a key approach to improve wheat yields and reduce losses due to fungal infections, especially in high rainfall environments such as southeast Kansas. Implementing conservation tillage can improve overall productive capacity of fields by reducing soil and nutrient losses, but may result in lower wheat yield or protein. This subtle change in soil moisture with tillage may be especially important in high rainfall areas, where winter rains keep soil moisture high.

Acknowledgment

This work is supported by the U.S. Department of Agriculture National Institute of Food and Agriculture, Hatch project 1018005, with partial funding from the Kansas Crop Improvement Association.

References

Sassenrath, G.F., M. Knapp, X. Lin. 2021. Southeast Kansas Weather Summary – 2020. *Kansas Agricultural Experiment Station Research Reports*: Vol. 7.

Wegulo, S.N., Bockus, W.W., Hernandez Nopsa, J., De Wolf, E.D., Eskridge, K.M., Peiris, K.H. S., Dowell, F.E. 2011. Effects of integrating cultivar resistance and fungicide application on fusarium head blight and deoxynivalenol in winter wheat. 2011. Papers in Plant Pathology. Paper 345. *http://digitalcommons.unl.edu/plantpathpapers/345*.

Wegulo, S.N., Bockus, W.W., Nopsa, J.F.H., Peiris, K.H.S., Dowell, F.E. 2013 Integration of fungicide application and cultivar resistance to manage fusarium head blight in wheat. Fungicides - Showcases of Integrated Plant Disease Management from Around the World, Dr. Mizuho Nita (Ed.), InTech, DOI: 10.5772/53096.

Table 1. Summary of fungicide treatments for Everest and KanMark wheat varieties

		Fungicide	
Cultivar	**Treatment #**	**Seed**	**In-season**
Everest	1	no	no
	2	no	yes
	3	yes	no
	4	yes	yes
KanMark	1	no	no
	2	no	yes
	3	yes	no
	4	yes	yes

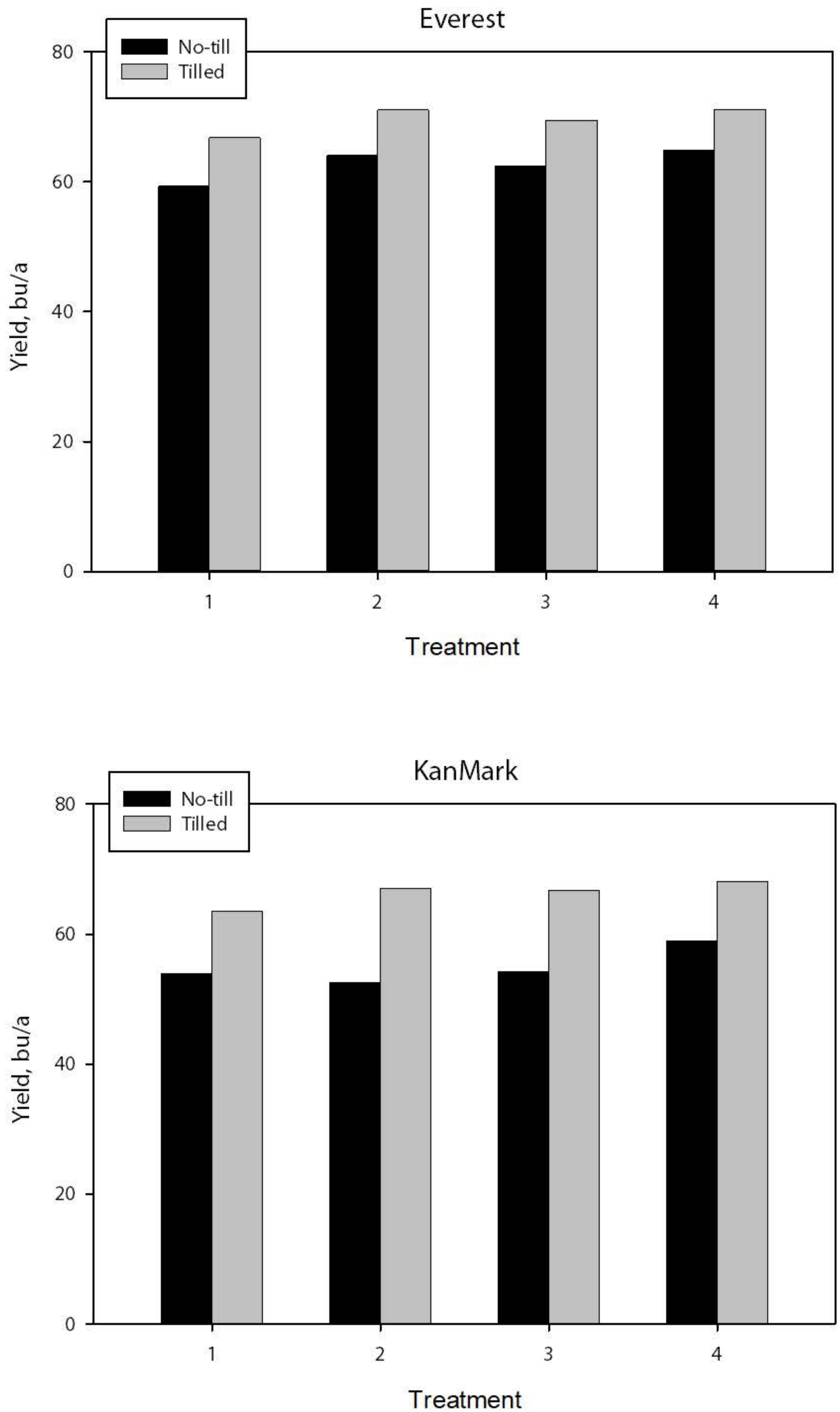


Figure 1. Wheat yield for Everest (top) and KanMark (bottom) under different management and fungicide treatments. Plots were no-till (black bar) or tilled (grey bar), and received no fungicide (1), seed treatment (2), in-season foliar fungicide (3), or both seed treatment and in-season fungicide (4).

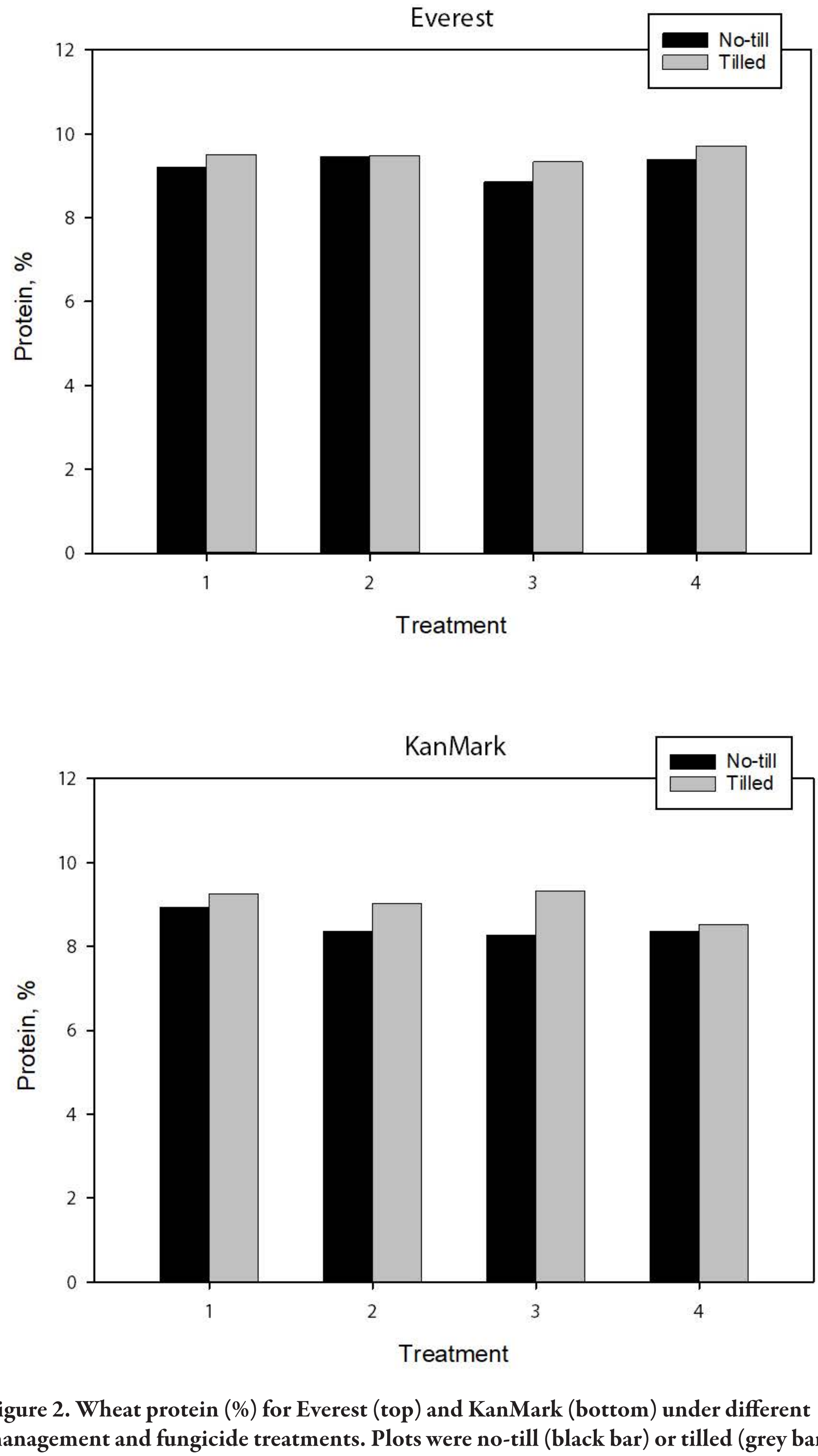


Figure 2. Wheat protein (%) for Everest (top) and KanMark (bottom) under different management and fungicide treatments. Plots were no-till (black bar) or tilled (grey bar), and received no fungicide (1), seed treatment (2), in-season foliar fungicide (3), or both seed treatment and in-season fungicide (4).

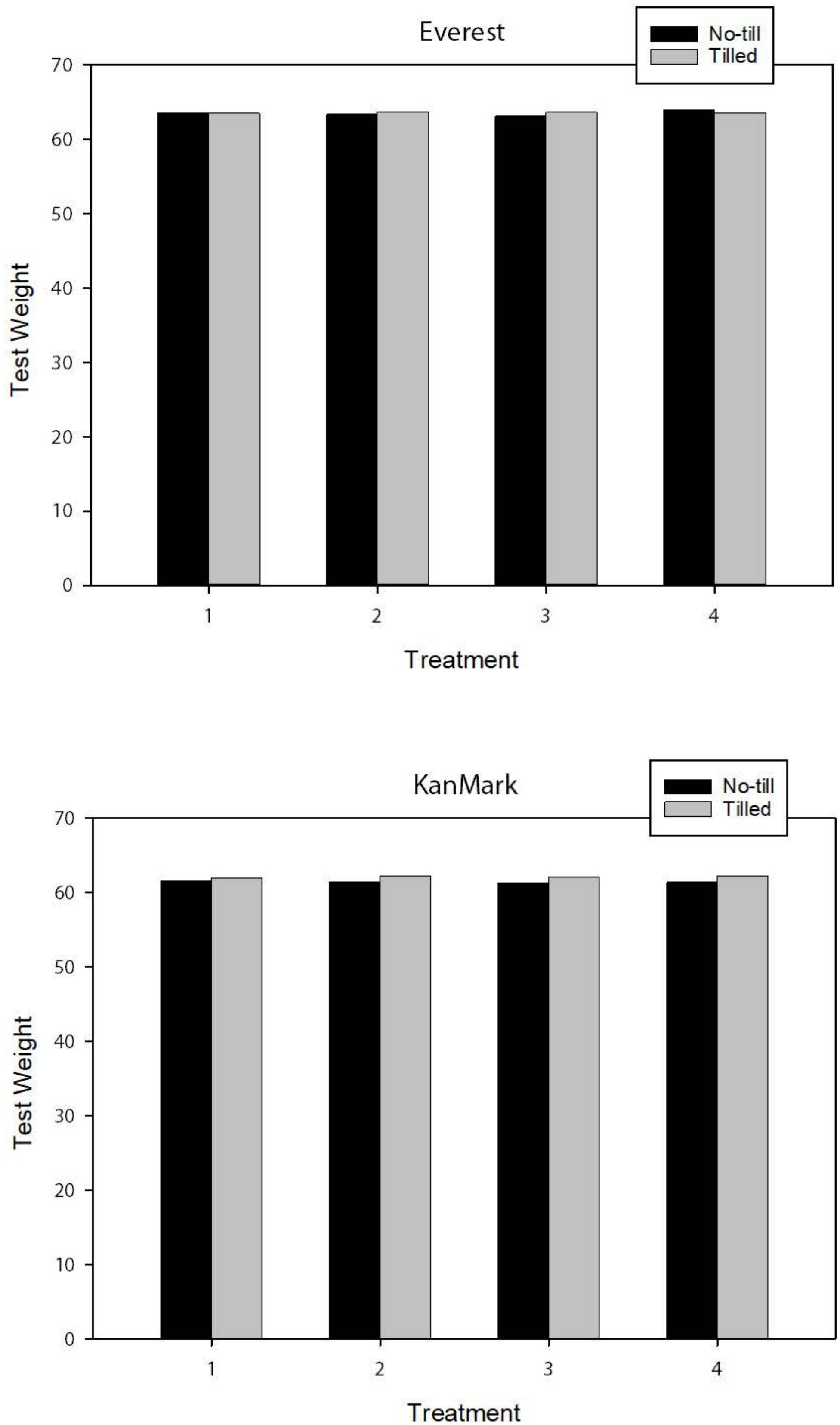


Figure 3. Wheat test weight (lb/bu) for Everest (top) and KanMark (bottom) under different management and fungicide treatments. Plots were no-till (black bar) or tilled (grey bar), and received no fungicide (1), seed treatment (2), in-season foliar fungicide (3), or both seed treatment and in-season fungicide (4).

Crop Production 2020 – Corn, Sorghum, Soybean, and Sunflower Variety Testing

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

Summary
This is a summary of the variety testing for corn, sorghum, soybean, and sunflower. Nine corn varieties were tested in 2020, with an average yield of 107.6 bu/a. Twenty-four cultivars of soybeans from maturity groups (MG) 3-4 and twenty-seven cultivars from MG4-5 were tested in both full-season and double-cropped management. Full-season beans yielded an average of 54.5 bu/a for MG3-4 and 58.8 bu/a for MG4-5, which was greater than the average yields in the double-cropped beans at 32 bu/a for MG3-4 and 40.5 bu/a for MG4-5. The state-wide average soybean yield in 2020 was higher than the 10-year average. Nine cultivars of oilseed sunflowers yielded 1307 lb/a across all cultivars, slightly below the 10-year state average yield.

Introduction
Crop production is dependent on many factors including cultivar selection, environmental conditions, soil, and management practices. This report summarizes results of the variety testing conducted at Parsons, KS. Soybeans tested included 24 varieties of maturity group (MG) 3-4 and 28 varieties of MG4-5. Soybean varieties were tested in both a full-season and a double-cropped soybean test. Nine corn varieties were tested at Parsons, and 9 sunflower varieties were tested. Individual variety results are available at the K-State Crop Performance Test web page (*http://www.agronomy.k-state.edu/services/crop-performance-tests/*).

Experimental Procedures
The Kansas State University Crop Performance Tests were conducted in replicated research fields throughout the state. This report summarizes crop production for southeast Kansas, focusing on crops grown at Parsons, KS. Crop varieties were tested in upland fields (Parsons silt loam soil) at the Southeast Research and Extension Center in Parsons. Poor stand establishment from excessive rain led to abandonment of sorghum plots at Parsons. For comparison, sorghum variety trial yields from Ottawa are used. All crop variety trials are managed with conventional tillage. Individual variety results are available at the K-State Crop Performance Test web page (*http://www.agronomy.k-state.edu/services/crop-performance-tests/*).

Full-season soybeans were planted in 30-in. rows on June 9, 2020, in Parsons, at 100,000 seed/a and harvested November 5, 2020. Double-cropped soybeans were planted June 23, 2020, at a rate of 100,000 seed/a, and harvested November 6, 2020. No fertilizer was applied. Weeds were controlled with glyphosate (1.5 qt/a), Dual II Magnum (2 pt/a), metribuzin (0.5 lb/a), and Authority XL (6 oz/a).

Sunflowers were planted June 9, 2020, at a rate of 23,800 seed/a in 30-in. rows at Parsons. Plots were fertilized at a rate of 80-46-30 lb/a N-P-K. Weed control was glyphosate (2 qt/a), Brawl II (2 pt/a), and Spartan (4 oz/a). Plots were harvested on November 5, 2020.

Corn varieties were planted on April 7, 2020, in 30-in. rows at a rate of 22,500 seed per acre. Plots were fertilized at a rate of 180-46-60 lb/a N-P-K. Weed control was glyphosate (2 qt/a), Dual II Magnum (1.5 pt/a), Atrazine 4L (2 qt/a), and 2,4-D (2 qt/a). Plots were harvested on October 9, 2020.

Sorghum varieties were planted at Parsons. Heavy spring rain reduced emergence and the variety tests were abandoned. Results from the variety trials at Ottawa are used for comparison to statewide yields. Eleven grain sorghum varieties were tested at Ottawa in a Woodson silt loam soil at a planting rate of 45,000 plants/a. Plots were fertilized at a rate of 140-48-31-10 lb/a N-P-K-S in still-tilled management. Details of Ottawa grain sorghum production can be found in the 2020 Kansas Grain Sorghum Hybrids Performance Test (https://bookstore.ksre.ksu.edu/pubs/SRP1161.pdf).

Results and Discussion

There was adequate moisture at planting for the full-season soybean test. Germination and plant stand were very good. The plants had an established root system, and were able to come through the dry summer very well. In contrast, the decreased rainfall made planting and germination of the double-cropped beans challenging. Limited moisture during the first three months of the double-cropped test resulted in poor weed control due to low canopy coverage and inactivated herbicides. High humidity in the fall slowed the drying process after soybean maturity, but harvest went well.

Soybeans were planted on 4.75 million acres in Kansas in 2020, with 1.19 million acres in southeast Kansas. Twenty-four cultivars of soybeans from maturity groups (MG) 3-4 were tested. Average yield in the full-season test was 54.5 bu/a, with a range of 44.7 to 62.9 bu/a (Figure 1A). Yields were less in the double-cropped beans, with an average of MG3-4 of 32 bu/a, ranging from 25.3–41.1 bu/a. Group 4-5 beans performed slightly better, the 27 varieties tested had an average in the full-season test of 58.8 bu/a, with a range from 51.4–64.6 bu/a (Figure 1B). Double-cropped MG4-5 yields were also less than full-season, with an average of 40.5 bu/a and a range from 28.2 to 44.3 bu/a. The statewide average soybean yield was 40.5 bu/a, which was higher than the 10-year average of 37.2 bu/a statewide.

Sunflowers were planted on 73,000 acres in Kansas in 2020, and 96% of the acres were harvested for an average statewide yield of 1,470 lb/a. In the variety trials, sunflowers were planted in good soil moisture. Plants germinated quickly and had good stand establishment. There were no notable problems with insects or disease in 2020. Some problems with lodging were noted due to wet conditions at harvest. Nine cultivars of oilseed sunflowers were grown in 2020, with an average yield of 1307 lb/a and a range from 886 to 1865 lb/a (Figure 2). This was slightly less than the 10-year state average yield of 1342 lb/a and the state average yield.

Corn was planted on 6.1 million acres in Kansas in 2020, an increase from the 10-year average but a slight decrease from last year. Ninety-four percent of planted acres were harvested for grain at a statewide average yield of 134 bu/a, and 4% were harvested for silage at a statewide average yield of 19.5 ton/a. As in 2019, heavy spring rains in excess of record-setting levels the prior year (Sassenrath et al., 2021) created detrimental conditions for early spring corn crop establishment in southeast Kansas. Nine corn varieties and three checks were tested at Parsons, ranging from relative maturity of 100 to 115 days. Average yield was 119.9 bu/a, and ranged from a low of 90.3 bu/a to 148.5 bu/a (Figure 3).

Grain sorghum was planted on 3 million acres in Kansas in 2020, an increase from last year and above the 10-year planting average of 2.8 million acres. Ninety-three percent of planted acres were harvested for grain at a statewide average yield of 85 bu/a. Two percent of planted acres were harvested for silage, with an average statewide yield of 15 tons/a. Eleven varieties and six check cultivars of grain sorghum were grown at Ottawa, producing an average of 137.5 bu/a, with a range from 99.8–164.0 bu/a (Figure 4).

Conclusions

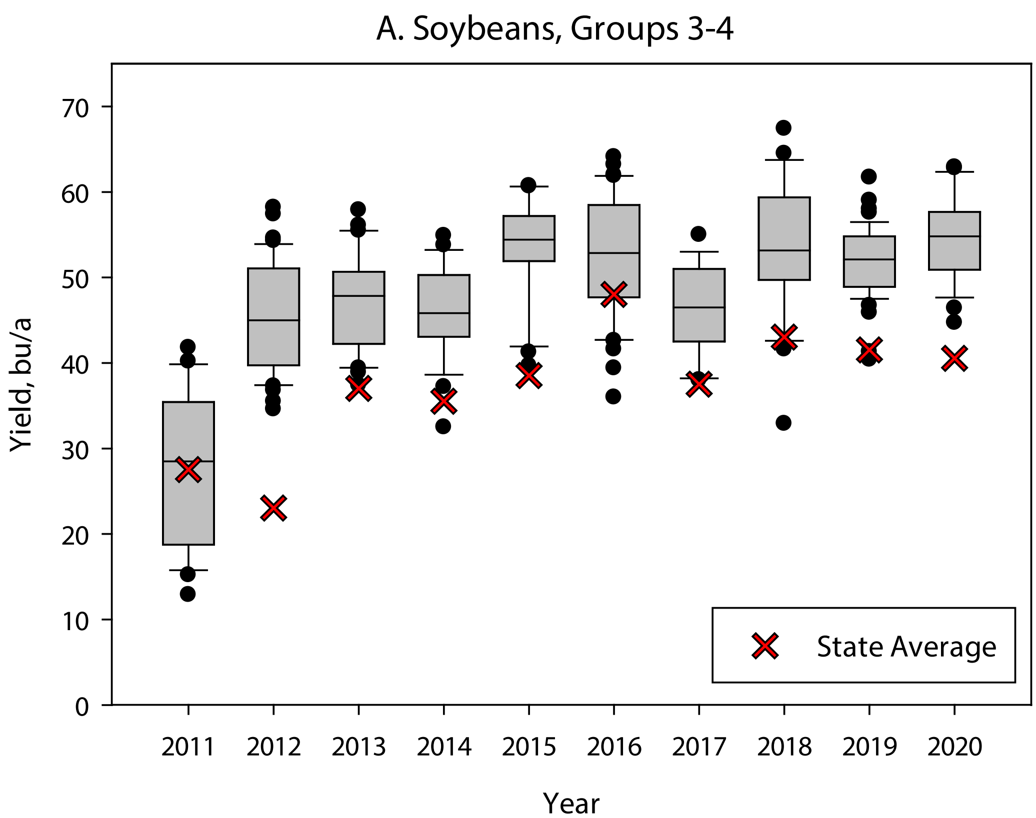
Southeast Kansas had exceptionally high rainfall until June (Sassenrath et al., 2021) that reduced crop establishment in the spring of 2020. By late spring, however, the rain stopped, creating dry conditions. Fields that missed the intermittent summer rains had reduced yields. Heat unit accumulation was near normal at Parsons. Though 2020 started out as a wet year, soybeans and sunflowers produced slightly better than average. Full season soybeans had more moisture at planting than double-cropped soybeans, and performed better.

Acknowledgment

These data are part of the 2020 Kansas Grain Sorghum Hybrids Performance Test, SRP1161 (https://bookstore.ksre.ksu.edu/pubs/SRP1161.pdf).

References

Sassenrath, G.F., M. Knapp, X. Lin. 2021. Southeast Kansas Weather Summary – 2020. Kansas Agricultural Experiment Station Research Reports: Vol. 7.



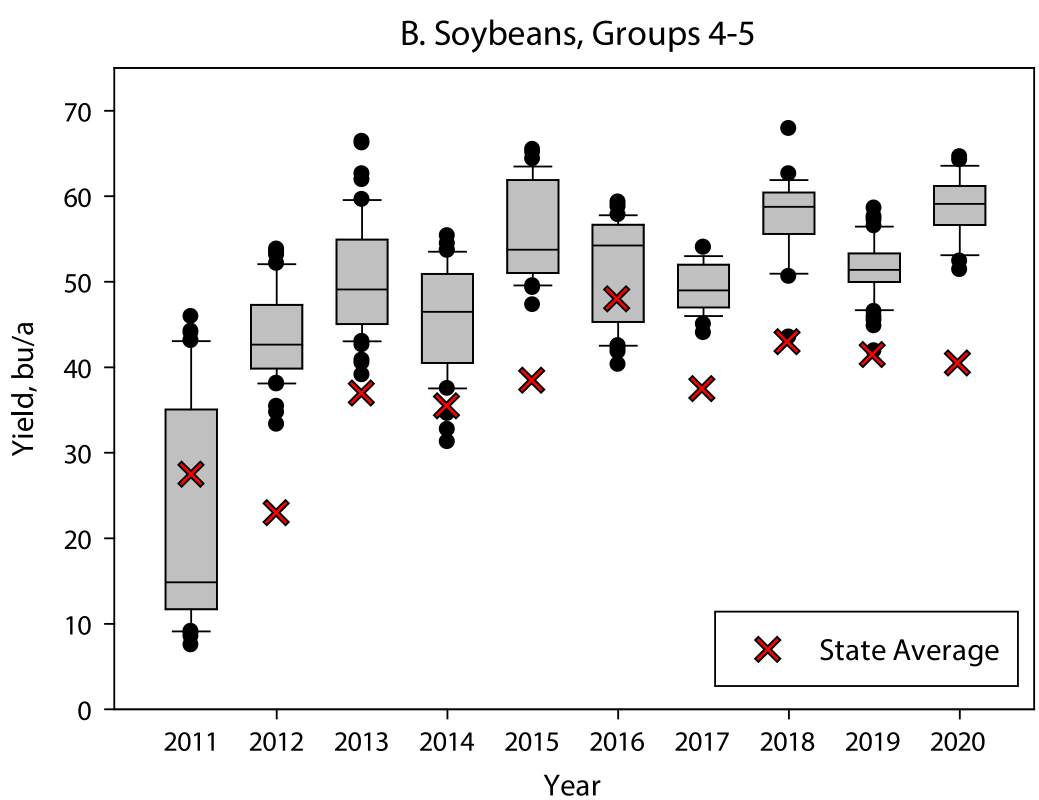


Figure 1. Comparison of soybean yield for full-season tests at Parsons. The line in the middle of the box plots is the median yield of all varieties. The upper and lower quartiles are given by the upper and lower edges of the boxes. The maximum and minimum values are given by the upper and lower "whiskers" extending from the box. Outliers are given as solid circles. For comparison, average reported yields from Kansas are highlighted as a red X.

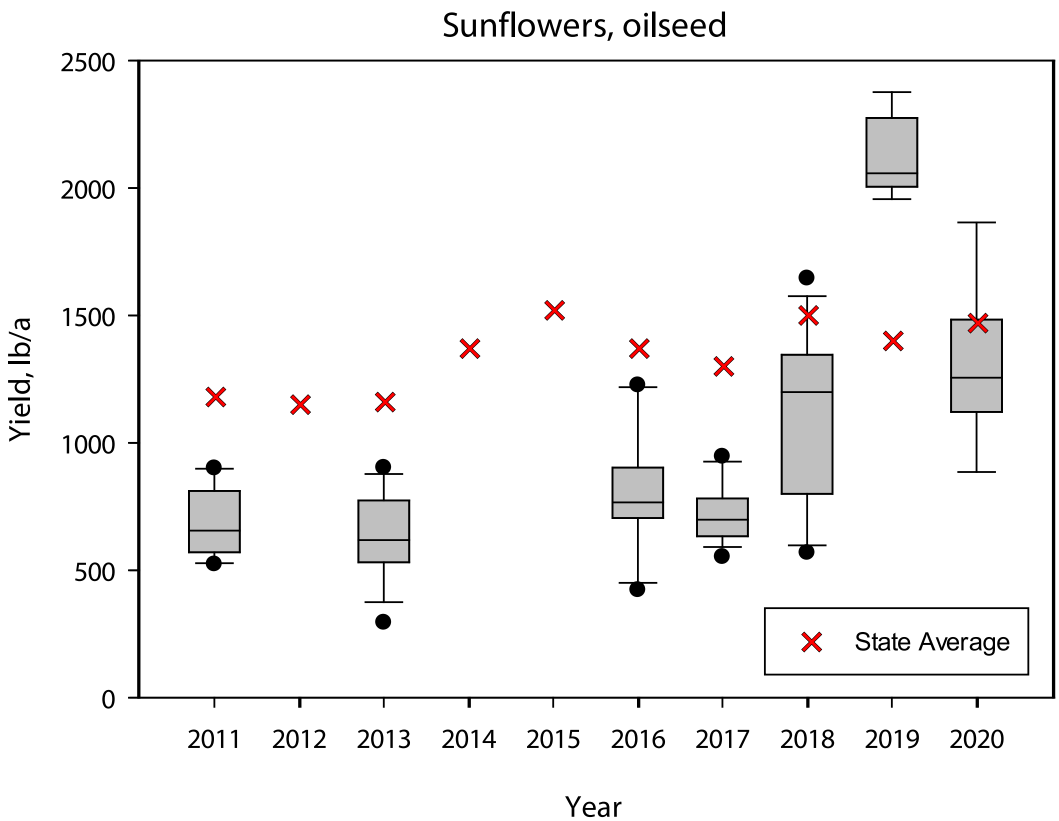


Figure 2. Oilseed sunflower yields from variety trials grown at Parsons, KS, from 2011 through 2020. Yield data were not available from the variety plots in 2012, 2014, or 2015. For comparison, average reported Kansas state yields are highlighted as a red X.

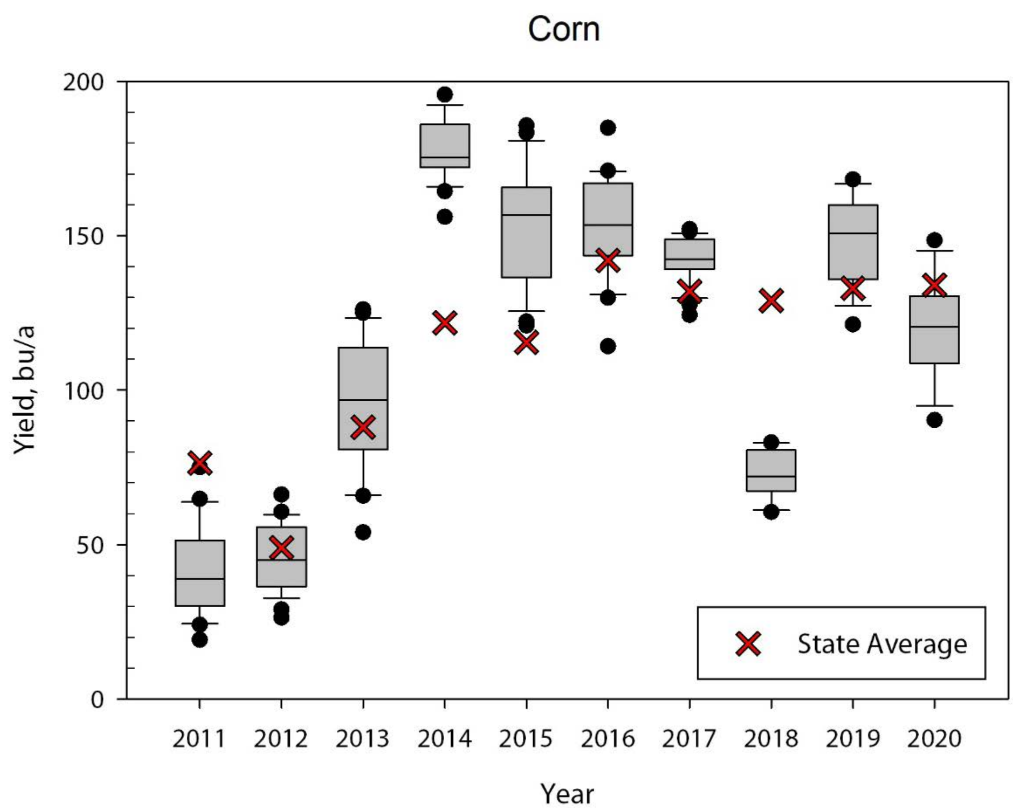


Figure 3. Corn yields at Parsons from variety trials grown from 2011 through 2020. For comparison, reported state average yields are highlighted as a red X.

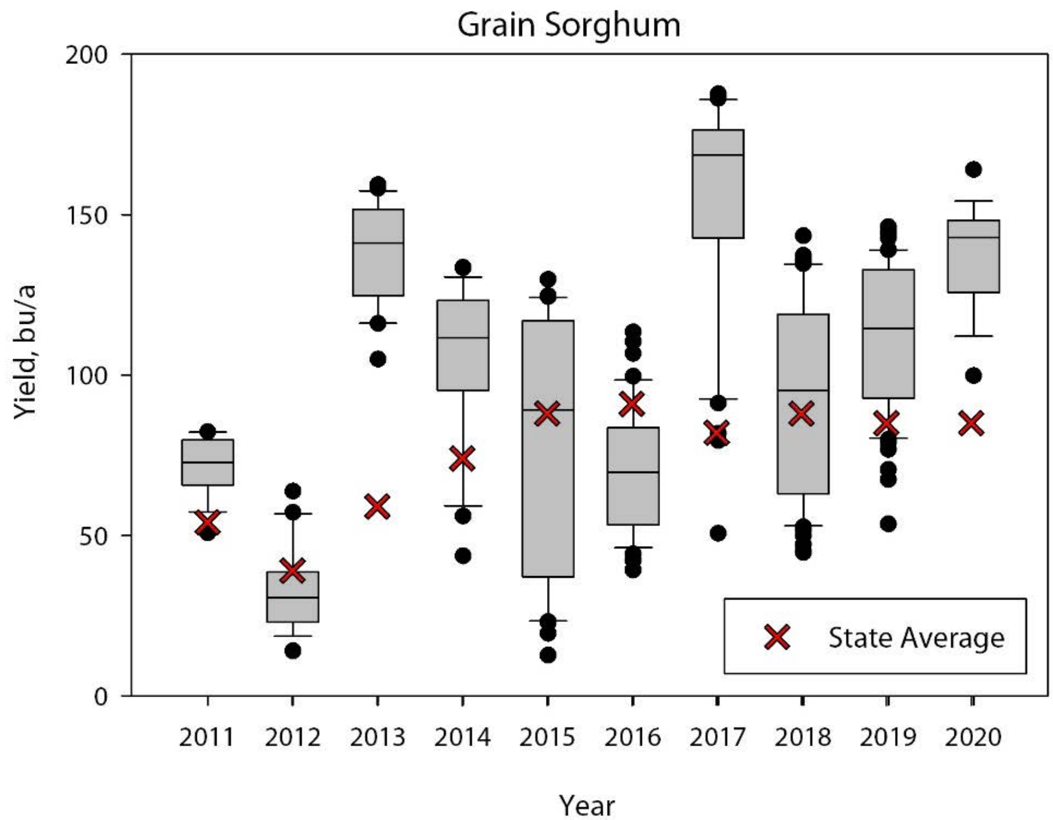


Figure 4. Grain sorghum yields from variety trials. 2011 through 2019 data were from Parsons. In 2020, the field at Parsons was flooded out. Data from Ottawa from 2020 are used for comparison. For comparison, reported state average yields are highlighted as a red X.

Using Cover Crops to Suppress Weeds and Improve Soil Health

J.A. Dille, L. Chism, and G.F. Sassenrath

Summary
Herbicide-resistant weeds are creating challenges for producers to control weeds in crop fields. This study explores the potential of cover crops to reduce weed pressure and improve soil health. Cover crops were planted after corn harvest in tilled and no-till fields, and included Graza radish, winter wheat, annual ryegrass, spring oats, winter oats, and forage collards. The control was fallow with herbicide application but no cover crop. Soil health was determined prior to cover crop termination. Graza radish and forage collards did not grow consistently in all plots due to poor germination and winter kill. Significant weed biomass was produced in the fallow plot or in plots with poor cover crop stands. Microbial biomass was much greater in the no-till field than in the tilled fields.

Introduction
Weed management is a critical component of good crop production. Predominant use of herbicides for weed management has resulted in the evolution of herbicide-resistant weed species. Alternative practices are needed to control weeds. Cover crops have been reported to reduce weed pressure. Cover crops are also useful in increasing the diversity of plants grown in a field, and contributing to improved soil health. This study was designed to determine weed emergence and growth in the presence of cover crops across crop fields in southeast Kansas.

Experimental Procedures
Cover crops were planted in replicated blocks in one no-till field and two tilled fields in the fall and included: control (fallow with herbicide, no cover crop); winter wheat; Graza radish; annual ryegrass; winter oat; and forage collards. We also compared a mix of radish + ryegrass seed either by drilling or broadcast methods. Initially, there was a difference in cover crop emergence and stand establishment between the drilled and broadcast; however, that difference had disappeared by the spring due to winterkill of radish. We also compared spring oat and winter oat cover crops.

Plant biomass samples were taken in the fall (2019) approximately 45 days after cover crop planting and again in the spring (2020). Total plant biomass was harvested from each plot, weighed and dried. The Canopeo app (Patrignani and Ochsner, 2015) was used to measure canopy coverage in the spring. Forage quality of biomass was measured for acid detergent fiber, neutral detergent fiber, and protein. Soil samples were taken in the fall and in the spring and assayed for nutrients and biological activity.

In the spring (2020), weed emergence was monitored across all cover crop plots using permanent 1.32 in. PVC rings (Figure 1). Weed species were identified, counted, and pulled from each ring at several times prior to cover crop termination. Plant biomass samples of both cover crop and weed communities were taken in the spring prior to termination of the cover crops. Soybean was then planted across the experimental area as the cash crop. Soybean yields were measured at harvest.

Results and Discussion

High rainfall in the fall of 2019 reduced emergence of some cover crops. Other cover crops were chosen for their sensitivity to cold temperatures. Graza radish, spring oats, and forage collards were winter-killed. This is a strategy that will limit the requirement for early-season burn down prior to planting cash crops. Soil organic matter (%) increased in all fields after cover crops. The increase in organic matter was stronger with grass cover crops, including ryegrass, winter oats, and winter wheat. Significant differences in soil organic matter were observed between the tilled and no-till fields, with more organic matter in the no-till field. Averaged across all cover crops, there was a much greater increase in organic matter in the no-till field (0.17%) than in the tilled fields (0.1%). This indicates the importance of reducing tillage to preserve soil organic matter. Soil organic matter has been shown to increase the productive capacity of fields.

Biomass samples of the cover crops and weeds were taken mid-May of 2020, prior to termination of the cover crops. Graza radish at one tilled field and forage collards at another were winter-killed and did not produce any measurable biomass (Figure 3). Significant weed biomass was produced in the fallow (no cover crop plots) with 750 lb/acre in tilled field 1, 803 lb/acre in tilled field 2, and 1,026 lb/acre in the no-till field. In the winter-killed cover crop plots, weed biomass was 785 lb/acre in Graza radish plots at field 2, and 410 lb/acre in forage collard plots at field 1. Clearly, with no cover crop present, much higher weed biomass was produced. Most significantly, no measurable weed biomass was harvested from plots with any cover crop in any of the fields. Weed control by cover crops was excellent.

Conclusions

Cover crops are a potential alternative to chemical control for weed management. Establishment of the cover crop is important to ensure adequate weed control. Cover crop species that produced the most biomass and hence provided the best weed control across these three southeast Kansas environments included wheat, ryegrass alone or with radish, and winter oat covers. Depending on the conditions, radish or collards may freeze-out before winter and provide inadequate weed control.

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References

Patrignani, A. and Ochsner, T.E., 2015. Canopeo: A powerful new tool for measuring fractional green canopy cover. Agronomy Journal, 107(6), pp. 2312-2320. *https://doi.org/10.2134/agronj15.0150*.

Figure 1. Rings were installed in cover crop plots to track weed emergence and species.

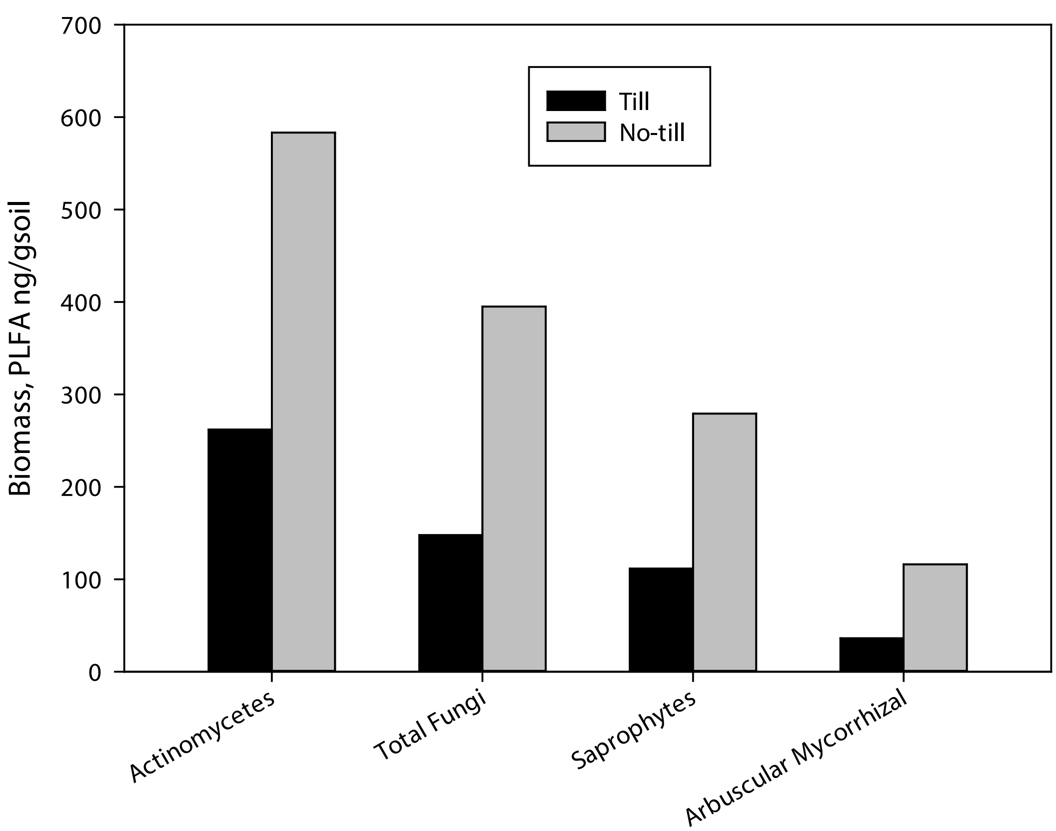

Figure 2. Differences in biological components between soils from till (dark grey) and no-till (light grey) crop production fields. PLFA = phospholipid fatty acid.

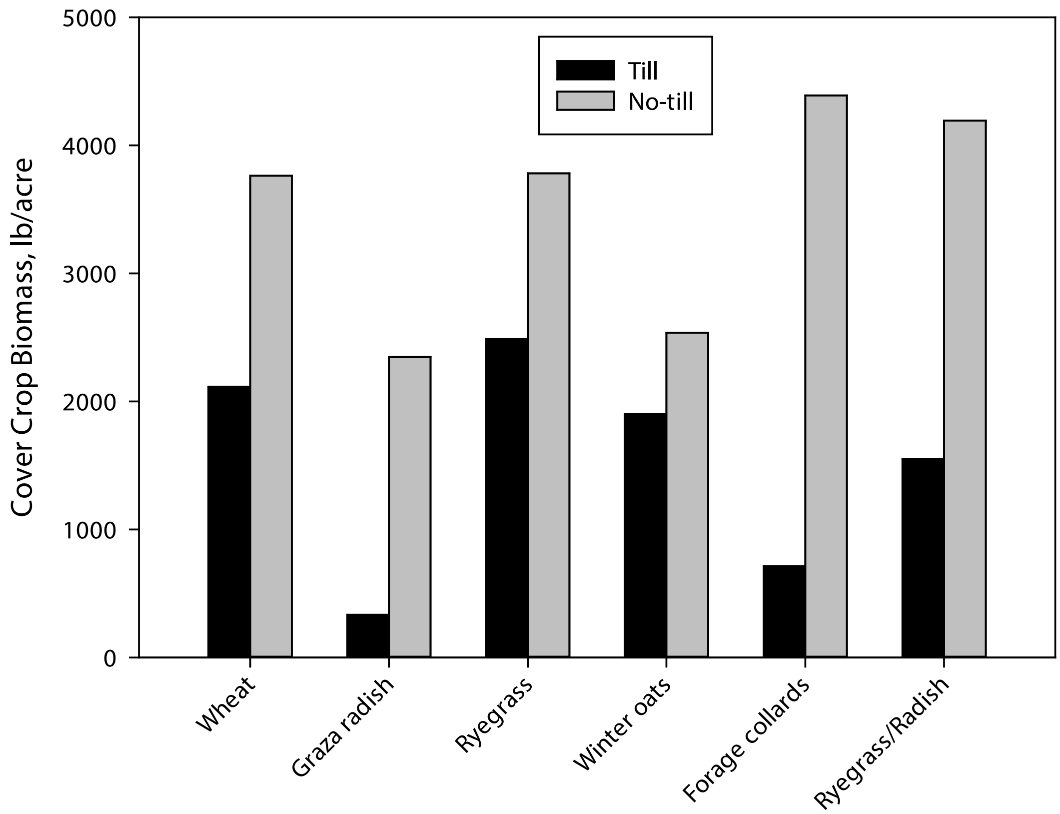

Figure 3. Cover crop biomass (lb/acre) produced by time of termination (May 18, 2020) in two tilled fields (dark grey) and one no-till field (light grey) in southeast Kansas. Cover crops were planted in the fall of 2019.

Southeast Kansas Weather Summary - 2020

G.F. Sassenrath, M. Knapp, and X. Lin

Summary
This is a summary of the weather conditions in southeast Kansas during the 2019/2020 growing season. The wet weather pattern that began in 2019 continued into the spring of 2020, creating adverse conditions for spring crop establishment. Dry conditions during the summer and fall limited crop and pasture production. Temperatures were very near the 10-year averages at each location.

Introduction
The southeast Kansas extension area covers 25 counties. The area ranges from the north near Ottawa, KS, to the west in Harper and Kingman counties. The region has a unique environment as it includes the highest rainfall area of Kansas. A significant rainfall gradient occurs in the region from east to west. A temperature gradient is observed from north to south. The varying climate impacts crop production in the region.

Crop production is sensitive to environmental conditions. This report summarizes the environmental conditions during the 2019/2020 growing season in comparison to previous years and the historical averages. Weather conditions are reported on a water year basis. A water year (WY) begins on October 1 of the preceding year, and continues through September 30 of the following year. WY20 refers to the period from October 1, 2019–September 30, 2020. This coincides with the wheat growing season.

Temperature plays a critical role in crop production. Early season soil temperatures are critical for seed germination. Air temperatures regulate crop development and progress through crop stages of development (vegetative, reproductive, and maturation). Temperatures that are too high or too low can negatively impact crop production and development. Calculation of the cumulative growing degree days (GDD) is a method of tracking crop progress through the growing season. Cumulative GDD are calculated by summing the daily "heat units" received each day above a given low temperature. Growing degree day information is available on the Kansas Mesonet website (*http://mesonet.k-state.edu/agriculture/degreedays/*). Rainfall is critical for crop establishment, growth, and development. Excessive rainfall can also contribute to crop disease development, especially in high-rainfall areas such as southeast Kansas.

Experimental Procedures
The Kansas State University Climatology Laboratory maintains weather stations throughout Kansas (*http://mesonet.k-state.edu*). These meteorological stations record weather parameters throughout the growing season. Information is available to be downloaded on a daily basis. All information presented here was downloaded from the stations at Harper, Ottawa, and Parsons, KS. Rainfall is reported on a water year (WY) basis, that begins October 1 and ends September 30 of the next year. Cumulative rainfall during the summer growing season was also calculated. Growing degree days were calculated using a base temperature of 50°F.

Results and Discussion

Rainfall during WY20 was on track to exceed that received during the record-setting previous year at all three locations (Figure 1). By the end of April, however, rainfall totals decreased to normal levels except in Parsons. Total rainfall in Harper for WY20 (28.8 inches) was near the average of 26.9 in. Rainfall totals in Ottawa decreased substantially after April, reducing total WY rainfall to 25.9 in., well below the average of 34.4 in. High rain events in Parsons continued throughout April in Parsons, creating problems for spring crop establishment (Sassenrath et al., 2021a). During April, the cumulative rainfall exceeded that received during the previous WY19. On May 15, 2020, Parsons received 4.7 in. of rain in one 24-hr period. However, after that, conditions at Parsons dried rapidly, creating challenges for double-cropped systems (Sassenrath et al., 2021b). The overall WY20 rainfall (49.9 in.) at Parsons was still well above the average of 38.7 in.

The decrease in rainfall during the summer growing season was more apparent in all locations (Figure 2). Harper received near-average rain of 18.3 in., compared to an average of 20.5 in. Ottawa received slightly more rain during the growing season (18.6 in.), which was substantially below the average for that area (26.2 in.) and more similar to the dry years of 2011 and 2012. Parsons received 16 in. of rain after the April deluge, which was less than the 20 in. average rainfall received from May–October. However, the total for the growing season was still above the 33.7 in. normally received, and well above the dry years of 2011 and 2012. The dry conditions created challenges for pasture establishment (Helwig et al., 2021), but contributed to higher wheat quality (Sassenrath et al., 2021c).

Temperatures in 2020 were reduced at Harper and Ottawa, but near normal for Parsons (Figure 3). Reduced heat unit accumulation caused slow crop development. This was observed as later harvest dates for corn (Sassenrath et al., 2021a). The 2020 growing season was nearly normal for the number of days with high temperatures (Figure 4). Excessive high temperatures reduce crop production. Note that Harper received on average more seasonal temperatures in excess of 90°F than Ottawa. Interestingly, Parsons on average has cooler summers, with fewer days of temperatures above 90°F. This may be due in part to higher rainfall, with more cloudy days.

Conclusions

The year 2020 was challenging for crop production due to excessive rainfall in the spring, limiting crop planting and crop establishment. Drier late spring/early summer conditions improved wheat quality, but impeded summer crop production and grass establishment.

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References

Helwig, D., M. Haywood, J. Farney, B.C. Pedreira, G.F. Sassenrath. 2021. Bermudagrass fertility trial in southeast Kansas, 2020. *Kansas Agricultural Experiment Station Research Reports*: Vol. 7.

Sassenrath, G.F. L. Mengarelli, J. Lingenfelser, X. Lin. 2021a. Crop production 2020 – Corn, Sorghum, Soybean and Sunflower Variety Testing. *Kansas Agricultural Experiment Station Research Reports*: Vol. 7.

Sassenrath, G.F., L. Mengarelli, J. Lingenfelser, X. Lin. 2021b. Southeast Kansas Wheat Variety Test Results – 2020. *Kansas Agricultural Experiment Station Research Reports*: Vol. 7.

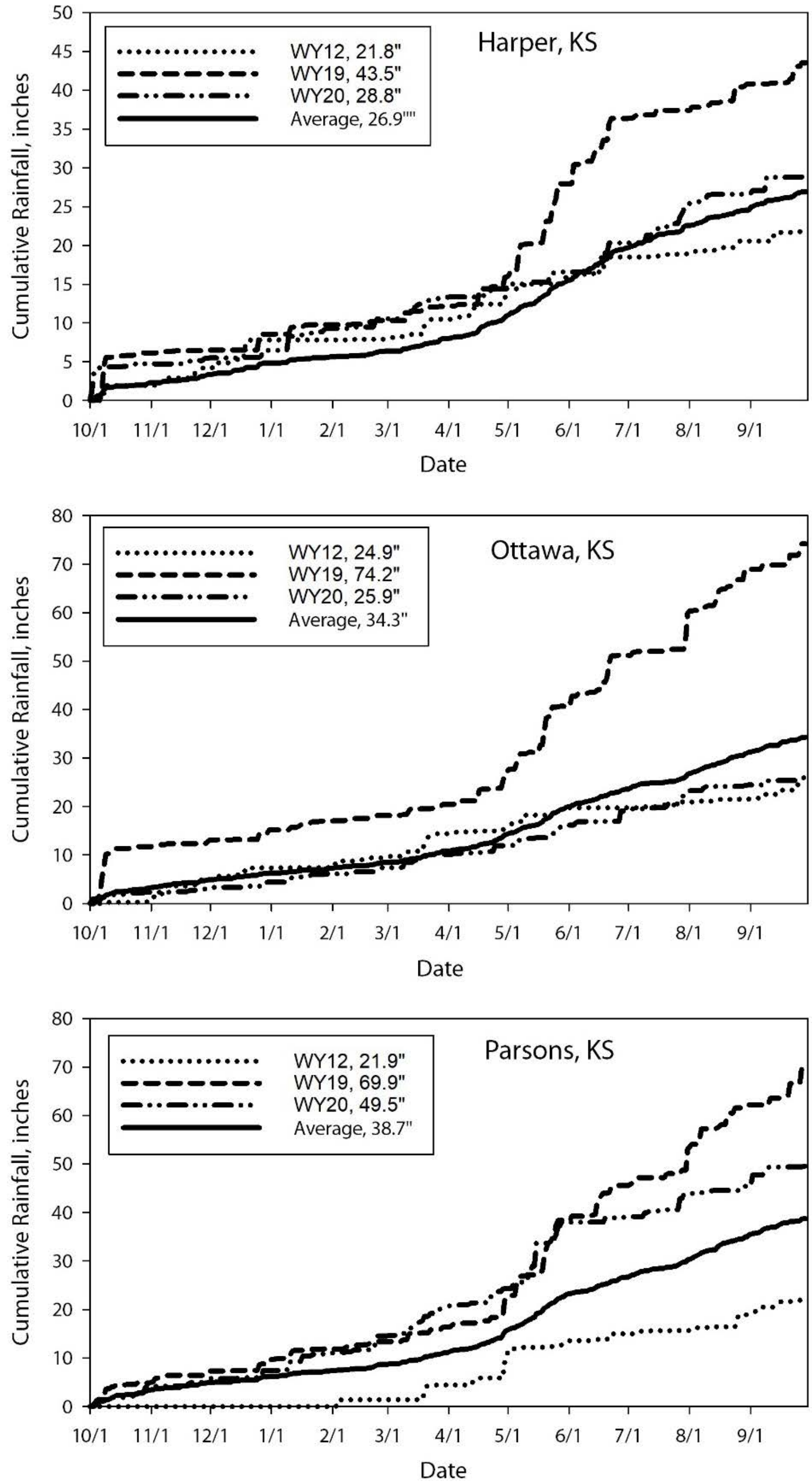


Figure 1. Cumulative rainfall during the water year from October 1 through September 30 at Harper, KS (upper), Ottawa (middle), and Parsons (lower). Ten-year average (solid black line) included for comparison. Rainfall total in inches given after each year in legend. Note difference in y-axis between locations.

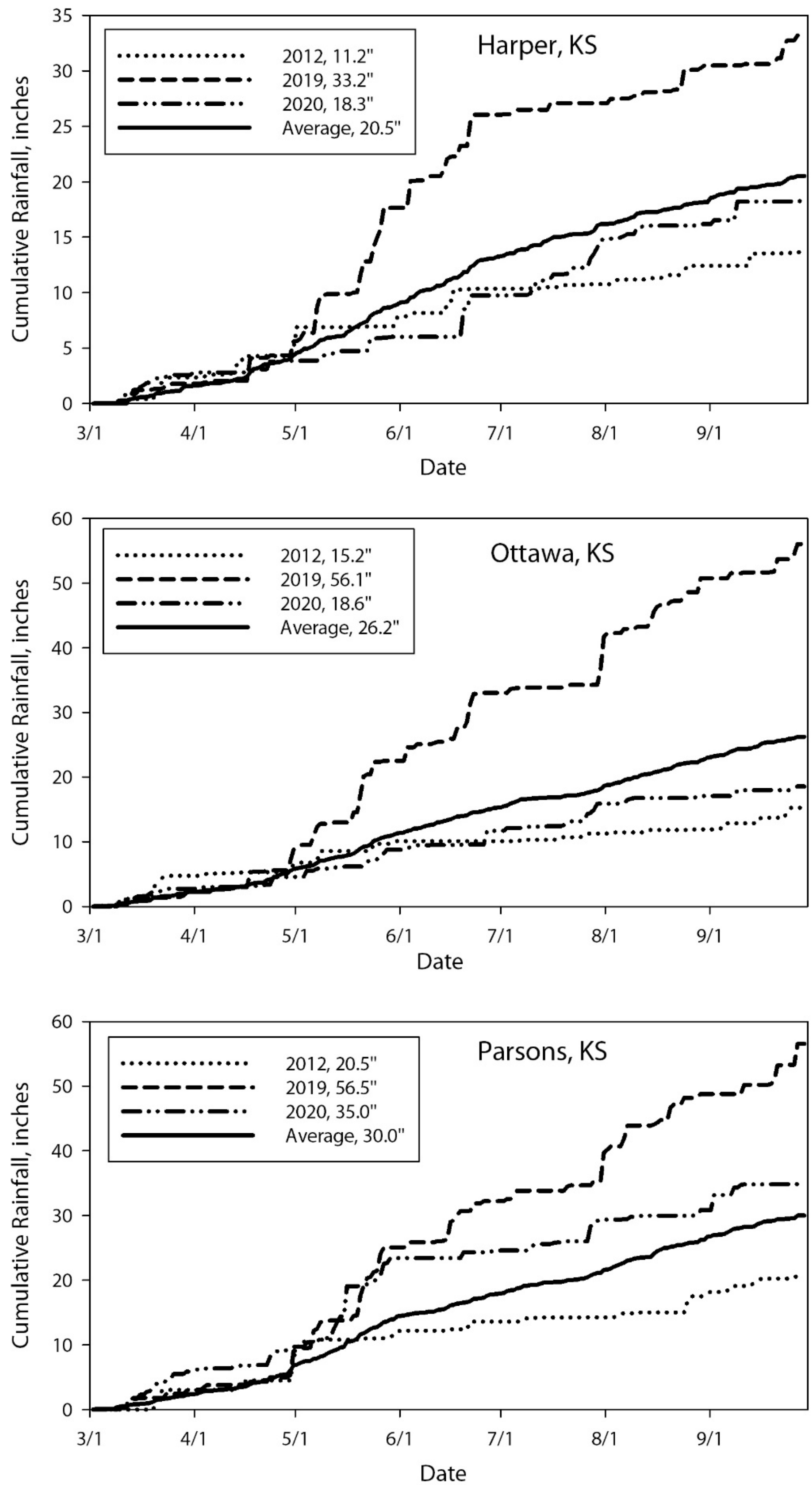


Figure 2. Rainfall during the summer crop production season during 2020 and preceding years at Harper (upper), Ottawa (middle), and Parsons (lower). Ten-year average (solid black line) included for comparison. Rainfall total in inches given after each year in legend. Note difference in y-axis scale between locations.

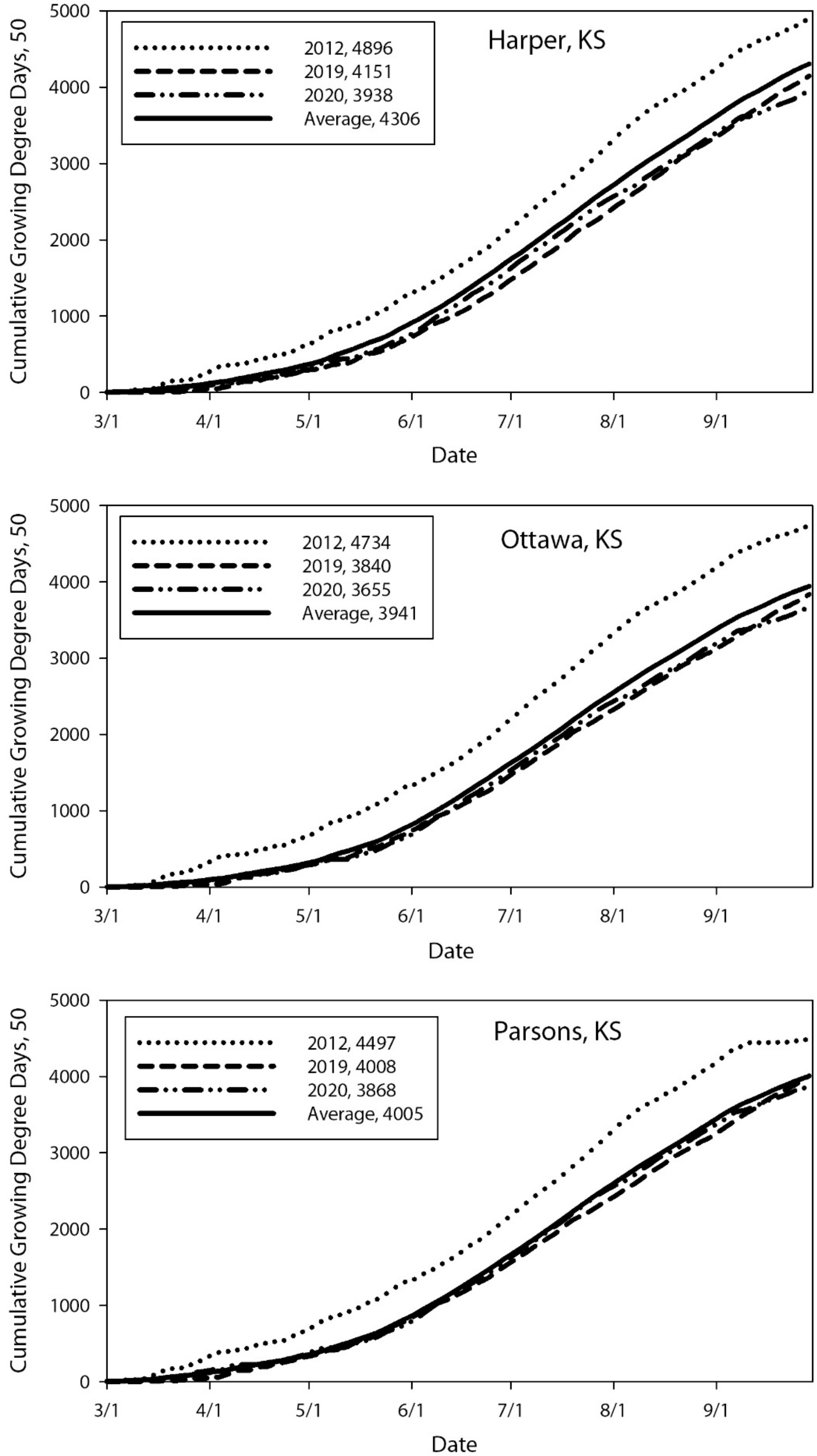


Figure 3. Cumulative growing degree days during 2020 and preceding years at Harper (upper), Ottawa (middle), and Parsons (lower). Ten-year average (solid black line) included for comparison. Cumulative growing degree days (GDD) calculated with a base temperature of 50°F during the summer growing season. Total GDD50 during growing season given in legend for each year.

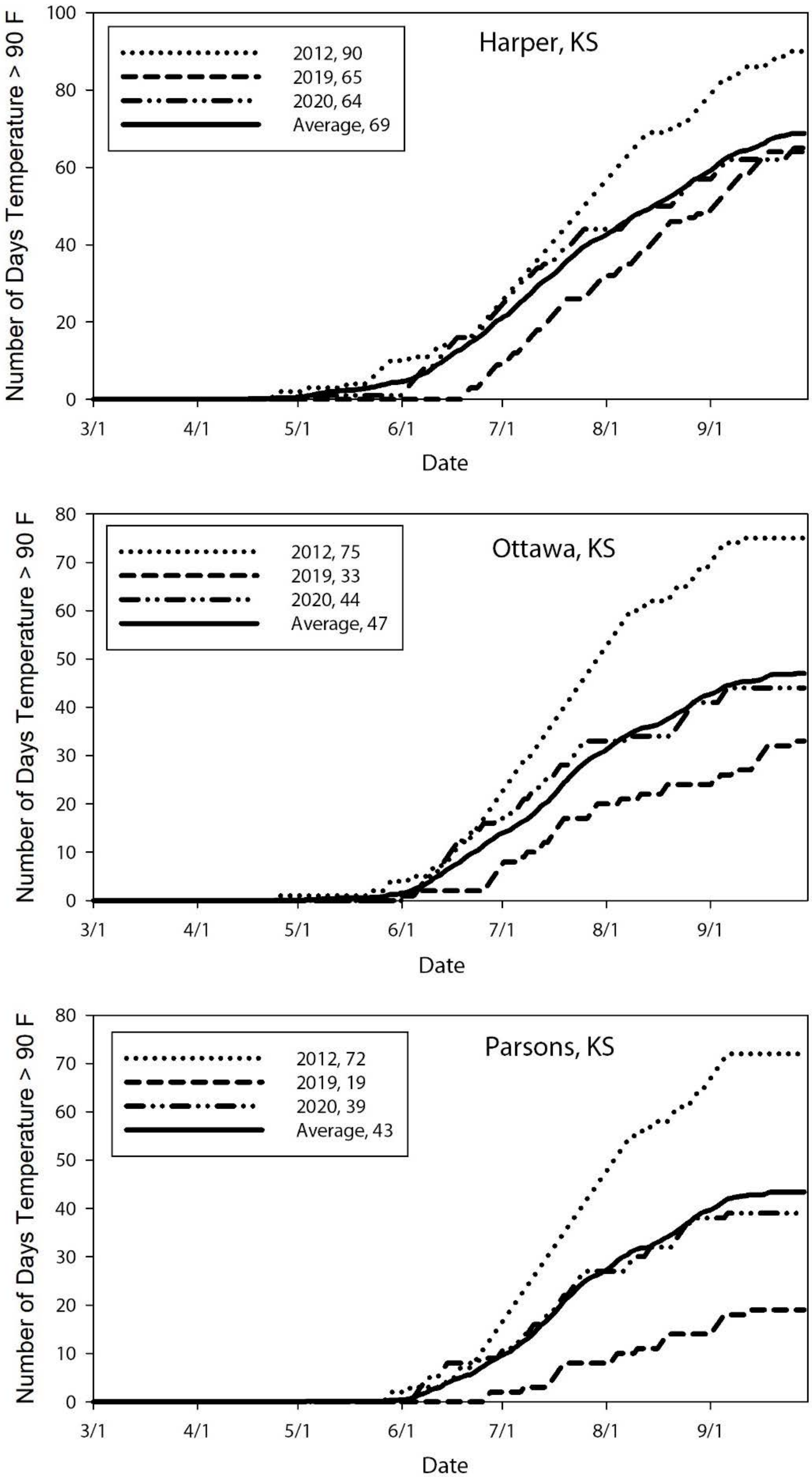


Figure 4. Number of days the maximum temperature was greater than 90°F days during 2020 and preceding years at Harper (upper), Ottawa (middle), and Parsons (lower). Ten-year average (solid black line) included for comparison. Total number of days of temperatures greater than 90°F are given after each year in legend.

Annual Summary of Weather Data for Parsons - 2020

2020 Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max	46.3	46.6	61.2	65.1	71.0	87.8	90.8	87.3	79.2	68.0	62.7	50.2	68.0
Avg. Min	26.3	26.1	41.3	41.8	52.2	66.2	70.4	63.5	57.3	41.5	37.3	26.2	45.8
Avg. Mean	36.3	36.3	51.3	53.5	61.6	77.0	80.6	75.4	68.3	54.7	50.0	38.2	56.9
Precip	3.64	3.54	6.16	3.4	12.66	1.08	4.38	1.44	3.97	4.36	3.27	1.55	49.47
Snow	1.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.0
Heat DD*	890	832	440	349	151	1	0	0	40	349	457	831	4337
Cool DD*	0	0	15	3	46	360	484	321	138	30	6	0	1401
Rain Days	8	11	17	10	15	3	10	7	8	10	8	8	115
Min < 10	0	2	0	0	0	0	0	0	0	0	0	0	2
Min < 32	25	22	4	7	0	0	0	0	0	5	13	23	99
Max > 90	0	0	0	0	0	7	18	10	1	0	0	0	36

Normal values (1981-2010)

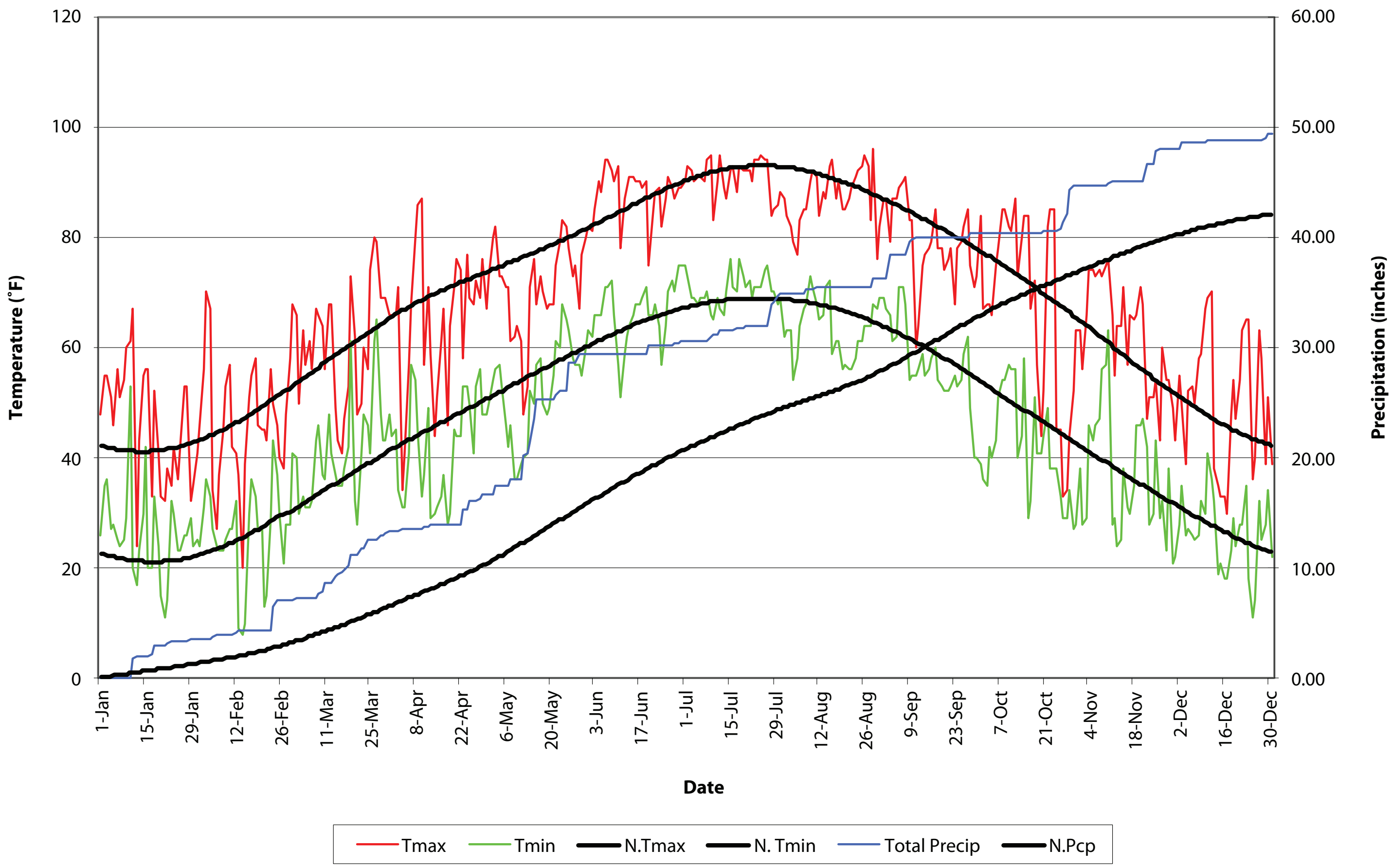
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max	42.0	47.6	57.1	67.1	75.7	84.4	90.0	90.3	81.3	69.6	56.6	44.2	67.2
Avg. Min	21.8	26.0	35.0	44.5	55.0	64.1	68.5	66.6	57.6	45.5	35.3	24.6	45.5
Avg. Mean	31.9	36.8	46.1	55.8	65.3	74.2	79.3	78.5	69.4	57.6	46.0	34.4	56.4
Precip	1.41	1.77	3.19	4.38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

continued

Departure from normal

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max	4.3	-1.0	4.1	-2.0	-4.7	3.4	0.8	-3.0	-2.1	-1.6	6.1	6.0	0.9
Avg. Min	4.5	0.1	6.3	-2.7	-2.8	2.1	1.9	-3.1	-0.3	-4.0	2.0	1.6	0.5
Avg. Mean	4.4	-0.5	5.2	-2.3	-3.7	2.8	1.3	-3.1	-1.2	-2.9	4.0	3.8	0.6
Precip	2.23	1.77	2.97	-0.96	6.73	-4.45	0.46	-1.85	-0.72	0.5	0.33	-0.51	6.5
Snow	-1.1	-0.7	-1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-2.4	-5.7
Heat DD	-137	42	-150	50	66	-8	-1	-1	-12	89	-118	-118	-297
Cool DD	0	0	13	-21	-50	75	42	-97	-49	1	4	0	-82

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


120
100
80
60
40
20
0
60.00
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30.00
20.00
10.00
0.00
Temperature (°F)
Precipitation (inches)
1-Jan
15-Jan
29-Jan
12-Feb
26-Feb
11-Mar
25-Mar
8-Apr
22-Apr
6-May
20-May
3-Jun
17-Jun
1-Jul
15-Jul
29-Jul
12-Aug
26-Aug
9-Sep
23-Sep
7-Oct
21-Oct
4-Nov
18-Nov
2-Dec
16-Dec
30-Dec
Date
Tmax
Tmin
N.Tmax
N. Tmin
Total Precip
N.Pcp

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