

SULFUR FERTILIZATION OF WHEAT IN KANSAS

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ABSTRACT

Field experiments evaluating the effects of sulfur fertilization on wheat yields and quality were initiated in 1982 and have continued through 1985. Sulfur rates, sources, and methods of application as well as nitrogen rates have been evaluated on various soil types across Kansas. Results to date show an inconsistent yield response to sulfur, with all significant yield increases occurring on sandy, low organic matter soils. Two of three sandy locations reported have responded to sulfur application at some time during the course of this work. The addition of sulfur has consistently increased wheat tissue sulfur levels and, to a lesser extent, grain sulfur levels. Ammonium sulfate and ammonium thiosulfate performed similarly as sulfur sources. Surface banding on 10-inch centers and broadcasting were equally effective methods of sulfur application. Sulfur fertilization had little effect on grain protein levels, but tended to increase the levels of sulfur-containing amino acids.

OBJECTIVES

High-yielding, semi-dwarf, lodging resistant varieties and hybrids were grown on 70% of the 1985 Kansas wheat acreage. Top yields in official performance tests and on farmer fields have exceeded 100 bushels per acre the last two years. These high yields require more sulfur from the soil. In addition, the use of concentrated, high analysis fertilizers which supply no sulfur is the rule. Other factors that may aggravate the potential sulfur problem in Kansas include declining organic matter levels and the increasing popularity of conservation tillage, which slows breakdown of existing organic matter resulting in slowed release of sulfur.

Research in Kansas in the early 1970's showed inconsistent response to sulfur application on wheat. In recent years, there have been field reports of wheat yield response to sulfur. Other research is ongoing relating to the role sulfur has in quality aspects of wheat.

With all of these factors in mind, work was initiated in the fall of 1982 and is continuing with the objectives of evaluating the effects of sulfur fertilization including sulfur rates, sources, and methods of application on wheat yields and quality characteristics in Kansas.

MATERIALS AND METHODS

Experiment I. This dryland field experiment has been conducted at two locations; the Estel Wyatt Farm in Shawnee county, a Eudora silt loam - Sarpy sand complex (Fluventic Hapludoll, coarse, mixed mesic) and on the North Central Experiment Field in Republic county, a Crete silt loam (Pachic Argiustoll, fine, montmorillinific, mesic). Soil test information on these sites is in Table 1.

Table 1. Initial soil test results for experimental sites.

Location	Depth in.	pH	O.M. %	Available	Bray-1	Exchangeable	Available
				N ppm	P -----lbs/A-----	K -----	S ppm
Wyatt Farm,	0-6	5.2	0.8	4	53	290	8
Exp. I and II	6-24	6.0	0.6	5	30	230	6
NC Field	0-6	5.6	2.6	16	57	500+	--
Exp. I	6-24	6.2	2.1	10	44	500+	--
Sandyland	0-6	5.7	0.7	4	45	270	6
Exp. II	6-24	6.3	0.5	7	--	---	10
Hewes Farm	0-6	7.0	0.5	12	32	370	6
Exp. II.	6-24	7.4	0.2	9	7	250	4

All combinations of nitrogen rates of 0, 60, and 120 pounds per acre and sulfur rates of 0, 15, 30, and 60 pounds per acre (urea and ammonium sulfate blends) were evaluated in randomized, complete block design studies with four replications. One-half of the N and S was applied preplant-incorporate and the remaining one-half was applied as a late winter topdress. Hard red winter wheat of the "Newton" variety was used, and excellent stands were obtained. If leaf diseases were assessed to be a potential problem, fungicide applications were made.

Tissue samples were taken at the early boot stage and analyzed for N and S. Grain yields were measured and individual plot grain samples were retained for moisture, protein, and mill and bake analyses.

Experiment II. This dryland field experiment was initiated in 1984 and has been run on three sites, on the Estel Wyatt Farm (adjacent to Experiment I), on the Sandyland Experiment Field in Stafford county, a Pratt loamy fine sand (Psammentic Haplustalfs, sandy, mixed, thermic), and on the Herb Hewes Farm in Gray county, a Pratt sand. Complete soil test results are in Table 1.

Sulfur rates of 0, 15, and 30 pounds per acre were used. Sulfur sources evaluated were ammonium sulfate (AS) and ammonium thiosulfate (ATS). AS and ATS applications were made as liquids either broadcast (through flat fan spray tips) or dribbled (surface-banded) on 10-inch centers as a late winter topdress. Nitrogen was balanced on all plots at 100 pounds per acre as ammonium nitrate.

Tissue and grain samples were taken as described for Experiment I.

RESULTS AND DISCUSSION

Experiment I. The effects of nitrogen and sulfur fertilization on wheat yields are summarized in Table 2. At the Shawnee county site (Wyatt Farm), only in 1984 did the addition of sulfur significantly increase yields. 1985 yields may have been affected by low pH and relatively high exchangeable Al^{+3} levels since the variety "Newton" is very susceptible to Al. This effect may have masked sulfur response as a visual response to sulfur was apparent during the growing season. On the higher organic matter soil in Republic county (North Central Field), sulfur fertilization has not significantly affected wheat yields. In 1983 and 1984, there appeared to be a trend toward higher yields with the addition of sulfur, but this trend reversed in 1985. The addition of nitrogen generally increased yields, and 120 lbs N/A produced significantly higher yields than 60 lbs N/A in three of the six site years.

Table 2. Effects of sulfur and nitrogen fertilization on wheat yields (Exp. I)

		Grain yield, bu/A						
N	S	Wyatt Farm, Shawnee Co.			North Central Field, Republic Co.			
		lbs/A	1983	1984	1985	1983	1984	1985
0	0		55	20	40	39	18	28
60	0		61	30	54	61	28	47
60	15		62	34	52	58	31	42
60	30		63	34	51	61	30	45
60	60		60	37	47	64	37	46
120	0		61	42	51	66	37	45
120	15		58	42	50	73	44	42
120	30		65	46	52	69	38	36
120	60		59	50	51	70	36	43
	LSD (.05)		NS	6	6	12	7	8
Mean Values:								
N Rate	60		62	34	51	61	31	45
	120		61	45	51	69	39	42
	LSD (.05)		NS	3	NS	6	4	NS
S Rate	0		61	36	52	64	32	46
	15		60	38	51	65	37	42
	30		64	40	51	65	34	41
	60		59	43	49	67	36	44
	LSD (.05)		NS	4	NS	NS	NS	NS

The effects of nitrogen and sulfur fertilization on wheat tissue N and S levels and grain protein and S levels for 1985 are summarized in Table 3. 1983 and 1984 data are not shown, but results were very similar to the 1985 data shown. The

Table 3. Effects of sulfur and nitrogen fertilization on wheat tissue and grain composition, 1985. (Exp. I)

N	S	Wyatt Farm, Shawnee Co.				North Central Field, Republic Co.				
		Tissue		Grain		Tissue		Grain		
		lbs/A	%N	%S	%Protein	%S	%N	%S	%Protein	%S
0	0		1.99	.08	11.0	.10	1.26	.07	10.5	.08
60	0		2.36	.10	12.4	.11	2.00	.14	11.1	.08
60	15		2.25	.15	11.8	.12	1.83	.12	11.0	.09
60	30		2.09	.15	11.6	.12	1.87	.13	11.1	.08
60	60		2.26	.18	12.3	.13	1.87	.13	11.4	.09
120	0		2.46	.10	13.2	.11	2.23	.15	12.5	.10
120	15		2.40	.14	13.4	.12	2.32	.20	13.0	.10
120	30		2.47	.15	13.3	.12	2.26	.23	13.1	.11
120	60		2.60	.21	13.2	.14	2.38	.28	13.0	.11
	LSD (.05)		0.15	.04	0.6	.01	0.22	.05	0.5	.01
Mean Values:										
N Rate	60		2.24	.14	12.0	.12	1.89	.13	11.2	.09
	120		2.48	.15	13.3	.12	2.30	.21	12.9	.10
	LSD (.05)		0.10	NS	0.4	NS	0.12	.03	0.3	.01
S Rate	0		2.41	.10	12.8	.11	2.11	.14	11.8	.09
	15		2.32	.14	12.6	.12	2.07	.16	12.0	.09
	30		2.28	.15	12.5	.12	2.06	.18	12.1	.09
	60		2.43	.19	12.7	.13	2.13	.20	12.2	.10
	LSD (.05)		NS	.04	NS	.01	NS	.04	NS	.01

addition of sulfur significantly increased tissue S levels and, to a lesser extent, grain S levels even though grain S levels were generally 0.12% S or lower. Sulfur fertilization had non-significant effects on tissue N levels and grain protein content. The addition of nitrogen increased tissue N levels and grain protein at both locations and at the Republic county site consistently increased tissue S levels.

Preliminary mill and bake data indicate little effect from sulfur fertilization but low flour protein levels have been a problem on getting meaningful mill and bake results. Amino acid analysis show higher levels of the sulfur-containing amino acids, methionine and cystine, when sulfur is added; but levels of these amino acids were not deficient on the sulfur check plots.

Experiment I was put out on another sandy location in Finney county in 1985, and no response to sulfur was noted, however, yields were severely depressed by hot, dry conditions during early grain fill.

This experiment will be repeated at several locations in 1986.

Experiment II. Yield results from experiment II, which evaluated S rates, sources, and methods of application are reported in Table 4. Sulfur fertilization

Table 4. Effects of sulfur rates, sources, and methods of application on wheat yields. (Exp. II)

S lbs/A	S Source	Method of Application	Grain yield, bu/A				
			Wyatt Farm Shawnee Co.		Sandyland Field Stafford Co.		Hewes Farm Gray Co.
			1984	1985	1984	1985	1985
0	---	---	45	47	57	32	45
15	ATS	B'cast	51	55	58	37	43
30	ATS	B'cast	48	51	57	36	38
15	AS	B'cast	53	50	55	38	42
30	AS	B'cast	55	51	57	37	42
15	ATS	Dribble	50	50	56	39	38
30	ATS	Dribble	54	49	61	37	42
15	AS	Dribble	55	52	60	39	41
30	AS	Dribble	53	52	58	37	42
LSD (.05)			NS	NS	NS	3	NS
Mean Values:							
S Rate	15		52	52	57	38	41
	30		53	51	58	37	41
LSD (.05)			NS	NS	NS	NS	NS
S Source	ATS		51	51	58	37	40
	AS		54	51	57	38	42
LSD (.05)			NS	NS	NS	NS	NS
Method of Application		B'cast	52	52	57	37	41
		Dribble	53	51	59	38	41
LSD (.05)			NS	NS	NS	NS	NS

significantly increased grain yields at the Sandyland Field in Stafford county in 1985, although no response was noted in 1984. The response to sulfur was significant even though yields were reduced by hot, dry conditions during early grain fill. Even though not statistically significant, yields increases of from 3 to 10 bushels in 1984, and 2 to 8 bushels in 1985 were noted with sulfur

fertilization at the Wyatt location in Shawnee County. An additional site was evaluated in 1985 (Hewes Farm, Gray Co.) and sulfur fertilization had little effect on grain yields at this location.

ATS and AS have performed similarly as sulfur sources at all locations. Likewise, both methods of sulfur application have performed equally well.

The effects of sulfur rates, sources, and methods of application on tissue S content, grain protein levels and grain S content are summarized in Table 5. The results shown are for 1985 only as 1984 and 1985 results were similar.

The addition of sulfur fertilizer tended to increase wheat plant tissue S levels and, to a lesser extent, grain S levels but these increases were not always significant. Grain S levels remained below 0.12% even when sulfur was applied.

There were no significant differences between sulfur sources or methods of sulfur application with respect to tissue or grain S content or grain protein levels.

Table 5. Effects of sulfur rates, sources, and methods of application on wheat tissue and grain composition, 1985. (Exp. II)

S lbs/A	S Source	Method of Application	Wyatt Farm Shawnee Co.			Sandyland Field Stafford Co.			Hewes Farm Gray Co.		
			Tissue %S	Grain %Pro. %S		Tissue %S	Grain %Pro. %S		Tissue %S	Grain %Pro. %S	
0	---	-----	.14	14.3	.10	.05	12.1	.08	.11	13.8	.10
15	ATS	B'cast	.15	13.7	.09	.12	11.9	.10	.13	14.0	.11
30	ATS	B'cast	.14	13.8	.10	.17	11.8	.10	.13	14.3	.11
15	AS	B'cast	.17	14.3	.10	.14	11.8	.10	.13	14.3	.10
30	AS	B'cast	.18	14.2	.11	.18	11.6	.11	.12	14.0	.11
15	ATS	Dribble	.17	14.6	.10	.15	11.8	.10	.13	14.2	.11
30	ATS	Dribble	.18	14.1	.10	.18	11.8	.12	.14	14.0	.10
15	AS	Dribble	.15	14.2	.09	.14	11.9	.10	.13	14.2	.11
30	AS	Dribble	.21	13.9	.10	.19	12.1	.11	.13	14.1	.11
LSD (.05)			NS	NS	NS	.03	NS	.01	NS	NS	NS
Mean Values:											
S Rate 15			.16	14.2	.09	.14	11.8	.10	.13	14.2	.11
30			.18	14.0	.10	.18	11.8	.11	.13	14.1	.11
LSD (.05)			NS	NS	NS	.02	NS	.01	NS	NS	NS
S Source											
ATS			.16	14.1	.09	.15	11.8	.10	.13	14.1	.11
AS			.18	14.2	.10	.16	11.8	.10	.13	14.2	.11
LSD (.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS
Method of											
Application											
B'cast			.16	14.0	.10	.15	11.8	.10	.13	14.2	.11
Dribble			.18	14.2	.10	.16	11.9	.11	.13	14.1	.11
LSD (.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS

Experiment II was conducted at another sandy site in Seward county in 1984 and no significant effects due to sulfur rate, source, or method of application were noted. This data is not reported, however, since yields were affected by a hailstorm.

Experiment II is being repeated at several locations in 1986. By gathering enough site years of data on several different soil types, we hope to be able to better predict where sulfur responses are likely in Kansas.