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RELATIONSHIP OF POTASSIUM TO STRESS-INDUCED LODGING IN GRAIN SORGHUM

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EFFECT OF POTASSIUM FERTILIZATION ON GRAIN SORGHUM

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Grain sorghum harvest can be slowed by lodged sorghum, a condition that occurs with some frequency in Kansas. Sorghum lodging is known to be associated with stress conditions of heat and summer drought in nonirrigated areas. Nutrient levels of N and K are known to be involved. This research was intended to further our knowledge on the effect of potassium fertilization on yield, lodging, and K uptake of sorghum.

Experimental Procedure:

In the summer of 1972 a field in Cherokee County was observed to be showing severe K deficiency on soybeans. Plant and soil samples were collected from the field and confirmed the visual observation. Permission was obtained from the farmer, Charles Yagher, to use the field as a site for a grain sorghum experiment in 1973.

The experiment was designed to follow-up on research of 1972 involving K rates, K sources and sorghum hybrids. The K rates were 40, 80, 160 and 320 lbs/A K_2O with KCl and K_2SO_4 as the K sources. The sorghum hybrids were selected from those of similar maturity used in 1972 plus one additional hybrid. The hybrids were Funks G522, Asgrow Dorado, Acco R1090, and Pioneer 8647. The K was applied to the experimental area with a plot fertilizer spreader and incorporated by double disking. The area was planted utilizing an experimental plot air planter calibrated to drop seed at a two inch spacing in 30 inch rows. The area was treated pre-emerge with Herban 21A and no cultivation was performed. The area was treated with a systemic for greenbug control. A blanket application of 140 lbs/A of N and 47 lbs/A of P_2O_5 was applied and incorporated by disking.

A composite soil sample was pulled from each plot in increments to a depth of four feet and analyzed by the standard procedures used in the Soil Testing Lab at Kansas State University. The chemical analysis data are given in Table 1. The area was found to test very uniform between reps indicating an excellent experimental site. The soil type for the area is a Cherokee silt loam.

Table 1. CHEMICAL ANALYSIS OF SOIL SAMPLES FROM YAGHER LOCATION[1]

Depth	pH	Lime Require.	Organic Matter	Avail. P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	Avail. Nitrates
in.		#/A ECC	%	#/A	#/A	ppm	ppm	ppm
0-6	7.1	--	1.4	21	90	1220	70	5.0
6-12	6.2	2300	1.1	4	124	1144	160	4.0
12-24	5.6	5300	1.0	2	307	1993	554	3.1
24-36	5.7	2200	0.6	3	243	1730	469	1.0
36-48	5.8	2000	0.4	2	209	1575	416	0.7

[1] Average of composite samples from three reps.

Leaf samples were pulled at two stages of maturity -- 6-8 leaf stage and early head emergence from each treatment. These samples were oven dried at 65°C, finely ground, and analyzed for K content. Grain yields were taken at maturity on hand harvested areas on each treatment. Grain yields were corrected to 12.5% moisture. No lodging had occurred at harvest so half the plot was left standing for evaluation of lodging at a later date -- approximately one month. Late lodging evaluations were made by counting the total number of plants in a 10 foot section of row and the number of these plants showing stalk deterioration due to stalk rot. No lodging had occurred at this time.

As a separate part of this research project, plant and soil samples were collected from farmer fields in late June and early July to assess the K status of farmer fields. These samples were collected in cooperation with the county agents. Fields sampled included corn, grain sorghum, soybean and alfalfa fields. The plant samples consisted of the last fully extended leaves for corn, sorghum and soybeans and of the top 4 to 6 inches of growth for alfalfa. The soil samples consisted of a composite tillage layer sample from the area of the field from which the plant sample was collected. At the time of sampling notes were taken on the visual appearance of the field and the stage of maturity of the crop. The soil samples were analyzed by the routine soil test procedures and the plant samples were analyzed for their content of nine nutrients -- N, P, K, Ca, Mg, Zn, Cu, Mn, and Fe.

Results

The 1973 growing season in southeastern Kansas was extremely dry in the area of the K experiment. Early season moisture was above normal with below normal rainfall in June, July and August. This extended dry period had a marked influence on K uptake.

Results for the K experiment are given in Tables 2 and 3. Considering the low rainfall during the 1973 season, excellent grain sorghum yields were obtained. Soybeans on an adjacent K rate experiment to the sorghum were a failure due to the dry weather and no results are reported. The analysis of variances are shown in Table 4 and show very few significant interactions indicating the factors are reacting independently.

Potassium application significantly increased mean grain yields with each increment of K. The yield data correlates well with leaf analysis data in that K content of the leaves was raised to an adequate level only at the highest K rate at the first sampling date (6/28/73). At early head emergence the K content in all leaf samples was below the sufficiency level. Previous K response data has shown optimum K rates to be much lower than 320 lbs/A K_2O shown in this experiment. The extremely dry weather over the summer undoubtedly made the broadcast and disk incorporated K positionally unavailable to the plant.

Table 2. EFFECT OF VARIETIES AND POTASSIUM RATES AND SOURCES ON YIELD, INCIDENCE OF STALK ROT AND POTASSIUM UPTAKE BY DRYLAND GRAIN SORGHUM
Charles Yagher Farm, Cherokee County, Kansas

K Rate	K Source	Variety	Grain Yield [1]	Stalk Rot [2]	K Content 6-28	K Content 7-23	K Content Grain
lbs/A K_2O			bu/A	%	----------	%----------	
0	---	Funks G522	52	9.9	0.43	0.45	0.34
0	---	Asgrow Dorado	48	9.3	0.52	0.48	0.36
0	---	Acco R1090	46	28.3	0.62	0.57	0.23
0	---	Pioneer 8647	64	40.9	0.48	0.51	0.32
40	KCL	Funks G 522	66	17.0	0.57	0.64	0.39
40	"	Asgrow Dorado	66	16.4	0.62	0.57	0.34
40	"	Acco R1090	58	21.0	0.55	0.50	0.42
40	"	Pioneer 8647	54	24.8	0.57	0.51	0.27
80	"	Funks G522	76	11.8	0.95	0.79	0.29
80	"	Asgrow Dorado	73	15.9	0.95	0.73	0.29
80	"	Acco R1090	76	47.5	0.95	0.72	0.30
80	"	Pioneer 8647	65	26.8	1.02	0.76	0.30
160	"	Funks G522	83	11.2	1.45	0.79	0.34
160	"	Asgrow Dorado	71	12.9	1.52	0.74	0.37
160	"	Acco R1090	78	31.7	1.55	0.80	0.30
160	"	Pioneer 8647	74	9.6	1.57	0.80	0.21
320	"	Funks G522	81	3.6	2.09	1.09	0.30
320	"	Asgrow Dorado	82	4.6	2.02	0.97	0.33
320	"	Acco R1090	87	7.7	2.01	0.75	0.30
320	"	Pioneer 8647	84	0.0	2.40	0.90	0.24
40	K_2SO_4	Funks G522	80	32.0	1.02	0.51	0.29
40	"	Asgrow Dorado	70	21.8	0.95	0.57	0.20
40	"	Acco R1090	75	58.1	0.88	0.62	0.27
40	"	Pioneer 8647	76	29.9	1.05	0.63	0.26
80	"	Funks G522	67	7.2	1.35	0.68	0.23
80	"	Asgrow Dorado	73	13.1	1.23	0.76	0.29
80	"	Acco R1090	70	33.1	1.21	0.77	0.29
80	"	Pioneer 8647	80	21.7	1.09	0.71	0.29
160	"	Funks G522	72	21.1	1.87	1.00	0.25
160	"	Asgrow Dorado	80	17.7	1.85	0.97	0.23
160	"	Acco R1090	78	19.4	1.87	0.84	0.22
160	"	Pioneer 8647	84	23.3	1.97	0.86	0.16
320	"	Funks G522	90	6.4	2.44	1.39	0.37
320	"	Asgrow Dorado	93	6.6	2.42	0.99	0.27
320	"	Acco R1090	84	16.1	2.37	1.25	0.37
320	"	Pioneer 8647	87	6.7	2.49	1.34	0.34

[1] Corrected to 12.5% moisture.

[2] Stalk rot observations taken October 16 and based on stalk deterioration not lodging.

Table 3. MEANS AND LSD'S FOR VARIETIES, K RATES, AND K SOURCES.

Means	Grain Yield	Stalk Rot	K Content 6-28	K Content 7-23	K Content Grain
	bu/A	%	%	%	%
Control	52	22.1	0.51	0.50	0.31
K Rates					
40	68	27.6	0.77	0.57	0.30
80	73	22.1	1.10	0.74	0.29
160	78	18.4	1.71	0.85	0.26
320	86	6.4	2.28	1.08	0.32
$LSD_{.05}$	5	7.4	0.15	0.21	NS
K Source					
KCl	73	16.4	1.30	0.75	0.31
K_2SO_4	79	20.9	1.63	0.88	0.27
$LSD_{.05}$	3	NS	0.10	NS	0.04
Hybrids					
Funks G522	74	13.8	1.47	0.86	0.31
Asgrow Dorado	73	13.6	1.45	0.79	0.29
Acco R1090	72	29.3	1.42	0.78	0.31
Pioneer 8647	74	17.8	1.52	0.81	0.26
$LSD_{.05}$	NS	5.6	NS	0.06	0.03

Table 4. ANALYSIS OF VARIANCE FOR EACH MEASUREMENT OF RESPONSE.

Source	df	Grain Yield MS [1]	Stalk Rot MS	K Content 6-28 MS	K Content 7-23 MS	K Content Grain MS
Rep	2	417.535	77.136	0.078	0.252	0.084
K Source (S)	1	704.708*	48.330	2.627**	0.316	0.045*
K Rate (R)	3	1409.200**	193.191**	10.719**	1.125**	0.014
SxR	3	249.527	50.189*	0.026	0.130	0.028
Error a	14	111.882	12.801	0.057	0.119	0.010
Varieties (V)	3	8.698	131.070	0.040	0.031*	0.0124**
VxS	3	161.401	1.359	0.022	0.017	0.0084*
VxR	9	25.952	15.698	0.023	0.021	0.0066*
VxSxR	9	96.271	19.332	0.016	0.032*	0.0024
Error b	48	109.052	17.351	0.021	0.010	0.0027

* Denotes significance at 5% probability level.
** Denotes significance at 1% probability level.
[1] MS - Mean Square

Significant differences were found between K sources for grain yield and K content of the leaf samples at the early sampling date with K_2SO_4 being superior to KCl. A trend toward higher K content with the K_2SO_4 was observed on the head emergence leaf samples, but was not significant at the 5% probability level.

Hybrid effects were not as evident in yield and K content in the leaf samples. Significant differences only showed on the head emergence leaf samples. These four hybrids were selected to be very close in maturity for ease of sampling and to reduce the effect of rainfall coming at a critical stage of plant development influencing the nutrient content among hybrids. Hybrids had the least influence on yield and K uptake.

Lodging was not a problem at this location even with the severe moisture stress that was present through most of the growing season. As stated in the procedure section, half of each plot was left standing at harvest to evaluate stalk deterioration at approximately one month past normal harvest date. At this time, it was found that no significant lodging had occurred, but stalk deterioration at the base was evident on individual plants. Each plot was evaluated and the results expressed as percent of the total plants showing stalk rot. The data as presented in Table 2 and 3 shows that stalk rot was influenced by K rate and hybrids, but not by K source. With increased K rates the percent of the plants showing stalk rot was decreased. The major decrease in stalk rot was at the highest K rate. The hybrids separate into two groups with Funks G522, Asgrow Dorado and Pioneer 8647 showing less stalk rot than Acco R1090.

The plant and soil sample survey of farmer fields revealed several locations with low K contents in the plant and soil samples, Table 6. The cultural practices and fertilizer application on each field is given in Table 5.

Table 5. CULTURAL AND FERTILIZER HISTORY ON PLANT AND SOIL SURVEY SAMPLES, 1973

Locations	Planting Date	Sampling Date	Leaves Extended	Visual Appearance	Fertilizer Applied, lbs/A [1] N	P_2O_5	K_2O	Other
Grain Sorghum								
CK 5	5-21	6-22	4	normal	30BC,31BD	60BC,31BD	30BC,31BD	
6	"	"	"	short	" "	" "	" "	
9	5-15	6-22	5	normal	56BC,12BD	48BD	48BD	
11	5-14	6-22	6	normal	112BC,12BD	36BD	60BC,36BD	
CR 1	5-28	6-22	4	short	87BC,21BD	54BD	37BC,21BD	
2	"	"	"	normal	" "	" "	" "	
6	-	-	4	normal	36BD	92BD	0	Manure
10	5-19	6-22	4-5	normal	67BC,12BD	48BD	48BD	
WO 3	-	7-6	5	normal	NA	NA	NA	
Corn								
AL 4	-	7-6	tassel	nitrogen	NA	NA	NA	
AN 1	5-7	6-21	6	normal	150	40	20	
2	"	"	"	short	"	"	"	
3	5-7	6-21	6	normal	"	"	"	
4	"	"	"	potassium	120	0	0	
5	5-5	6-21	8	normal	180BC	60BC	200BC	
6	"	"	"	short	"	"	"	
CK 1	5-10	6-22	6	normal	57BC,23BD	23BD	23BD	
2	5-14	6-22	6	nitrogen	10BD	35BC,40BD	62BC,40BD	
4	5-22	6-22	5	mild K	127BC,5BD	60BC,20BD	60BC,20BD	
7	5-17	6-22	7	normal	95BC,34BD	60BC,34BD	30BC,34BD	
8	5-14	6-22	6	mild N	68BC,12BD	29BC,28BD	30BC,28BD	
10	5-14	6-22	7	normal	112BC,12BD	36BD	60BC,36BD	
CR 3	L May	6-22	6	normal	22BD	45BD	0	
4	"	"	"	nitrogen	0	0	0	
5	-	6-22	7	mild K	125BC,22BD	55BD	36BD	
7	5-15	6-22	6	normal	27BD	54BD	27BD	
9	-	6-22	6	normal	100BC,14BD	55BD	55BD	
LI 1	-	6-21	5	nitrogen	NA	NA	NA	
Soybeans								
AL 1	-	7-6	4	normal	NA	NA	NA	
2	-	7-6	4	chlorotic	NA	NA	NA	
3	-	7-6	5	normal	NA	NA	NA	
MG 1	-	7-10	5	potassium	NA	NA	NA	
WO 1	-	7-6	5-6	Normal	NA	NA	NA	
2	-	"	"	potassium	NA	NA	NA	
4	-	7-6	4	normal	NA	NA	NA	
Alfalfa								
CK 3	1968	6-22	E Blo	potassium	0	0	0	
CR 8		6-22	Pre Blo	potassium	0	0	0	
11		7-9	E Blo	boron	9BC	23BC	18BC	
11a		"	"	"	"	"	"	
12		7-9	E Blo	boron	0	0	0	
LI 1		6-21	E Blo	boron	NA	NA	NA	
2		6-21	E Blo	potassium	NA	NA	NA	

[1] BC - broadcast, BD - banded, SD - sidedressed and NA - not available

Table 6. SOIL AND PLANT ANALYSES ON SOIL AND PLANT SURVEY SAMPLES, 1973.

Soil Analysis							Plant Analysis								
		Avail	Exchangeable			DTPA									
Ident.	pH	P	K	Ca	Mg	Zn	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe
		#/A	#/A	ppm	ppm	ppm	--------	--------	%	--------	--------	--------	--------	ppm	--------
Grain Sorghum															
CK 5	6.2	65	164	736	144	8.0	3.34	.17	1.10	.55	.26	55	6.9	35	113
6	6.6	64	154	826	142	6.8	3.26	.18	1.40	.58	.21	54	7.6	53	123
9	6.9	14	118	807	87	4.5	3.30	.15	1.80	.72	.22	42	5.9	43	120
11	5.7	13	252	977	275	17.0	3.38	.17	2.60	.54	.20	98	8.0	68	107
CR 1	7.1	30	173	1357	183	0.9	3.83	.29	1.50	.55	.22	23	8.0	68	136
2	7.4	41	214	1072	109	1.0	3.74	.25	1.40	.72	.28	24	8.3	68	144
6	6.7	30	193	931	103	0.8	3.24	.30	1.00	1.18	.35	28	8.0	275	141
10	5.0	17	223	547	154	6.3	3.98	.29	1.80	.36	.18	94	9.3	275	146
WO 3	6.5	180	730	1780	571	4.1	4.64	.21	2.60	.37	.24	38	10.4	21	223
Corn															
AL 4	7.2	22	148	1092	307	1.0	1.63	.15	0.80	.39	.41	27	7.6	29	74
AN 1	6.5	18	320	2347	211	2.0	2.80	.23	1.10	.78	.37	25	10.6	70	128
2	6.7	17	317	2121	192	1.6	2.43	.24	1.20	.80	.48	20	8.3	58	120
3	7.0	16	204	1650	220	1.2	4.24	.27	0.85	.49	.42	22	8.0	68	121
4	7.0	17	238	1710	217	1.3	3.75	.39	0.25	.90	.85	26	11.0	87	141
5	6.4	60	267	1286	260	1.3	3.42	.23	1.80	.60	.30	24	8.0	42	121
6	6.4	62	275	1279	254	1.7	2.48	.17	2.30	.66	.23	16	5.9	50	129
CK 1	6.4	14	148	755	114	4.2	3.59	.19	1.25	.58	.29	74	9.3	125	103
2	6.9	20	193	703	304	7.3	2.02	.14	2.65	.43	.19	28	4.6	32	86
4	6.9	60	178	892	105	9.4	3.46	.15	1.90	.57	.22	67	9.6	47	123
7	6.6	90	159	905	132	5.9	3.04	.19	1.20	.74	.26	32	6.2	85	85
8	7.1	65	214	899	104	10.4	2.42	.18	2.60	.78	.10	48	5.9	43	83
10	5.7	12	299	924	260	19.9	2.23	.20	2.80	.55	.21	238	10.3	46	70
CR 3	6.1	28	243	1195	254	1.8	3.21	.21	1.50	.49	.26	27	9.3	123	121
4	6.3	54	233	1181	249	2.2	2.60	.28	1.90	.48	.25	24	6.6	85	128
5	6.4	24	164	1106	270	0.8	1.85	.27	1.70	.51	.35	22	8.3	65	131
7	7.6	10	193	1967	107	3.5	2.00	.22	1.25	.82	.35	47	10.3	98	121
9	7.0	19	204	1077	126	2.2	3.12	.19	2.10	.59	.16	29	9.0	71	123
L1 1	7.3	37	173	762	59	1.3	2.12	.25	2.20	.54	.18	17	9.6	64	105
Soybeans															
AL 1	7.1	29	380	2155	383	21+	4.89	.28	2.30	1.19	.45	134	12.0	45	186
2	6.5	42	437	1937	435	21+	5.35	.28	2.20	1.13	.41	327	15.7	26	201
3	7.3	32	248	2048	409	17.1	4.86	.27	1.20	1.26	.67	81	12.0	40	177
MG 1	6.9	53	168	1458	142	3.8	4.32	.22	0.50	1.03	.65	53	10.3	36	107
WO 1	7.0	24	204	1230	266	1.9	4.68	.34	4.00	1.29	.87	59	13.3	66	264
2	6.5	28	138	1167	249	3.2	5.45	.29	1.20	1.17	.65	54	12.6	34	150
4	7.0	105	271	1539	387	2.6	5.50	.38	1.00	1.50	.68	54	11.3	40	213
Alfalfa															
CK 3	7.2	16	193	1336	266	9.5	4.06	.29	1.10	1.31	.41	52	11.3	49	100
CR 8	7.4	28	209	1788	251	21+	3.52	.22	1.00	1.36	.31	44	8.3	31	78
11	6.2	46	267	1092	194	10.2	2.79	.10	0.90	1.12	.32	34	9.6	78	72
11a	6.7	37	183	931	97	1.4	3.19	.12	0.80	1.14	.25	24	8.0	52	58
12	6.8	35	159	742	78	6.3	2.45	.10	0.90	1.06	.26	40	8.0	20	55
L1 1	6.0	11	456	2146	507	1.1	2.89	.23	1.20	1.18	.29	34	8.0	54	56
2	6.9	19	238	1300	204	2.3	2.93	.35	1.30	1.63	.27	43	8.3	55	64

In some cases, the agents were not able to obtain the fertilizer history on the field. The fertilization reported by the farmers would suggest that many farmers are applying potassium in the southeastern area for corn and grain sorghum. The fertilization histories for the soybeans and alfalfa locations is incomplete and no conclusions on fertilizer practices can be drawn.

The plant analysis data for K would suggest less than adequate K levels at several locations, but in several cases soil test K levels and K fertilization would be considered adequate. The extremely dry weather over the two to three week period prior to sampling has undoubtedly limited K uptake in several of these fields. The low K levels in the alfalfa would suggest more attention should be given to K fertilization of alfalfa in this area.

Summary:

Based on results from the past three years some general statements can be made concerning K fertilization of grain sorghum.

1. Yield responses to K applications can be obtained on grain sorghum. Present recommendations made at Kansas State University should be increased for low and very low testing soils. Revised fertilizer recommendations will include this change.

2. Potassium application will reduce the amount of lodging when this is a problem. Higher K rates are necessary to reduce stalk deterioration than are necessary for optimum grain production. However, lodging incidence in sorghum is more complex than just having adequate K.

3. Potassium applications have generally increased K content of leaf samples pulled at the 6-8 leaf stage and at head emergence. In spite of relatively high K application rates, K content of the leaf samples in some cases have been low probably reflecting dry surface soil conditions. The data would suggest that incorporation of the K is essential.

4. Variety differences in K content and lodging were evident, but few interactions with K rates were found.