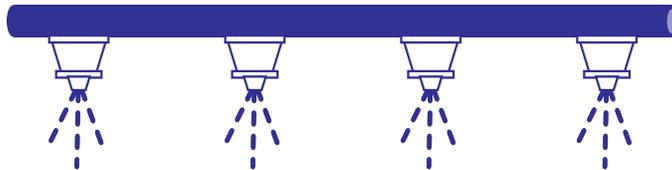




KANSAS STATE UNIVERSITY



KANSAS FERTILIZER RESEARCH 2018

K-STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

KANSAS FERTILIZER RESEARCH 2018

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Precipitation Data

Month	Manhattan	SWREC Tribune	SEARC Parsons	ECK Exp. Field Ottawa
----- in. -----				
2016				
August	6.10	3.51	4.32	8.67
September	6.03	2.11	4.47	4.34
October	2.25	0.04	7.20	1.41
November	0.60	0.02	0.86	0.37
December	1.07	0.70	0.53	1.05
Total 2016	40.96	19.97	44.86	38.46
Departure from normal	+6.16	+2.07	+1.89	-1.84
2017				
January	1.45	0.80	2.14	1.12
February	0.42	0.06	0.22	0.12
March	4.22	1.21	2.35	2.76
April	4.11	4.67	11.97	7.04
May	3.99	5.00	7.89	2.05
June	3.60	2.46	3.80	7.92
July	1.43	4.53	5.46	4.29
August	6.09	1.66	8.12	4.40
September	1.08	2.70	2.62	0.29

continued

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Month	NCK Exp. Field Belleville	KRV Exp. Field	SCK Exp. Field Hutchinson	ARC Hays
----- in. -----				
2016				
August	7.25	4.96	8.43	3.78
September	2.24	10.33	5.84	2.08
October	1.87	1.15	0.66	0.66
November	0.91	0.23	0.50	1.18
December	1.16	0.75	0.96	0.57
Total 2016	35.57	39.73	20.94	26.73
Departure from normal	+4.97	+4.09	+10.30	+3.82
2017				
January	1.04	1.14	2.37	1.25
February	0.22	0.32	0.17	0.10
March	1.26	3.75	3.35	1.50
April	3.06	5.21	4.16	7.83
May	8.98	5.51	5.44	4.58
June	3.47	5.42	1.83	3.82
July	2.85	2.57	0.61	1.53
August	1.46	5.79	2.53	3.08
September	2.221	1.21	2.91	2.17

SWREC = Southwest Research Extension-Center; SEARC = Southeast Agricultural Research Center;
 ECK = East Central Kansas; NCK = North Central Kansas; KRV = Kansas River Valley;
 SCK = South Central Kansas; ARC = Agricultural Research Center.

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

A.J. Schlegel and H.D. Bond

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2017, N applied alone increased yields by 70 bu/a, whereas P applied alone increased yields by less than 10 bu/a. Nitrogen and P applied together increased yields up to 130 bu/a. This is 10 bu/a less than the 10-year average, where N and P fertilization increased corn yields up to 140 bu/a. Application of 120 lb/a N (with highest P rate) produced 93% of maximum yield in 2017, which is similar to the 10-year average. Application of 80 instead of 40 lb P₂O₅/a increased average yields 10 bu/a. Average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P₂O₅/bu). At the highest N and P rate, apparent fertilizer nitrogen recovery in the grain (AFNR_g) was 42% and apparent fertilizer phosphorus recovery in the grain (AFPR_g) was 61%.

Introduction

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and potassium (K) fertilization. The study is conducted on a Ulysses silt loam soil with an inherently high K content. No yield benefit to corn from K fertilization was observed in 30 years, and soil K levels remained high, so the K treatment was discontinued in 1992 and replaced with a higher P rate.

Procedures

This field study is conducted at the Tribune Unit of the Kansas State University Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a without P and K; with 40 lb/a P₂O₅ and zero K; and with 40 lb/a P₂O₅ and 40 lb/a K₂O. The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P₂O₅). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids [Pioneer 34B99 (2008); DeKalb 61-69 (2009); Pioneer 1173H (2010); Pioneer 1151XR (2011); Pioneer 0832 (2012-2013); Pioneer 1186AM (2014); Pioneer 35F48 AM1 (2015); Pioneer 1197 (2016); and Pioneer 0801 (2017)] were planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2008, 2010, 2015, and 2017 crops. The corn is irrigated to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 15.5% moisture. Grain samples were collected at harvest, dried, ground and analyzed for N and P concentrations. Grain N and P content (lb/bu) and removal (lb/a) were calculated. Apparent fertilizer N recovery in the grain (AFNR_g) was calculated as N uptake in treatments receiving N fertilizer minus N uptake in the unfertilized control divided by N rate. The same approach was used to calculate apparent fertilizer P recovery in the

grain (AFPR_g). Aerial application of insecticide was used for control of grasshoppers on July 18 and hail damage occurred on August 18.

Results

Corn yields in 2017 were 25% lower than the 10-year average (Table 1). Nitrogen alone increased yields 70 bu/a, whereas P alone increased yields less than 10 bu/a. However, N and P applied together increased corn yields up to 130 bu/a. Maximum yield was obtained with 200 lb/a N with 80 lb/a P₂O₅. Corn yields in 2017 (averaged across all N rates) were 10 bu/a greater with 80 than with 40 lb/a P₂O₅.

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of 0.6 lb/bu. Maximum N removal (lb/a) was greatest at the highest yield levels, which were attained with 200 lb N and 80 lb P₂O₅/a. At the highest N and P rate, AFNR_g was 42% and AFPR_g was 61%. Similar to N, average P concentration increased with increased P rates but decreased with higher N rates. Grain P content (lb/bu) of about 0.15 lb P/bu (0.34 lb P₂O₅/bu) was greater at the highest P rate with low N rates. Grain P removal averaged 29 lb P/a at the highest yields.

Acknowledgment

The International Plant Nutrition Institute partially supported this research project.

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2008–2017

Fertilizer		Yield										Mean
N	P ₂ O ₅	2008*	2009	2010*	2011	2012	2013	2014	2015*	2016	2017*	
----- lb/a -----		----- bu/a -----										
0	0	36	85	20	92	86	70	86	92	74	44	68
0	40	57	110	21	111	85	80	95	103	78	47	79
0	80	52	106	28	105	94	91	98	104	86	52	82
40	0	62	108	23	114	109	97	106	113	105	60	90
40	40	105	148	67	195	138	125	153	164	145	92	133
40	80	104	159	61	194	135	126	149	162	135	90	132
80	0	78	123	34	136	128	112	117	131	118	70	105
80	40	129	179	85	212	197	170	187	195	196	132	168
80	80	139	181	90	220	194	149	179	193	193	129	167
120	0	65	117	28	119	134	114	115	124	109	62	99
120	40	136	202	90	222	213	204	213	212	212	142	185
120	80	151	215	105	225	211	194	216	216	223	162	192
160	0	84	139	49	157	158	122	128	144	142	84	121
160	40	150	210	95	229	227	199	211	215	226	154	192
160	80	146	223	95	226	239	217	233	216	238	165	200
200	0	99	155	65	179	170	139	144	162	159	114	139
200	40	152	207	97	218	225	198	204	214	216	148	188
200	80	157	236	104	231	260	220	238	221	235	174	208

continued

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2008–2017

Fertilizer		Yield										Mean
N	P ₂ O ₅	2008*	2009	2010*	2011	2012	2013	2014	2015*	2016	2017*	
ANOVA (P>F)												
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
MEANS												
Nitrogen, lb/a												
0		48e	100e	23e	103d	88f	80e	93e	100e	79e	48e	76e
40		91d	138d	50d	167c	127e	116d	136d	146d	129d	81d	118d
80		115c	161c	70c	189b	173d	143c	161c	173c	169c	110c	146c
120		118c	178b	74bc	189b	186c	171b	181b	184b	182b	122b	158b
160		127b	191a	80ab	204a	208b	179ab	190ab	192ab	202a	134a	171a
200		136a	199a	89a	209a	218a	186a	196a	199a	203a	145a	178a
LSD _(0.05)		9	12	9	13	10	10	10	9	10	11	7
P ₂ O ₅ , lb/a												
0		71b	121c	36b	133b	131c	109b	116c	128b	118b	72c	103c
40		122a	176b	76a	198a	181b	163a	177b	184a	179a	119b	157b
80		125a	187a	81a	200a	189a	166a	186a	185a	185a	129a	163a
LSD _(0.05)		6	9	7	9	7	7	7	6	7	8	5

*Note: Hail events on 8/14/2008, 7/23/10, 5/28/15, and 8/18/17. ANOVA = analysis of variance. LSD = least significant difference.

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2008–2017

Fertilizer		Grain				Grain removal		*AFNR _g	*AFPR _g
N	P ₂ O ₅	N	P	N	P	N	P		
----- lb/a -----		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
0	0	0.98	0.232	0.47	0.110	31	7	---	---
0	40	0.95	0.313	0.45	0.148	34	12	---	25
0	80	0.95	0.322	0.45	0.152	36	12	---	15
40	0	1.17	0.184	0.55	0.087	49	8	45	---
40	40	0.97	0.304	0.46	0.144	60	19	73	67
40	80	0.98	0.324	0.46	0.153	60	20	73	36
80	0	1.26	0.181	0.60	0.085	62	9	38	---
80	40	1.05	0.259	0.50	0.122	83	20	65	73
80	80	1.02	0.312	0.48	0.148	79	25	61	49
120	0	1.26	0.175	0.60	0.083	58	8	23	---
120	40	1.13	0.230	0.54	0.109	98	20	56	70
120	80	1.10	0.299	0.52	0.141	99	27	57	55
160	0	1.25	0.179	0.59	0.085	71	10	25	---
160	40	1.18	0.245	0.56	0.116	106	22	47	82
160	80	1.17	0.283	0.55	0.134	110	27	49	54
200	0	1.24	0.188	0.59	0.089	80	12	25	---
200	40	1.19	0.241	0.56	0.114	105	21	37	78
200	80	1.18	0.297	0.56	0.140	115	29	42	61

continued

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2008–2017

Fertilizer		Grain				Grain removal		*AFNR _g	*AFPR _g
N	P ₂ O ₅	N	P	N	P	N	P		
ANOVA (P>F)									
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.035	0.088
MEANS									
Nitrogen, lb/a		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
0		0.96e	0.289a	0.46e	0.137a	34f	10e	---	20d
40		1.04d	0.271b	0.49d	0.128b	56e	16d	64a	52c
80		1.11c	0.250c	0.53c	0.118c	75d	18c	55b	61b
120		1.16b	0.235d	0.55b	0.111d	85c	18bc	45c	63ab
160		1.20a	0.236d	0.57a	0.111d	96b	19b	40d	68ab
200		1.20a	0.242cd	0.57a	0.115cd	100a	21a	35e	70a
LSD _(0.05)		0.02	0.011	0.01	0.005	4	1	5	8
P ₂ O ₅ , lb/a									
0		1.19a	0.190c	0.56a	0.090c	59b	9c	31b	---
40		1.08b	0.265b	0.51b	0.126b	81a	19b	56a	66a
80		1.07b	0.306a	0.50b	0.145a	83a	23a	56a	45b
LSD _(0.05)		0.01	0.008	0.01	0.004	3	1	4	5

*AFNR_g and AFPR_g = Apparent Fertilizer N Recovery (grain) and Apparent Fertilizer P Recovery (grain). ANOVA = analysis of variance. LSD = least significant difference.

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

A.J. Schlegel and H.D. Bond

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2017, N applied alone increased yields 53 bu/a, whereas N and P applied together increased yields up to 67 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 77 bu/a. Application of 80 lb/a N (with P) was sufficient to produce almost 90% of maximum yield in 2017, which is slightly less than the 10-year average. Application of potassium (K) has had no effect on sorghum yield throughout the study period. Average grain N content reached a maximum of ~0.7 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P₂O₅/bu) and grain K content reached a maximum of 0.19 lb/bu (0.23 lb K₂O/bu). At the highest N, P, and K rate, apparent fertilizer recovery in the grain was 32% for N, 66% for P, and 39% for K.

Introduction

This study was initiated in 1961 to determine responses of continuous grain sorghum grown under flood irrigation to N, P, and K fertilization. The study is conducted on a Ulysses silt loam soil with an inherently high K content. The irrigation system was changed from flood to sprinkler in 2001.

Procedures

This field study is conducted at the Tribune Unit of the Kansas State University Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P₂O₅ and zero K; and with 40 lb/a P₂O₅ and 40 lb/a K₂O. All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 85G46 in 2008–2011, Pioneer 84G62 in 2012–2014, Pioneer 86G32 in 2015, and Pioneer 84G62 in 2016–2017) was planted in late May or early June. Irrigation is used to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 12.5% moisture. Grain samples were collected at harvest, dried, ground, and analyzed for N, P, and K concentrations. Grain N, P, and K content (lb/bu) and removal (lb/a) were calculated. Apparent fertilizer N recovery in the grain (AFNR_g) was calculated as N uptake in treatments receiving N fertilizer minus N uptake in the unfertilized control divided by N rate. The same approach was used to calculate apparent fertilizer P recovery in the grain (AFPR_g) and apparent fertilizer K recovery (AFKR_g). Aerial application of insecticide was used for control of grasshoppers on July 18 and hail damage occurred on August 18.

Results

Grain sorghum yields in 2017 were 8% lower than the 10-year average (Table 1). Nitrogen alone increased yields 53 bu/a while P alone increased yields less than 10 bu/a. However, N and P applied together increased yields up to 67 bu/a. Averaged across the past 10 years, N and P applied together increased yields up to 77 bu/a. In 2017, 40 lb/a N (with P) produced about 88% of maximum yield, which is greater than the 10-year average of 83%. The 10-year average for 80 lb/a N (with P) and 120 lb/a N (with P) was 93 and 95% of maximum yield, respectively. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of ~0.7 lb/bu. Maximum N removal (lb/a) was obtained with 160 lb N/a or greater with P. Similar to N, average P concentration increased with P application but decreased with higher N rates. Grain P content (lb/bu) of ~0.15 lb P/bu (0.34 lb P₂O₅/bu) was similar for all N rates when P was applied. Grain P removal was similar for all N rates of 40 lb/a or greater with P removal ranging from 18 to 22 lb/a. Average K concentration (%) and content (lb/bu) tended to decrease with increased N rates. Similar to P, K removal was similar for all N rates of 40 lb/a or greater plus K ranging from 22 to 26 lb/a. At the highest N, P, and K rate, apparent fertilizer recovery in the grain was 32% for N, 66% for P, and 39% for K.

Acknowledgment

The International Plant Nutrition Institute partially supported this research project.

Table 1. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2008–2017

Fertilizer			Grain sorghum yield										
N	P ₂ O ₅	K ₂ O	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
----- lb/a -----			----- bu/a -----										
0	0	0	66	64	51	75	78	62	90	89	80	70	73
0	40	0	60	70	51	83	90	77	94	102	91	79	80
0	40	40	65	76	55	88	93	72	96	97	91	80	81
40	0	0	92	84	66	106	115	94	115	122	106	87	99
40	40	0	111	118	77	121	140	114	144	160	142	120	125
40	40	40	105	109	73	125	132	110	142	155	137	118	121
80	0	0	114	115	73	117	132	102	120	133	120	104	113
80	40	0	128	136	86	140	163	136	151	173	154	123	139
80	40	40	126	108	84	138	161	133	164	178	160	129	138
120	0	0	106	113	70	116	130	100	116	127	108	93	108
120	40	0	131	130	88	145	172	137	162	177	164	121	143
120	40	40	136	136	90	147	175	142	170	178	170	131	147
160	0	0	105	108	74	124	149	117	139	150	135	120	122
160	40	0	138	128	92	152	178	146	171	181	173	137	150
160	40	40	133	140	88	151	174	143	176	179	161	131	147
200	0	0	120	110	78	128	147	119	139	155	151	123	127
200	40	0	137	139	84	141	171	136	165	177	167	131	145
200	40	40	135	129	87	152	175	138	170	179	170	131	147

continued

Table 1. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2008–2017

Fertilizer			Grain sorghum yield										
N	P ₂ O ₅	K ₂ O	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
ANOVA (P>F)													
Nitrogen			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs. P-K			0.745	0.324	0.892	0.278	0.826	0.644	0.117	0.806	0.943	0.727	0.932
N × P-K			0.005	0.053	0.229	0.542	0.186	0.079	0.012	0.002	0.001	0.084	0.006
MEANS													
Nitrogen, lb/a			----- bu/a -----										
0			64d	70c	52c	82d	87d	70d	94e	96d	87d	76d	78d
40			103c	104b	72b	117c	129c	106c	134d	146c	129c	108c	115c
80			123b	120a	81a	132b	152b	124b	145c	161b	145b	119b	130b
120			124ab	126a	82a	136ab	159ab	126b	149bc	161b	147b	115bc	133b
160			125ab	125a	84a	142a	167a	135a	162a	170a	156a	129a	140a
200			131a	126a	83a	141a	165a	131ab	158ab	170a	163a	129a	140a
LSD _(0.05)			7	11	5	8	9	8	9	8	8	9	6
P ₂ O ₅ -K ₂ O, lb/a													
0 - 0			101b	99b	68b	111b	125b	99b	120b	129b	117b	99b	107b
40 - 0			117a	120a	80a	130a	152a	124a	148a	162a	149a	119a	130a
40 - 40			117a	116a	79a	133a	152a	123a	153a	161a	148a	120a	130a
LSD _(0.05)			5	7	4	6	6	5	6	5	6	6	4

ANOVA = analysis of variance. LSD = least significant difference.

Table 2. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on grain N, P, and K content of irrigated grain sorghum, Tribune, KS, 2008–2017

Fertilizer			Grain						Grain removal			*AFNR _g	*AFPR _g	*AFKR _g
N	P ₂ O ₅	K ₂ O	N	P	K	N	P	K	N	P	K			
lb/a			%			lb/bu			lb/a			%		
0	0	0	1.02	0.263	0.361	0.50	0.129	0.177	36	9	13	---	---	---
0	40	0	1.01	0.315	0.385	0.50	0.154	0.189	39	12	15	---	18	---
0	40	40	1.01	0.312	0.382	0.50	0.153	0.187	40	12	15	---	18	7
40	0	0	1.13	0.239	0.345	0.55	0.117	0.169	54	11	17	45	---	---
40	40	0	1.09	0.318	0.373	0.53	0.156	0.183	66	19	23	76	58	---
40	40	40	1.10	0.311	0.370	0.54	0.152	0.181	64	18	22	70	52	27
80	0	0	1.33	0.223	0.339	0.65	0.109	0.166	73	12	19	47	---	---
80	40	0	1.22	0.298	0.357	0.60	0.146	0.175	82	20	24	58	63	---
80	40	40	1.18	0.306	0.360	0.58	0.150	0.176	79	21	24	54	66	35
120	0	0	1.39	0.210	0.336	0.68	0.103	0.164	73	11	18	31	---	---
120	40	0	1.32	0.286	0.354	0.65	0.140	0.174	92	20	25	46	61	---
120	40	40	1.32	0.306	0.358	0.64	0.150	0.175	95	22	26	49	73	39
160	0	0	1.41	0.233	0.345	0.69	0.114	0.169	84	14	21	30	---	---
160	40	0	1.38	0.307	0.361	0.68	0.150	0.177	101	22	26	41	76	---
160	40	40	1.35	0.286	0.353	0.66	0.140	0.173	97	20	25	38	64	38
200	0	0	1.42	0.238	0.349	0.70	0.117	0.171	88	15	22	26	---	---
200	40	0	1.39	0.285	0.357	0.68	0.140	0.175	98	20	25	31	63	---
200	40	40	1.39	0.291	0.359	0.68	0.143	0.176	99	21	26	32	66	39

continued

Table 2. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on grain N, P, and K content of irrigated grain sorghum, Tribune, KS, 2008–2017

Fertilizer			Grain			Grain removal			*AFNR _g	*AFPR _g	*AFKR _g			
N	P ₂ O ₅	K ₂ O	N	P	K	N	P	K						
----- lb/a -----			----- % -----			----- lb/bu -----			----- lb/a -----			----- % -----		
ANOVA (P>F)														
Nitrogen			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Linear			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Quadratic			0.001	0.005	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.094	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.911	---	
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	---	---	---
P vs. P-K			0.363	0.900	0.680	0.363	0.900	0.680	0.614	0.922	0.925	---	---	---
N × P-K			0.285	0.009	0.231	0.285	0.009	0.231	0.080	0.001	0.003	0.029	0.093	---
MEANS														
Nitrogen, lb/a														
0			1.01e	0.297a	0.376a	0.50e	0.146a	0.184a	38e	11d	14d	---	18c	7c
40			1.11d	0.289a	0.363b	0.54d	0.142a	0.178b	61d	16c	20c	64a	55b	27b
80			1.24c	0.276b	0.352c	0.61c	0.135b	0.172c	78c	18ab	22b	53b	64a	35a
120			1.34b	0.267b	0.349c	0.66b	0.131b	0.171c	86b	18bc	23b	42c	67a	39a
160			1.38ab	0.275b	0.353c	0.68ab	0.135b	0.173c	94a	19a	24a	36d	70a	38a
200			1.40a	0.272b	0.355c	0.68a	0.133b	0.174c	95a	19ab	24a	29e	64a	39a
LSD _(0.05)			0.04	0.012	0.006	0.02	0.006	0.003	4	1	1	6	8	5
P ₂ O ₅ -K ₂ O, lb/a														
0 - 0			1.28a	0.234b	0.346b	0.63a	0.115b	0.169b	68b	12b	18b	36b	---	---
40 - 0			1.24b	0.302a	0.365a	0.61b	0.148a	0.179a	80a	19a	23a	50a	56	---
40 - 40			1.22b	0.302a	0.364a	0.60b	0.148a	0.178a	79a	19a	23a	48a	56	---
LSD _(0.05)			0.03	0.008	0.004	0.01	0.004	0.002	3	1	1	5	5	---

*AFNR_g, AFPR_g, and AFKR_g= Apparent Fertilizer N Recovery (grain), Apparent Fertilizer P Recovery (grain), and Apparent Fertilizer K Recovery (grain). ANOVA = analysis of variance. LSD = least significant difference.

Nitrogen Application Effects on Forage Sorghum Biomass Production and Nitrates

A.K. Obour, J.D. Holman, and D.B. Mengel

Summary

Forage sorghum (*Sorghum bicolor* (L.) Moench) is an important annual forage crop but prone to high nitrate concentration, which can cause toxicity when fed to cattle. Field experiments were conducted over four site-years across western Kansas to determine the optimum nitrogen (N) rate for no-till forage sorghum biomass accumulation and also investigate the effect of N fertilization on sorghum forage nitrate content. Nitrogen fertilizer rates were 0, 25, 50, 75, 100, and 125 lb N/a arranged in a randomized complete block design with four replications. Forage sorghum responded positively to N fertilizer application in 2 of 4 site-years. Maximum DM production was 5545 lb/a and occurred with an available N rate of 114 lb N/a. However, the economic optimum N rate ranged from 76 to 89 lb/a when N fertilizer cost was \$0.43/lb N and hay price ranged from \$0.02 to \$0.03/lb DM. Forage nitrate concentration exceeded the virtually safe limit of 3000 ppm for cattle when available N rate was beyond 55 lb/a. Because high forage nitrate content reduces the economic and feed value of forages, we recommend growers apply no more than 55 lb/a available N to forage sorghum grown under rain-fed conditions.

Introduction

Forage sorghum (*Sorghum bicolor* (L.) Moench) is a highly productive annual summer forage that can be grazed, hayed or ensiled for winter feed, confined feeding, or grazed to supplement native pasture. Recently, there has been interest in growing forage sorghum for hay or grazing in place of fallow to increase residue cover as part of an integrated forage or cover crop system. The high water use efficiency and heat and drought tolerance of sorghum makes it an ideal forage crop choice for growers in the water-limited Great Plains environment. Furthermore, due to the declining saturated thickness of the Ogallala and High Plains aquifers, there is a need for more water-efficient forages such as sorghum compared to corn silage or alfalfa.

Despite the great potential of forage sorghum as animal feed, high nitrate content is a major concern when fed to cattle. Forage containing 3,000 ppm nitrates are generally considered safe as livestock feed, nitrate concentrations between 3,000 and 6,000 ppm may be limit fed, and concentrations > 9,000 ppm should not be fed to livestock. Ensiling reduces nitrate concentration but still requires caution when fed. Environmental stressors (including drought, frost, or cloudy weather conditions) and high manure or N fertilizer application rates can predispose forage crops to accumulate greater nitrate concentration in the aboveground biomass.

Nitrogen application generally increased DM production, but excessive N application will also increase nitrate concentration in the harvested biomass. Limited research has been conducted on forage sorghum DM production and nitrate concentration responses to N fertilizer application in the semi-arid Great Plains region. Objectives of

this study were to determine optimum N rates and quantify forage sorghum hay nitrate concentration as affected by N application under rain-fed no-till conditions in the semi-arid central Great Plains.

Procedures

Treatments were six N fertilizer rates (0, 25, 50, 75, 100, and 125 lb N/a) applied prior to planting, conducted over four site-years near Garden City and Jetmore, KS. At each site-year, the N fertilizer rates were arranged in a randomized complete block design with four replications. Individual plot sizes were 10-ft wide × 30-ft long. All plots at each site-year received a blanket application of P and S fertilizers prior to seeding based on recommendations from soil tests conducted at the Kansas State University Department of Agronomy Soil Testing Laboratory. Seasonal precipitation was recorded for all site-years from nearby weather stations (Table 1). Weed control at each site-year was accomplished with a pre-plant burn down using appropriate herbicides. Forage sorghum at each site-year was planted the first week in June depending on weather and soil conditions.

The plots were harvested at heading which is when most producers harvest to optimize both forage hay biomass production and nutritive value. Due to limited moisture availability to generate regrowth, forage was harvested only once in August at heading. During each harvest, a 3-ft wide × 30-ft long forage strip was harvested from each plot to a 5-inch stubble height using a Carter small plot forage harvester (Carter Manufacturing Company, Inc., Grand Haven, MI). Forage plots were intentionally harvested at a higher stubble height to match Kansas State University recommendations to retain soil residue cover and avoid the lowest portions of the plant which are normally greater in nitrate concentration. Fresh weights of samples were recorded, sub-samples were weighed, and oven dried at 50°C for at least 48 hours in a forced-air oven for DM determination. Oven-dried samples were ground to pass through a 1-mm mesh screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ), sequentially. The ground samples were then analyzed for N concentration by dry combustion using a LECO CN analyzer (LECO Corporation, St. Joseph, MI). In addition, forage samples were extracted with 2 M KCl and nitrate concentration determined colorimetrically by cadmium reduction. The amount of N removed was computed by multiplying N concentration by forage DM biomass accumulation. Nitrogen use efficiency (NUE; lb DM/ lb N uptake) was also computed.

Statistical analysis with the Proc Mixed procedure in SAS version 9.4 (Cary, NC) was used to examine sorghum DM production, CP, nitrate concentration, and NUE as a function of N application. Site-year and N rates were considered fixed effects, and block nested within site-year as random. Mean comparisons were done using Tukey's Honest Significant Difference (HSD) test. Interaction and treatment effects were considered significant when *F* test *P* values were ≤ 0.05. Regression analyses were conducted to determine the relationship between DM production, nitrate concentration and available N (soil plus fertilizer application rate) using data from site-years with a response to N application. A quadratic response model was used to describe DM response to N fertilizer application rate, and the agronomic maximum N rate (N_{max} , lb N/a) was determined by equating the first derivative of the quadratic function to zero. Similarly, the economic optimum N rates (EONR, lb N/a) were calculated by setting the first

derivative of the quadratic response curve of the relationship between DM production and available N rate equal to the price ratio of the N fertilizer cost and the price of sorghum hay. The EONR rates were then computed for fertilizer price range of \$300 to \$800/ton of urea fertilizer, and hay value of \$40 to \$120/ton DM.

Results

Forage Biomass Production

Site-year \times N rate interaction had an effect on forage DM accumulation (Table 2). This occurred because sorghum DM showed no significant response to N application in 2013 and 2014 at Garden City and Jetmore, KS, respectively. This was mostly due to greater residual $\text{NO}_3\text{-N}$ at Garden City and possibly greater N mineralization from soil organic matter decomposition from previous alfalfa crop at the Jetmore site. In site-years when DM yield responded positively to N fertilizer application, forage DM produced with 50 lb N/a was similar to that obtained with greater N rates. Across site-years, average DM production was least in 2012 at Garden City and the most in 2014 at Jetmore. This corresponds well with the growing season precipitation measured at each of the study sites (Table 1).

Total DM produced over the two site-years (2012 growing season at Garden City and Jetmore) that responded to N fertilizer rate were combined and modelled with a quadratic response model. The model showed a maximum DM production of 5545 lb/a that occurred with available N rate (soil plus fertilizer N) of 114 lb/a (Figure 1). However, the EONR ranged from 37 to 105 lb N/a available N depending on N fertilizer and sorghum hay price (Table 3). At lower sorghum hay prices, N fertilizer price had a significant effect on EONR that a grower should apply. For instance, at \$0.02 to \$0.03/lb hay price, the EONR varied greatly with a change in N fertilizer price. However, when sorghum hay price was set at \$0.06/lb DM, little change in EONR was observed with change in fertilizer price (Table 3). Using a current local urea fertilizer price of \$0.43/lb N (Midland Marketing, personal communication) and hay value of \$0.02 to \$0.03/lb DM, the EONR ranged from 76 to 89 lb N/a (Table 3).

Forage Nitrate Concentration

Forage nitrate concentration differed with site-year and N fertilizer application rate. Averaged across N rates, nitrate concentration was most at Jetmore in 2014 and least at Garden City in 2012 (Table 2). The observed differences in forage nitrates correspond well with initial residual soil profile N concentration measured at each site-year. Residual soil test N in 2012 at Garden City was 23 lb, and 123 lb/a at this same site in 2013 (Table 2). The significantly greater soil nitrates mostly contributed to greater forage nitrate concentrations in 2013 at this site. Greater forage nitrate concentration at Jetmore in 2012 could be due to relatively warmer temperatures in summer of 2012 at this site (Table 1) that resulted in high nitrate accumulation. Using the forage nitrate data at Jetmore only, nitrate concentration responded linearly to available N rate. The regression analysis showed a 35.7 ppm increase in forage nitrate concentration with each lb of available N (Figure 2). In general, available N amounts beyond 55 lb/a resulted in forage nitrate concentration exceeding the virtually safe limit of 3000 ppm for cattle consumption. This finding suggests supplementing 50 to 60 lb N/a (residual soil nitrate plus fertilizer) will produce adequate forage biomass and also reduce nitrate concentration in the harvested feed.

Nitrogen Uptake and Nitrogen Use Efficiency

Site-year \times N rate interaction had an effect on N uptake. Increasing N fertilizer application increased N uptake only in 2012 at Garden City and Jetmore but not in 2013 or 2014 growing seasons. This is possibly due to greater available N in 2013 at Garden City and 2014 at Jetmore. In general, N uptake was most in 2014 at Jetmore and the least in 2012 at Garden City, mostly due to differences in DM produced (Table 2).

Nitrogen use efficiency computed as DM produced per unit of N uptake was not affected by N application rate except at Jetmore in 2012. Applying N fertilizer decreased NUE from 81 lb DM/lb N with no N to 62 lb DM/lb N at the highest N rate of 125 lb N/a (Table 2). In general, NUE was most at Garden City in 2012 and least at this same site in the 2013 growing season (Table 2). This observation could be explained by the greater DM response to N fertilizer application in 2012 compared to 2013 when there was no response to N due to greater residual soil N.

Table 1. Total monthly precipitation at the study locations in southwest Kansas

Month	Garden City		30-year average	Jetmore		30-year average
	2012	2013		2012	2014	
	----- Precipitation, in. -----					
January	0.01	0.41	0.45	0.01	0.43	0.67
February	0.56	0.82	0.55	1.29	0.78	0.74
March	1.93	0.12	1.42	1.99	0.15	2.07
April	2.43	0.47	1.75	2.30	0.71	1.91
May	0.15	0.81	2.91	1.18	0.78	3.25
June	1.11	2.49	3.35	0.89	8.86	3.06
July	2.32	1.95	2.86	2.58	4.32	3.14
August	1.89	5.26	2.52	6.09	2.30	2.30
Total	10.4	12.33	15.81	16.33	18.33	17.14

Table 2. Forage sorghum biomass production, nitrogen (N) uptake and forage nitrate responses to N fertilizer over four site-years in southwest Kansas

N rate	Soil NO ₃	Biomass	Forage NO ₃	N uptake	NUE [§]
	----- lb/a -----		ppm	lb/a	lb/lb
Garden City 2012					
0	23	1884 b [†]	156 a	23 b	83 a
25	23	3295 ab	164 a	36 ab	93 a
50	23	4606 a	170 a	43 ab	109 a
75	23	5160 a	258 a	55 a	98 a
100	23	4480 a	399 a	51 ab	92 a
125	23	5263 a	337 a	60 b	90 a
HSD [†]		2035	ns [‡]	30.2	ns
<i>P</i> -value		0.0004	0.06	0.01	0.11
Garden City 2013					
0	123	3492 a	3694 a	60 a	59 a
25	123	4120 a	3703 a	69 a	59 a
50	123	4403 a	4062 a	80 a	55 a
75	123	4477 a	3954 a	75 a	59 a
100	123	4601 a	4019 a	78 a	59 a
125	123	4476 a	3530 a	79 a	56 a
HSD		ns	ns	ns	ns
<i>P</i> -value		0.32	0.85	0.18	0.19

continued

Table 2. Forage sorghum biomass production, nitrogen (N) uptake and forage nitrate responses to N fertilizer over four site-years in southwest Kansas

N rate	Soil NO ₃	Biomass	Forage NO ₃	N uptake	NUE [§]
	lb/a		ppm	lb/a	lb/lb
Jetmore 2012					
0	12	3504 b	556 b	43 b	81 ab
25	12	4914 ab	615 b	61 bc	83 a
50	12	5035 ab	3885 a	75 ab	68 abc
75	12	6741 a	4402 a	95 a	70 abc
100	12	6225 a	5009 a	97 a	64 bc
125	12	5940 ab	5777 a	97 a	62 c
HSD		2685	2423	30	18
<i>P</i> -value		0.02	<0.0001	0.006	0.004
Jetmore 2014					
0	23	8385 a	2294 b	89 a	96 a
25	23	8383 a	3330 ab	95 a	91 a
50	23	8471 a	5111 ab	98 a	88 a
75	23	7663 a	7408 a	83 a	95 a
100	23	7091 a	5536 ab	81 a	89 a
125	23	8894 a	4562 ab	107 a	84 a
HSD		ns	4304	ns	ns
<i>P</i> -value		0.25	0.016	0.39	0.9

[†]Means followed by same lower case letter (s) within a site-year are not significantly different using Tukey's Honest Significant Difference (HSD) test.

[‡]HSD is minimum difference between two treatments used to declare they are significantly different using Tukey's Honest Significant Difference Test.

[§]NUE = Nitrogen use efficiency.

[¶]NS = not significant.

Table 3. Economic optimum nitrogen (N) rates (EONR, lb/a) as a function of N fertilizer price and forage sorghum hay value

N price/forage value (\$/lb DM)	0.02	0.03	0.04	0.05	0.06
\$/lb N	EONR (lb/a)				
0.33	85	95	100	103	105
0.43	76	89	95	99	102
0.54	66	82	90	95	98
0.65	56	76	85	91	95
0.76	47	69	80	87	92
0.87	37	63	76	83	89

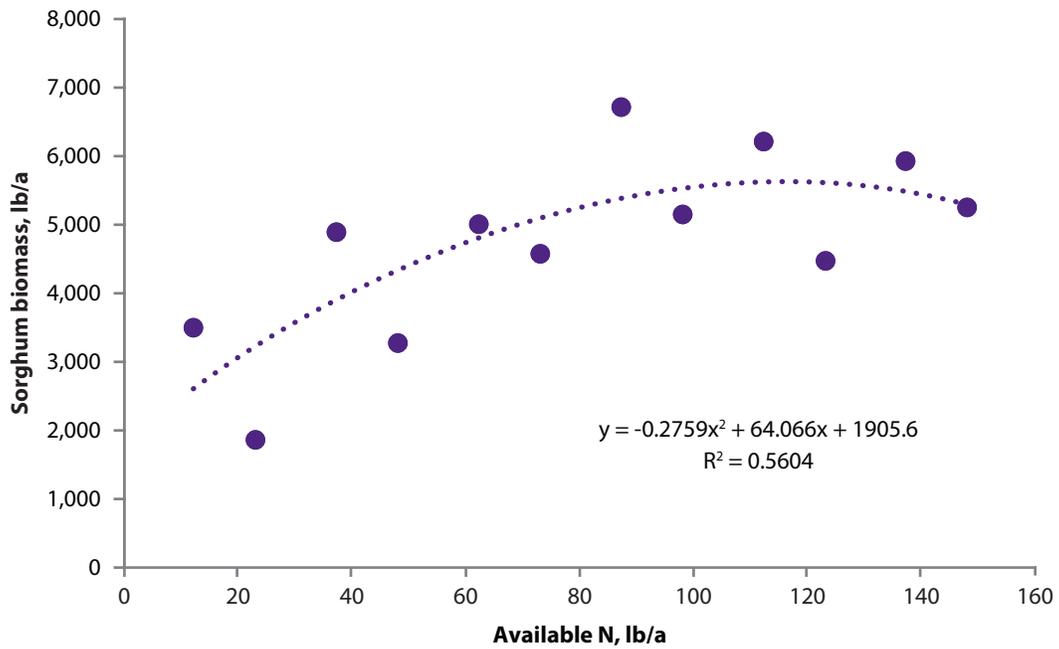


Figure 1. Forage sorghum biomass response to available N (soil plus fertilizer N) over two site-years (Garden City and Jetmore in 2012 growing season) in southwest Kansas.

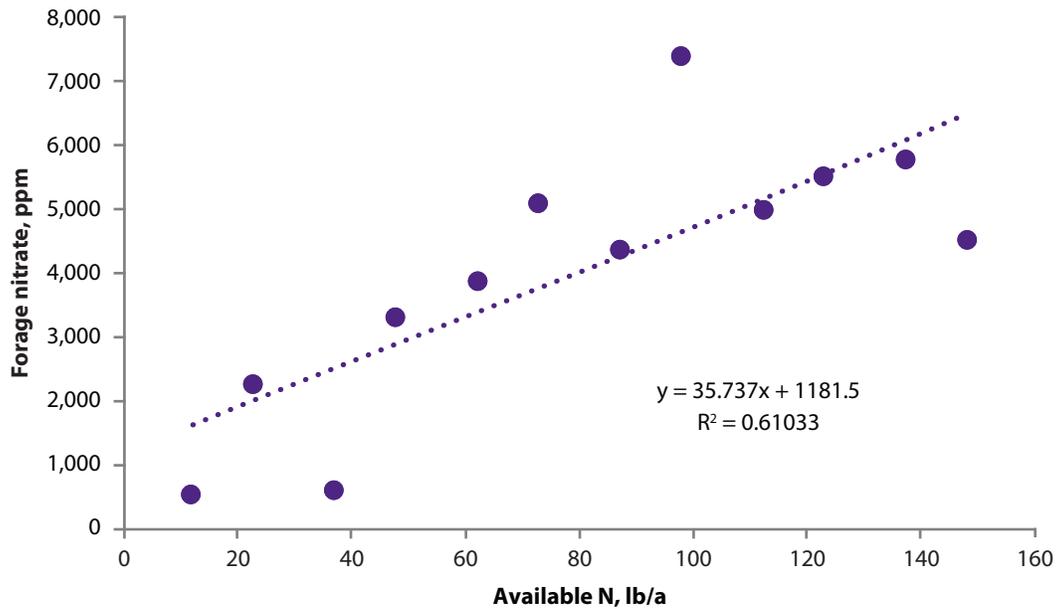


Figure 2. Response of forage sorghum biomass nitrate concentration to available N at Jetmore, KS, in 2012 and 2014 growing seasons.

Seeding Rate and Nitrogen Application Effects on Spring Oat and Triticale Forage

A.K. Obour, J.D. Holman, and A.J. Schlegel

Summary

Spring oat (*Avena sativa* L.) and triticale (*X Triticosecale* Wittmack) are important cool-season annual forage crops in dryland production systems. However, information on best agronomic management practices including seeding rate and nitrogen (N) fertilizer recommendations are limited. Field experiments were conducted to determine optimum N rates and also investigate seeding rate effect on oat and triticale forage production. Treatments were three seeding rates (75, 100, and 125% of recommended seeding rate) and five N rates (0, 10, 30, 50, and 70 lb N/a) in a split-plot treatment arrangement conducted over four site-years across western Kansas. Site-year ($P < 0.0001$), N rate ($P < 0.0001$), and site-year \times N rate interaction ($P < 0.001$) all affected forage dry matter (DM) production. However, seeding rate had no effect on forage DM or nutritive value in both oat and triticale. Across sites, oat DM produced with 30 lb N/a was similar to yields with increased N rates. Similarly, triticale DM production increased with N application rates but not beyond 50 lb/a. Increasing N application rates increased crude protein (CP) and *in-vitro* dry matter digestibility (IVDMD), while decreasing acid detergent fiber (ADF) and neutral detergent fiber (NDF) concentrations. Our findings suggest growers can plant oat and triticale forage at 25% less than the recommended seeding rate with no significant decrease in forage production.

Introduction

Spring oat and triticale are important forage crops in dryland and limited irrigation crop production systems in western Kansas. Previous research in western Kansas showed that growing spring forages in place of fallow reduced soil erosion and increased fallow precipitation use efficiency compared to summer fallow, and increased profitability compared to fallow in years with average to above average rainfall. Despite the great potential of spring forages, information on seeding rate and nitrogen fertilizer recommendations are limited. These management practices can affect forage productivity and nutritive value.

Current N fertilizer recommendations for oat and triticale are based on a very limited dataset. In dryland crop production systems in western Kansas, cool-season forages are usually planted in the spring into winter wheat (*Triticum aestivum* L.) or a summer crop (corn or grain sorghum) stubble. Residual nutrients from the previous crop could provide adequate nutrients for the spring forage crop. However, lower spring temperatures and N immobilization from the previous crop residue often limit early-season N availability for oat or triticale forage. Additional fertilizer application may be needed to boost forage production. Adequate fertility might increase tillering and yield potential, even at lower seeding rates. Moreover, N application in excess of crop uptake can result in environmental quality degradation, economic loss, and forages high in nitrate concentration. It is therefore imperative that site-specific N fertilizer research is conducted to fine-tune N fertilizer rates for these cool-season forages to improve yields and environmental quality.

Seeding rate is an important crop management practice that affects forage production. It is suggested that spring oat and triticale grown for forage be planted at 25 to 50% greater seeding rates than when managed for grain production. The increase in plant density will allow for greater early crop establishment, smaller stems, and increased DM production. To our knowledge, the effect of seeding rate on oat or triticale forage DM production and its interaction with N fertilizer rates has not been extensively studied in semiarid dryland environments. Determining the optimum seeding rate for oat and triticale is important because seed costs constitute a significant component of the variable cost in forage production systems. The objectives of this study were to (1) determine N fertilizer rate effects on DM production and nutritive value for oat and triticale forage, and (2) quantify effect of seeding rate on oat and triticale forage yield and its interaction with N fertilizer application under dryland conditions in western Kansas.

Procedures

Field experiments were conducted over four site-years across three locations (Garden City, Hays, and Jetmore) in western Kansas during 2015 and 2016 growing seasons. The experimental design was a randomized complete block with three replications in a split-plot arrangement. The main plots were three seeding rates (75, 100, and 125% of the recommended oat and triticale forage seeding rates) and five N fertilizer rates (0, 10, 30, 50, and 70 lb N/a) as sub-plots. The 100% oat forage recommended seeding rate was 64 lb/a and the 100% of the recommended seeding rate for triticale was 72 lb/a. Individual plots sizes were 10-ft wide × 30-ft long. Nitrogen source at all site-years was urea, which was broadcasted after crop emergence. Plots at each site-year received a blanket application of 15 lb P₂O₅/a prior to seeding. Weed control was accomplished with a pre-plant burn down of glyphosate [isopropylamine salt of *N*-(phosphonomethyl) glycine] and 2, 4-dichlorophenoxyacetic acid. Planting for both crops at each site-year were done in March, with planting date dependent on weather and soil conditions.

Oat and triticale were harvested at heading to optimize forage DM accumulation and nutritive value. Forage harvests were performed the first or second week in June. During each harvest, a 3- × 30-ft forage strip was harvested from each plot using a Carter plot forage harvester (Carter Manufacturing Company, Inc, Grand Haven, MI) to 3-in. stubble height. Fresh weights of samples were recorded, sub-samples were weighed, and oven dried at 60°C for at least 48 hours in a forced-air oven for DM determination. Oven-dried samples were ground to pass through a 1-mm mesh screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ). The ground samples were then analyzed for forage nutritive value [crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), *in-vitro* dry matter digestibility (IVDMD)], and tissue nutrient concentrations (Ward Laboratories, Inc., Kearney, NE) using Foss 6500 near infrared spectroscopy (NIRS).

Results

Forage Yield

Seeding rate had no significant effect on oat ($P = 0.80$) or triticale ($P = 0.59$) forage DM produced. Averaged across site-years and N fertilizer rates, oat DM was 3592 lb/a with 75% of the recommended seeding rate, 3679 lb/a for 100% recommended seeding rate and 3616 lb/a for the 125% of the recommended seeding rate treatment. Similarly, triticale forage production with 75% of the recommended seeding rate was 4106 lb/a,

4362 lb/a for 100% recommended seeding rate, and 4280 lb/a for 125% recommended seeding rate. This finding suggests the current recommended seeding rate for spring oat and triticale managed for forage, 64 and 72 lb/a, respectively, could be reduced 25% without significant yield penalties. This is important because seed costs account for a significant portion of the variable cost in forage production. Savings accrued through reduced seeding rate could increase profitability of the production system.

Site-year ($P < 0.0001$), N rate ($P < 0.0001$), and site-year \times N rate interaction ($P < 0.001$) all affected forage DM produced (Tables 1 and 2). Averaged across N rates, forage DM production was least in 2016 at Jetmore and the most in 2015 at Garden City. Forage production at Hays was intermediate between that of Garden City and Jetmore. Less DM production at Jetmore was partly due to uneven distribution of growing season precipitation at this site (data not shown). Spring oat and triticale were planted on March 15 and the site received no measurable rain until a heavy rainfall on April 16 (4.8 inches) and another 2.1 inches on April 29. The two large rainfall events constituted $>60\%$ of the total active growing season precipitation (March through May). This resulted in intermittent drought conditions most of the growing season, which had an effect on forage production. Greater residual soil N and average precipitation in 2015 in Garden City resulted in greater DM production compared to the other site-years.

The site-year \times N rate interaction effects on forage production possibly occurred because of greater initial soil N concentration in 2015 at Garden City that resulted in no significant response to N application at this site (Tables 1 and 2). Except 2016 at Hays, oat forage DM produced with 30 lb N/a was similar to that obtained with greater N fertilizer rates (Table 1). Above-normal growing season precipitation amounts in 2016 at Hays resulted in greater DM response to N fertilizer application but DM plateaued at 50 lb/a. Averaged across the four site-years, there was no significant increase in oat DM accumulation beyond 30 lb/a. Similarly, across site-years, triticale DM production of the unfertilized control was 80% of that obtained with 70 lb/a. However, triticale DM accumulation plateaued with 50 lb N/a (Table 2).

Forage Nutritive Value

The site-year \times N rate interaction, N rate, and site-year had an effect on spring oat and triticale forage CP concentration (Table 1 and 2). Greater CP concentration measured in Garden City was mostly due to relatively greater initial residual N concentration at this site. Lesser CP concentration at Hays compared to that measured at Jetmore could be attributed to N dilution effects, a process that results in decreased N content as DM accumulation increased. In general, CP concentration increased with an increase in N fertilizer application at each site-year (Tables 1 and 2). Averaged across site-years, N fertilizer application to oat increased CP concentration from 11.7% with the unfertilized control to 13.8% when 70 lb N/a was applied. Crude protein concentration in triticale forage ranged from 12.8% with no fertilizer N to 14% with 70 lb N/a. The CP requirement for growing replacement heifers with body weight (BW) of 1200 lb at maturity ranged from 10.2% (with growing BW of 660 lb) to 8.1% (with growing BW of 960 lb) assuming the forage contains $\geq 60\%$ total digestible nutrients (NRC, 2000. Nutrient requirement of beef cattle). Therefore, average CP concentration of the treatments at all site-years (except the control in 2016 at Hays) in the current study were

greater than the minimum CP requirement for growth or maintenance of grazing beef cattle.

Oat and triticale ADF, NDF, IVDMD, and nutrient concentration were affected by N fertilizer application (Table 3). In general, ADF and NDF concentrations decreased with increase in N fertilizer application rate in both oat and triticale forage. In the present study, lignin concentration decreased slightly with increased N fertilizer rates (Table 3) and could partly account for the observed decrease in ADF and NDF concentrations when N was applied. The IVDMD concentration as a measure of forage digestibility increased with N fertilizer application rate in both oat and triticale. This observation was expected because application of N fertilizer decreased ADF and NDF concentrations, both of which affect forage digestibility. Forage oat calcium (Ca), phosphorus (P), and potassium (K) concentrations increased with an increase in N fertilizer application rate. However, P concentration in triticale forage was not affected by N fertilizer application rate.

Table 1. Oat forage mass and crude protein (CP) concentration as affected by nitrogen (N) application at three locations in western Kansas

N rate lb/a	2015	2015	2016	2016	Mean
	Garden City	Hays	Hays	Jetmore	
	Forage DM, lb/a				
0	6667 a [†]	1461 c	3156 c	279 c	2891 c
10	6696 a	2164 b	3729 b	393 bc	3246 b
30	7103 a	3733 a	4077 b	710 ab	3906 a
50	6739 a	3716 a	4735 a	882 a	4018 a
70	6907 a	3646 a	4901 a	886 a	4085 a
Means	6822 A	2944 C	4120 B	630 D	
	CP concentration, %				
0	15.3 b	8.7 b	7.7 c	15.0 bc	11.7 d
10	15.9 ab	8.7 b	9.1 b	14.1 c	12.0 d
30	16.8 a	9.2 ab	9.3 b	14.6 c	12.5 c
50	16.2 a	9.4 a	11.2 a	15.8 b	13.2 b
70	16.8 a	9.7 a	11.7 a	17.0 a	13.8 a
Means	162 A	91 D	98 C	153 B	

[†]Means followed by same lower case letter(s) within a site-year are not significantly different. Upper case letter(s) denotes comparisons between site-years. All mean comparison were conducted using the least squares means (LSMEANS) and adjusted Tukey multiple comparison procedure ($P > 0.05$).

Table 2. Triticale forage mass and crude protein (CP) concentration as affected by nitrogen (N) application at three locations in western Kansas

N rate lb/a	2015	2015	2016	2016	Mean
	Garden City	Hays	Hays	Jetmore	
	Forage mass, lb/a				
0	7128 a [†]	2851 c	4454 c	452 c	3721 d
10	7429 a	3132 c	5024 b	499 c	4021 c
30	7285 a	3756 ab	5357 ab	681 bc	4269 b
50	7376 a	4124 a	5632 a	1060 ab	4548 a
70	7597 a	4086 a	5788 a	1272 a	4686 a
Means	7363 A	3590 C	5251 B	793 D	
	CP concentration, %				
0	15.7 b	9.8 c	12.0 c	13.8 b	12.8 b
10	16.3 b	9.9 c	12.6 b	13.6 b	13.1 b
30	17.3 a	12.1 a	12.7 b	14.0 b	14.0 a
50	17.0 a	11.0 b	12.9 ab	13.7 b	13.6 ab
70	16.3 b	11.4 b	13.4 a	15.0 a	14.0 a
Means	16.5 A	10.8 D	12.7 C	14.0 B	

[†]Means followed by same lower case letter(s) within a site-year are not significantly different. Upper case letter(s) denotes comparisons between site-years. All mean comparison were conducted using the least squares means (LSMEANS) and adjusted Tukey multiple comparison procedure ($P > 0.05$).

Table 3. Oat and triticale acid detergent fiber (ADF), neutral detergent fiber (NDF), *in-vitro* dry matter digestible (IVDMD), lignin, calcium (Ca), phosphorus (P), and potassium (K) concentrations as affected by nitrogen (N) application at three locations in western Kansas

N rate, lb/a	ADF	NDF	IVDMD	Lignin	Ca	P	K
Oat	----- % -----						
0	37.3 a [†]	61.0 a	76.1 c	2.8 a	0.40 b	0.29 c	2.52 d
10	36.8 ab	60.0 b	76.6 bc	2.7 ab	0.40 b	0.29 c	2.61 c
30	36.3 bc	60.0 b	77.2 ab	2.7 ab	0.42 a	0.31 b	2.78 b
50	36.2 bc	59.0 c	77.7 a	2.6 b	0.43 a	0.32 a	2.89 a
70	36.0 c	60.0 b	77.9 a	2.6 b	0.43 a	0.32 a	2.96 a
Triticale							
0	37.7 a	63.5 a	72.0 b	3.7 a	0.37 b	0.29 a	2.32 c
10	37.6 a	63.6 a	72.1 b	3.7 a	0.38 ab	0.29 a	2.37 c
30	36.8 b	62.5 b	73.3 a	3.5 a	0.38 ab	0.30 a	2.47 b
50	37.1 ab	63.1 ab	72.5 b	3.6 a	0.38 ab	0.30 a	2.43 b
70	37.0 ab	62.4 b	73.3 a	3.5 a	0.39 a	0.30 a	2.54 a

[†]Means followed by same letter(s) within site-year are not significantly different using the least squares means (LSMEANS) and adjusted Tukey multiple comparison procedure ($P > 0.05$).

Effect of Drilled Seeding and Nitrogen Rate on Grain Sorghum Yield in Southwest Kansas

A.J. Foster, A. Schlegel, I.B. Cuvaca, J.D. Holman, I.A. Ciampitti, C. Thompson, D. Ruiz Diaz, and R. Currie

Summary

This study compared drilled planted sorghum at four seeding rates to planted sorghum at three different nitrogen (N) fertility levels at two locations in southwest Kansas (Garden City and Tribune). In 2017, at the Garden City location using a John Deere experimental sorghum drill and at Tribune using a regular John Deere drill, higher yields were produced with drilled seeded sorghum with 60,000 and 80,000 seeds/a at both locations. Likewise, at both locations, there was no difference in yield between the planted and drilled sorghum at the same seeding rate. Nitrogen fertilizer did not interact with seeding rate to affect yield in Garden City, but significantly increased yield with an increased rate of application at the Tribune location. In general, the effect of nitrogen rates and seeding rates on sorghum yield was observed to be influenced by other management and environmental factors. The results of this study suggested that there was no yield penalty for drilling or planting sorghum at the same seeding rate.

Introduction

Drilled sorghum is normally done at the super-high population at row spacing between 7.5 and 10 inches, compared to rows planted at the spacing between 15 and 30 inches. Thompson (1983) growing super-thick sorghum at the Hays Research Station from 1974–1977, found that sorghum planted in narrow rows (12–18 in.) often produced higher yields than when planted in wide rows (24–40 in.). Norwood (1982) in Garden City repeated Thompson’s work also concluded that yield of high population narrow row sorghum could exceed that of the low population-wide row when subsoil moisture and precipitation were adequate. The conclusion from the work of Thompson and Norwood was that subsoil moisture and precipitation were big drivers for the high population, narrow row sorghum to equal or exceed the yield of the low population wide row. Since then, most researchers have found yield response to plant population to be variable depending on the environment. Overall, the consensus is that under conditions of adequate moisture, the yield of high population sorghum can continue to increase but can decrease under dry conditions. Moisture still remains the key for successful dryland sorghum production in southwest Kansas. Thus, the very familiar saying, “moisture and fertility are joined at the hip.” Thompson’s and Norwood’s work did not evaluate narrow row at population under 25,000 seeds/a and at a spacing less than 10 in. We hypothesized that drilled sorghum at lower population could make better use of water resources and produce similar yields to drilled sorghum at higher populations, and planted sorghum at the same population. Thus, the objective of this study is to evaluate drilled sorghum at different populations ranging from 20,000 to 80,000 seeds/a at a row spacing of 10 in. or less at different nitrogen rates. Furthermore, most farmers in southwest Kansas own both a drill and a planter. Thus, it is not just an

agronomic issue, but it is also about getting better value from a single piece of equipment in an already economically challenging wheat-sorghum-fallow production system.

Procedures

Experiments were conducted under dryland conditions at two locations in western Kansas (Southwest Research-Extension Center in Garden City and Tribune) to determine the interaction of seeding rate and nitrogen rate under narrow row sorghum in southwest Kansas. At the Garden City location, a John Deere sorghum experimental drill was used, while at the Tribune location research plot-sized equipment was used. The experimental design was a split plot design with seeding rate as the main plot and nitrogen rate as the subplot. The main plot size in Garden City was 30-ft wide × 40-ft long and the subplots were 10-ft wide × 40-ft long. In Tribune, the main plot was 60-ft wide × 50-ft long and the subplots were 20-ft wide × 50-ft long.

Planting Dates and Plot Layout

Sorghum variety Dekalb 3707 was planted at both locations, on June 12, 2017, in Garden City and June 6, 2017, in Tribune. A randomized complete block design with a 5 × 3 factorial treatment arrangement with four replications was used at both locations. At Garden City, sorghum was planted on 15 in. row spacing using a 40-ft wide John Deere experimental sorghum no-till drill. The drilled seeding rates were 20,000, 40,000, 60,000, and 80,000 seeds/a and the planted sorghum was seeded at 20,000 seeds/a with a planter at 30 in. row spacing with a John Deere 7300 planter.

At Tribune, sorghum was planted on 7.5 in. row spacing with a John Deere 1590 no-till drill. The drilled seeding rates were 20,000, 40,000, 60,000, and 80,000 seeds/a and the planted sorghum was seeded at 40,000 seeds/a with a planter at 30 in. row spacing with a John Deere 1700 planter. The three factors were three nitrogen rates (0, 50, and 100 lb/a) at both locations.

At both locations, potassium (K) and phosphorus (P) were applied based on the soil test recommendations provided by the Kansas State University Department of Agronomy Soil and Plant Testing Laboratory, Manhattan, KS.

Herbicide management at Garden City was the application of glyphosate at 1.25 qt/a + Harness at 2.5 pt/a + Starane Ultra at 0.75pt/a applied pre-plant on June 1, 2017. At Tribune, Atrazine at 1 lb/a + Rifle at 16 oz /a was applied early on February 16, 2017, followed by 80 oz/a Lumax E2 + 48 oz/a Gramoxone + 0.50% v/v NIS and applied pre-emergence on June 10, 2017.

Data Collection and Analysis

The Garden City location was harvested using a 7.5-ft wide head plot combine and Tribune was harvested with a 5-ft wide head. Crop weights were adjusted to 13% moisture.

Data were analyzed using PROC GLM with SAS 9.4 (SAS Institute, Inc., Cary, NC) and a model statement appropriate for a factorial design. Treatment means were separated by Fisher's projected least significant difference test.

Results

Garden City

Drilled sorghum at the higher populations produced the highest yield, but there was no difference in grain yield between the planted sorghum at 20,000 seeds/a and the drilled sorghum at the same seeding rate (Figure 1). Nitrogen rate did not interact with population or affect sorghum yield independently in the study.

Tribune

Similar to Garden City, higher yield was produced at the higher drilled seeding rate and there was no difference in grain yield between planted sorghum and drilled sorghum at the same seeding rate (Figure 2). Sorghum yield increased with the increased rate of nitrogen fertilizer (Figure 3).

Conclusion

The result observed in the study can be attributed to the influence of planting equipment, planting date, and environmental condition. At the Garden City location, the later planting date and the drier condition at and after planting might have contributed to the low yield obtained. At the Tribune location, the response to nitrogen fertilizer may be attributed to the influence of a hail storm on August 18. These results indicate the complexity of seeding rate with the management and environmental condition. Additionally, these results suggest that there is no yield penalty for drilling or planting sorghum at the same population.

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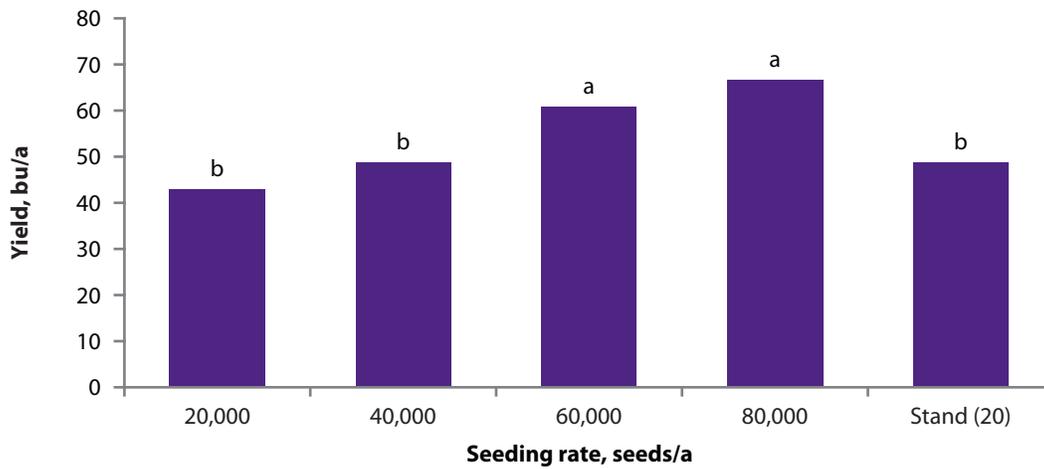


Figure 1. Grain sorghum yield affected by four drilled seeding rates and the standard planting rate (20,000 seeds/a) averaged across three different nitrogen rates at Garden City, KS.

^{ab}Different letters are not significantly different.

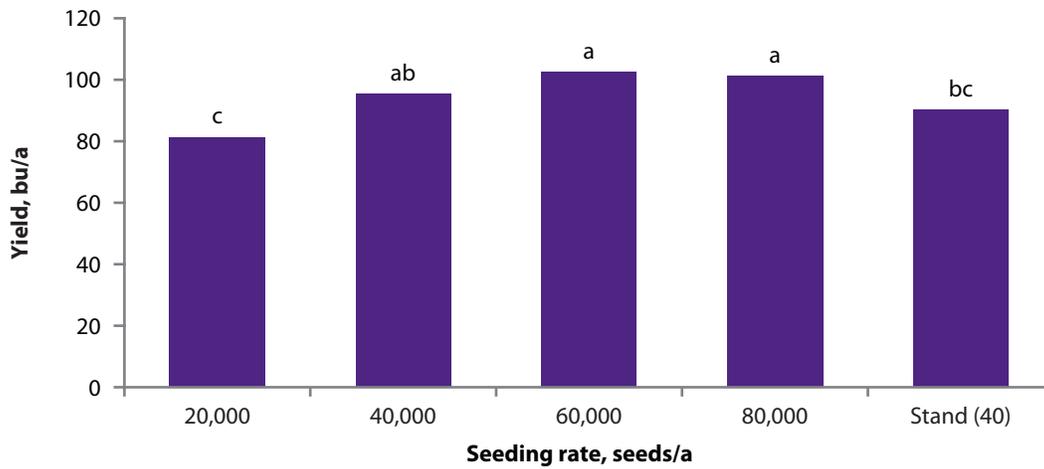


Figure 2. Grain sorghum yield affected by four drilled seeding rates and the standard planting rate (40,000 seeds/a) averaged across three different nitrogen rates at Tribune, KS.

^{abc}Different letters are not significantly different.

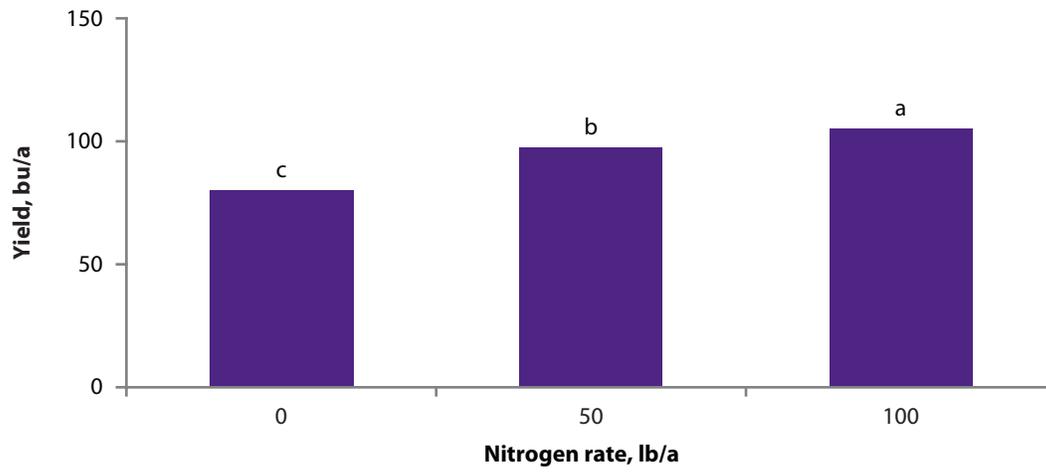


Figure 3. Grain sorghum yield affected by nitrogen rate under four drilled seeding rates and the standard planting rate in Tribune, KS.

^{abc}Different letters are not significantly different.

Integrating Half Rates of Dicamba and Atrazine with Increasing Sorghum Density and Nitrogen Rate for Palmer Amaranth Control

I.B. Cuvaca, A.J. Foster, and R.S. Currie

Summary

In-season weed control options for grain sorghum (*Sorghum bicolor*) are limited. Palmer amaranth (*Amaranthus palmeri*) can significantly reduce sorghum yield. Integrating half rates of dicamba and atrazine with increasing sorghum density and nitrogen rate could speed up canopy closure and therefore suppress Palmer amaranth (PA). A study was conducted at the Southwest Research-Extension Center near Garden City, KS from 2016 to 2017 to determine if PA could be suppressed with half-rates of dicamba and atrazine applied as preemergent (PRE) with increasing sorghum density (60,000, 90,000, and 120,000 seeds/a), and nitrogen rate (0, 100, and 200 lb/a). Sorghum grain yield was reduced by about 40% with the integration of increased sorghum density and nitrogen rate with half rates of dicamba and atrazine. Therefore, integrating half-rates of dicamba and atrazine applied as PRE with increasing sorghum density and nitrogen rate may not be an effective strategy for Palmer amaranth control.

Introduction

Sorghum is an important crop in Kansas. However, in-season weed control options for sorghum are limited. Season-long interference by Palmer amaranth exacerbates the limitation, due to PA's resistance to multiple herbicides that have different modes of action.

This 2-year study investigated the ability of a contrasting combination of cultural and chemical practices to control Palmer amaranth while maintaining or improving sorghum grain yield. Particular research emphasis was to evaluate the effect(s) of integrating half-rates of dicamba and atrazine applied as PRE with increasing sorghum density and nitrogen rate on PA control and grain yield in an irrigated environment.

Procedures

Experimental Site

Field experiments were conducted at the Southwest Research-Extension Center, near Garden City, KS, in 2016 and 2017. The soil at the site was predominantly Richfield silt loam (fine, montmorillonitic, mesic Aridic Argiustoll).

Experimental Design

Three planting densities (60,000, 90,000, and 120,000 seeds/a), three nitrogen rates (0, 100, and 200 lb/a), and two in-season weed control levels (weedy vs. weed free) were evaluated for their ability to control Palmer amaranth while maintaining grain yield of sorghum using a completely randomized block design with split-split plot arrangement

and four replicates. Planting density, nitrogen rate, and in-season weed control were treated as the main plot, sub-plot, and sub-sub plot factors, respectively.

Plot Establishment and Management

Experimental plots were established using a John Deere planter in a field with a natural infestation of Palmer amaranth. Each sub-sub plot was planted to 4 rows of sorghum at 22.5 ft (2016) or 35 ft (2017) long. The field was disked and field cultivated to assure a weed-free seedbed at planting. Sorghum, “DK 3707,” was planted on June 20, 2016, and May 24, 2017, in rows 30 in. apart, and 0.5 lb/a dicamba tank-mixed with 2 lb/a atrazine + .25% v/v Induce (surfactant) was sprayed across all plots at the spike stage or after sorghum had sprouted, but prior to sorghum emergence to avoid potential injury from the herbicide. No other weed species but Palmer amaranth was allowed to grow within the plots to avoid unwanted sources of variation. Further, hand-pulling and hoeing were done as necessary in plots assigned for in-season weed control. Irrigation was supplied to meet 120% of crop evapotranspiration. Sorghum was harvested at physiological maturity and yields were adjusted to 13% grain moisture.

Data Collection

Yield and other parameters including sorghum height and headcount, and Palmer amaranth number, height, and biomass were estimated from the two central rows. Only grain yield will be presented in this report.

Data Analysis

Data were analyzed using SAS version 9.3 (SAS Institute Inc., Cary, NC).

Results

Nitrogen rate and seeding rate did not affect sorghum yield independently or in combination. Controlling Palmer amaranth in plots increased sorghum yield by 50 bu/a (56%) in 2017 and 35 bu/a (32%) in 2016 (Figure 1).

Conclusion

In both years of the study, Palmer amaranth reduced sorghum yield by an average of about 40%. Clearly, integration of greater sorghum density (>60,000 seeds/a) in conjunction with increased N rate and half rates of dicamba and atrazine is not an effective strategy to control Palmer amaranth.

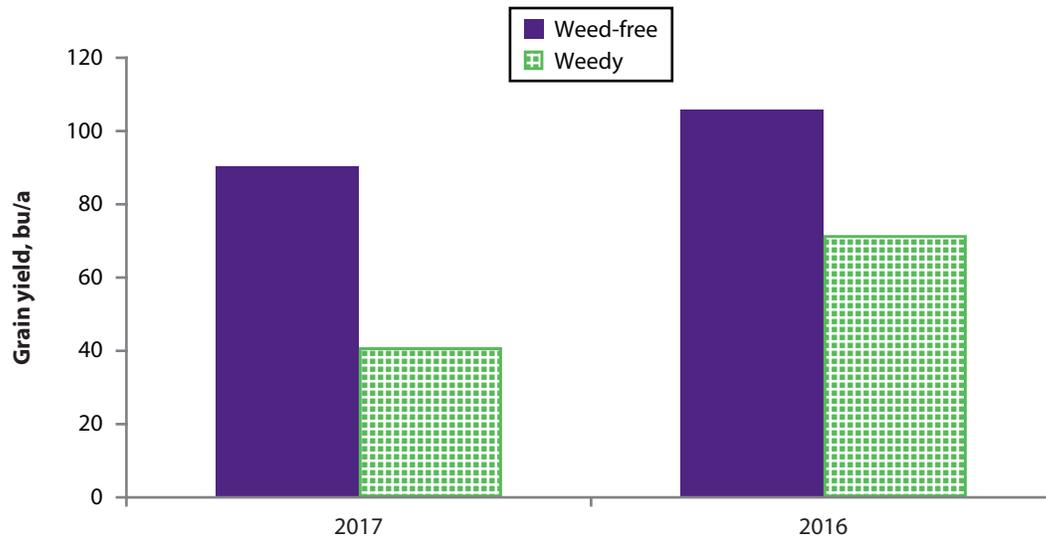


Figure 1. Sorghum grain yield as influenced by in-season weed control.

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

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

Summary

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

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

Introduction

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

Experimental Procedures

The experiment was established on two adjacent sites in fall 2012 (Site 1) and fall 2013 (Site 2) at the Parsons Unit of the Kansas State University Southeast Agricultural Research Center. The soil at both sites was a Parsons silt loam soil with initial soil test values of 5.9 pH, 2.8% organic matter, 4.2 ppm P, 70 ppm K, 3.9 ppm $\text{NH}_4\text{-N}$, and 37.9 ppm $\text{NO}_3\text{-N}$ in the top 6 inches at Site 1; and 6.5 pH, 2.2% organic matter, 6.7 ppm P, 58 ppm K, 6.8 ppm $\text{NH}_4\text{-N}$, and 12.3 ppm $\text{NO}_3\text{-N}$ in the top 6 inches at Site 2. The experimental design was a split-plot arrangement of a randomized complete block. The six whole plots were combinations of P_2O_5 and K_2O fertilizer levels allowing for two separate analyses: 1) applying four levels of P_2O_5 consisting of 0, 25, and 50 lb/a each year and a fourth treatment of 100 lb/a only applied at the beginning of the study; and 2) conducted a 2×2 factorial combination of two levels of P_2O_5 (0, 50 lb/a) and two levels of K_2O (0, 40 lb/a). Subplots were four levels of N fertilization consisting of 0, 50, 100, and 150 lb/a. Phosphorus and K fertilizers were broadcast applied in the fall as 0-46-0 (triple superphosphate) and 0-0-60 (potassium chloride). Nitrogen was broadcast applied in late winter as 46-0-0 (urea) solid. Second-year samplings and harvests from each site were as follows. Early growth yield as an estimate of grazing potential in early spring was taken at E2 (jointing) growth stage on April 23, 2015 at Site 1 and on April 22, 2016 at Site 2 from a subarea of each plot not used for later spring and fall harvests. Spring yield was measured at R4 (half bloom) on May 19, 2015

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

Results and Discussion

Third-year production of tall fescue (Site 1 in 2015 and Site 2 in 2016) was affected by an interaction between N and P fertilization at Site 1, but predominately by N fertilization at Site 2, with little response to K at either site. At site 1 in 2015, early yield at the E2 (jointing) growth stage, to estimate forage available if grazed early, was increased with 50 lb N/acre without P fertilization, but higher N rates did not increase E2 yield (Table 1). However, with P fertilization, early yield at E2 increased with N rates up to 150 lb/a. At R4 hay harvest in 2015, yield was increased by N additions up to 100 lb/a with no P, but with 25 lb P₂O₅/acre yield was increased to more than 3 ton/acre with 150 lb N. Fall harvest yield was increased by N rates up to 150 lb/a with no P. However, fall yields that were obtained with higher N rates and P fertilization were lower than with no P and high N rates and the response to N was less. This potentially may be because of residual unused N due to lower R4 yields without P fertilization. Total yield ranged up to nearly 4 ton/a with P fertilization and higher N rates.

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

Table 1. Third-year yield of newly established tall fescue in the spring and fall 2015 as affected by the interaction of P₂O₅ and N fertilization rates at Site 1

P ₂ O ₅	N	Yield			
		Spring		Fall harvest	Total (R4 + Fall)
		E2 (jointing)	R4 (half-bloom)		
	lb/a	ton/acre, 12% moisture			
0	0	0.08	0.50	0.26	0.76
	50	0.49	1.49	0.38	1.87
	100	0.48	1.98	0.70	2.68
	150	0.50	1.76	1.12	2.88
25	0	0.09	0.59	0.36	0.96
	50	0.52	1.83	0.44	2.27
	100	0.81	2.80	0.55	3.35
	150	0.96	3.12	0.69	3.82
50	0	0.12	0.67	0.39	1.06
	50	0.42	1.75	0.39	2.14
	100	0.92	3.02	0.56	3.58
	150	1.25	3.13	0.68	3.81
100†	0	0.13	0.65	0.38	1.03
	50	0.55	2.17	0.55	2.71
	100	0.84	3.03	0.58	3.61
	150	1.11	3.24	0.68	3.92
LSD _(0.05)		0.04	0.31	0.17	0.35

†The 100 lb P₂O₅/a rate was only applied at the beginning of the study (Fall 2012).

Table 2. Third-year yield of newly established tall fescue in the spring and fall 2016 as affected by P₂O₅ and N fertilization rates at Site 2

P ₂ O ₅	Yield			
	Spring		Fall harvest	Total (R4 + Fall)
	E2 (jointing)	R4 (half-bloom)		
lb/a	----- ton/acre, 12% moisture -----			
0	0.26	1.09	0.84	1.94
25	0.23	1.02	0.79	1.81
50	0.23	1.08	0.82	1.89
100†	0.27	0.99	0.89	1.88
LSD _(0.05)	NS	NS	NS	NS
N				
0	0.06	0.16	0.84	1.00
50	0.13	0.74	0.63	1.37
100	0.34	1.41	0.81	2.22
150	0.46	1.87	1.06	2.93
LSD _(0.05)	0.20	0.09	0.13	0.15

†The 100 lb P₂O₅/a rate was only applied at the beginning of the study (Fall 2013).

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

D.W. Sweeney

Summary

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

Introduction

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

Experimental Procedures

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

Results and Discussion

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

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

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

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

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

D.W. Sweeney and D. Shoup

Summary

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

Introduction

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

Experimental Procedures

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

Results and Discussion

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

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

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

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

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

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

Response of Soybean Grown on a Claypan Soil in Southeastern Kansas to the Residual of Different Plant Nutrient Sources and Tillage¹

D.W. Sweeney, P. Barnes,² and G. Pierzynski

Summary

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

Introduction

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

Experimental Procedures

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

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

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

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tillage operations were done in appropriate plots as in previous years. A subarea of 20 × 20 ft near the center of each 1-acre plot was designated for crop yield and growth measurements. Samples were taken for dry matter production at V3-V4 (approximately 3 weeks after planting), R2, R4, and R6 growth stages. Yield was determined from the center 4 rows (10 × 20 ft) of the subarea designated for plant measurements in each plot.

Results and Discussion

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

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

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

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

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