IMPACT OF NITROGEN AND SULFUR FERTILIZATION ON WHEAT YIELD AND QUALITY

R.W. Mullen and E.M. Lentz
Ohio State University/Ohio Agricultural Research and Development Center, Wooster, OH
mullen.91@osu.edu

Abstract

Sulfur (S) contributed by rainfall has decreased by 50% over the last twenty-seven years and may increase the need for S supplementation by fertilization. Nitrogen (N) application is typically split applied in Ohio with some applied in the fall and remainder applied in the spring near first green-up. The objective of this study was to compare N application source and timing with and without S fertilization. Two experimental locations were established in the fall of 2004. Urea and urea-ammonium nitrate (UAN) were applied at green-up and Feekes 6. Sulfur was applied as either ammonium sulfate (AMS) or gypsum at two different rates (20 and 40 lb S/acre). Sulfur fertilization did not affect grain yield, grain protein, or test weight at one site but did increase grain protein at the 40 lb S/acre rate at the other. Based on the results, sulfur fertilization does not appear to be benefit wheat production in Western Ohio at present.

Introduction

Nitrogen (N) fertilization of wheat in Ohio is typically split into two applications. One small application is made in the fall prior to seeding, and the other application is made in the spring around first green-up. The rates applied in the fall are small (typically 30 pounds) due to the potential for N loss in the high rainfall environment. Spring N application rates approach 80 to 100 pounds of N per acre applied as either urea or urea-ammonium nitrate (UAN – 28-0-0). Early spring applications near green-up are primarily made because ground is still frozen and will support the weight of a typical applicator.

Improved sulfur (S) scrubbers in the industrial sector have decreased the amount of S contributed annually by rainfall. Annual S deposition in Ohio has decreased by 50% over the last twenty-seven years (NADP, 2005). This may lead to greater demand for S in Ohio crops. An interaction between N and S fertilization has often been alluded to by some researchers.

The objective of this work was to compare the impact of N application timing and source on wheat grain yield and quality. Additionally, S rate and source were also evaluated to determine the impact of S fertilization and the potential interaction effects of N and S on wheat grain yield and quality.

Materials and Methods

In fall 2004, 'Hopewell' (a soft red winter wheat) was planted into an undisturbed soil of recently harvested soybeans at the Ohio State University/Ohio Agricultural Research and Development Center's Northwest and Western Research Stations near Hoytville and South

Charleston, Ohio, respectively. Soil types were clay for the northwest site and silt loam for the western site. Soil phosphorus, potassium and pH were in the optimal range for wheat as described in the *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat & Alfalfa* (1996). Prior to planting, 30 lb/A of N was surface applied as UAN. Treatments received 80 lb N/A and 20 or 40/A of S from the following blends: ammonium sulfate/urea, gypsum/urea, ammonium sulfate/UAN. Checks included a zero spring N rate, 80 lb N/A as urea, and 80 lb N/A as UAN. All treatments were surface applied as a single application at green-up or early stem elongation (Feekes 6) (Large, 1954). In addition, a N response curve was established with UAN at 20 lb increments (40 to 120 lb N/A) applied at green-up.

Flag leaves were collected to determine N and S content at flowering (Feekes 10.5). Plots were approximately 10 feet wide and 75 feet long. Row spacing was 7.5 inches. The center five feet of each plot was harvested to estimate grain yield. Test weight and flour protein were determined by the USDA soft wheat quality laboratory in Wooster, OH. Experimental design was a completely randomized block with four replications. Statistical analysis was conducted with a General Linear Model using contrast statements in SAS (SAS, 2000).

Results and Discussion

Wheat Grain Yield

Significant responses to N rate of application were observed at both locations (Tables 1 & 2). At both locations, all measured parameters increased as N application rate increased suggesting that N may have been limiting even at the highest rate. This may reflect significant loss of N after application.

Application of urea at Feekes 6 resulted in increased yield compared to urea applied at green-up at the Northwest Research Station (Table 3). Maximum yields could be attained by applying UAN at green-up or Feekes 6 or by applying urea at Feekes 6 (Table 3). Ammonium sulfate applied with urea at green-up did result in increased yields, but was not affected by rate (Table 4). Nitrogen applied with the ammonium sulfate may be responsible for the yield increase. The ammonium sulfate material used at the Northwest Research Station was liquid with an analysis of 8-0-0-8.

Grain yield was unaffected by any of the experimental factors at the Western Research Station (Tables 5-8).

Grain Test Weight

Sulfur fertilization did not impact grain test weight at the either location (data not shown for Northwest and Tables 7 and 8). A significant interaction was noted between N source and N application timing at the Northwest Research Station. Urea applied at green-up resulted in lower test weights than urea applied at Feekes 6 or UAN applied at either time (Table 3). At the Western Research Station, the urea source of N increased test weight significantly compared to UAN (Table 5).

Grain Protein
Sulfur fertilization did not affect grain protein when urea was applied at green-up at the Northwest Research Station (Table 4). At Feekes 6, gypsum applied at the 40 lb/acre rate did increase grain protein significantly compared to all other treatments (Table 4). At the Western Research Station, a similar phenomenon occurred where sulfur (independent of source) applied at the 40 lb/acre rate increased grain protein compared to all other treatments. Urea application significantly increased grain protein compared to the UAN source (Table 9).

Conclusions

The N response portion of the experiment did not appear to supply enough N at green-up to ensure N was not limiting at either location. This may be partially due to N loss with such an early application time and potentially due to the UAN source. Sulfur application appears to have increased grain yields slightly when ammonium sulfate was applied with urea at green-up at the Northwest Research Station. This may be partially due to the N contribution of the ammonium sulfate source and not a true S response. Urea application at Feekes 6 showed no corresponding increase in yield. Considering the amount of N that was applied (same rate as the S treatment) the response was much smaller than would be expected. Grain test weight and protein were also relatively unaffected by sulfur fertilization (exception being a protein response at the high rate of gypsum applied at Feekes 6 with urea at the Northwest Research Station). Based on the results, sulfur fertilization does not appear to be benefit wheat production in Western Ohio at present.

References

Large, E.C. 1954. Growth stages in cereals. Plant Pathol. 3:128-129.

National Atmospheric Deposition Program. 2005. Available online at http://nadp.sws.uiuc.edu/ (confirmed October 5, 2005).

SAS Institute. 2000. SAS/STAT user's guide. Release 8.1 ed. SAS Inst., Cary, NC.

Vitosh, M.L., J.W. Johnson, and D.B. Mengel (eds). 1996. Tri-State Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa. Michigan State University, Extension Bulletin E-2567, East Lansing, MI.

Table 1. Main effect of N rate on wheat grain yield, test weight, and grain protein at the Northwest Research Station, 2004-2005.

N rate, lb/ac	Grain yield, bu/ac	Test weight, lb/bu	Grain protein, %
0	46	58.8	6.4
40	59	59.1	6.8
60	61	59.2	6.9
80	69	59.5	7.3
100	74	59.9	7.6
120	80	60.1	8.0
Contrasts			
Linear	***	***	***
Quadratic	NS	*	NS

,,*,NS – significant at the 0.01, 0.05, and 0.1 probability level and non-significant

Table 2. Main effect of N rate on wheat grain yield, test weight, and grain protein at the Western Research Station, 2004-2005.

N rate, lb/ac	Grain yield, bu/ac	Test weight, lb/bu	Grain protein, %
0	61	57.4	6.3
40	75	57.4	6.4
60	79	57.7	6.6
80	93	58.0	7.0
100	93	58.6	8.0
120	98	58.5	7.6
Contrasts			
Linear	***	***	***
Quadratic	NS	NS	**

,,*,NS – significant at the 0.01, 0.05, and 0.1 probability level or non-significant

Table 3. Simple effects of N source and N time of application on wheat grain yield, test weight, and grain protein at the Northwest Research Station, 2004-2005.

N source	N time of application	Grain yield, bu/ac	Test weight, lb/bu	Grain protein, %
Urea	Green-up	69 b†	59.4 c	7.1 c
	Feekes 6	77 a	60.1 a	7.9 a
UAN	Green-up	76 a	59.7 b	7.5 b
	Feekes 6	77 a	60.0 ab	7.8 a

†-means followed by the same letter are not significantly different using LSD (α = 0.1)

Table 4. Simple effects of urea time of application, S rate, and S source on wheat grain yield, test weight, and grain protein at the Northwest Research Station, 2004-2005.

N time of application	S source	S rate, lb/ac	Grain yield, bu/ac	Grain protein, %
Green-up	---	0	67 d†	7.1 d
	AMS	20	70 c	7.2 d
		40	70 c	7.1 d
	Gypsum	20	69 cd	7.2 d
		40	70 c	7.3 d
Feekes 6	---	0	78 a	7.9 bc
	AMS	20	78 a	8.2 b
		40	74 b	7.7 c
	Gypsum	20	77 ab	8.1 b
		40	79 a	8.6 a

†-means followed by the same letter are not significantly different using LSD (α = 0.1)

Table 5. Main effect of N source on wheat grain yield, test weight, and grain protein at the Western Research Station, 2004-2005.

N source	Grain yield, bu/ac	Test weight, lb/bu	Grain protein, %
Urea	98 a†	59.0 a	9.4 a
UAN	93 a	58.2 b	7.3 b

†-means followed by the same letter are not significantly different using Fisher's F-test (alpha of 0.1)

Table 6. Main effect of N application timing on wheat grain yield at the Western Research Station, 2004-2005.

N time of application	Grain yield, bu/ac	Test weight, lb/bu
Green-up	97 a†	57.2 a
Feekes 6	95 a	58.9 a

†-means followed by the same letter are not significantly different using Fisher's F-test (alpha of 0.1)

Table 7. Main effect of S rate on wheat grain yield and test weight at the Western Research Station, 2004-2005.

S rate, lb/ac	Grain yield, bu/ac	Test weight, lb/bu
0	95	56.1
20	99	59.1
40	94	58.9
Contrasts		
Linear	NS	NS
Quadratic	NS	NS

,,*,NS – significant at the 0.01, 0.05, and 0.1 probability level or non-significant

Table 8. Main effect of S source on wheat grain yield, test weight, and grain protein at the Western Research Station, 2004-2005.

S source	Grain yield, bu/ac	Test weight, lb/bu	Grain protein, %
AMS	98 a†	59.1 a	9.6 a
Gypsum	95 a	58.9 a	9.7 a

†-means followed by the same letter are not significantly different using Fisher's F-test (alpha of 0.1)

Table 9. Simple effects of urea application timing and S rate on grain protein at the Western Research Station, 2004-2005.

N time of application	S rate, lb/ac	Grain protein, %
Green-up	0	9.1 c†
	20	9.3 c
	40	9.3 c
Feekes 6	0	9.7 b
	20	9.8 b
	40	10.3 a

†-means followed by the same letter are not significantly different using LSD ($\alpha = 0.1$)

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Program Chair:
Brad Joern
Purdue University
West Lafayette, IN
(765) 494-9767

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772 – 22nd Avenue South
Brookings, SD 57006
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