TIMING OF SPRING N APPLICATION TO SOFT RED WINTER WHEAT

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Introduction

Historically, in the northern Corn Belt, the majority of the N for winter wheat is applied as a single application when fields become green and initiate spring growth (Greenup). Time between initial spring greenup and early stem elongation (Feekes GS 6) is relatively short (four to six weeks). During this time, the potential for N loss is generally low because soil and air temperatures are cold enough to minimize volatilization and nitrification. Producers attempt to apply N at greenup because field conditions often are firm enough for application equipment and the belief that early applications increase tiller number (heads per acre). Urea and urea-ammonium nitrate (UAN) are often used as N sources because of availability and cost. Ammonium sulfate (AMS) may be available as an N and S source, but generally more expensive than other N sources. Producers and retailers may also apply N two to four weeks before greenup to distribute spring workload. In some years, wet field conditions delay spring applications past Feekes GS 6. Information is needed to determine the risks a producer may encounter applying spring N at different times. Earlier N timing studies were based on calendar dates rather than growth stage. Applications based on growth stage may provide more predictable information for the producer. The objective of this study was to measure agronomic responses to a single application of spring N at different growth stages for soft red winter wheat.

Procedures

For three years (2000-2002) soft red winter wheat was planted into an undisturbed soil of recently harvested soybeans at the Ohio Agricultural Research and Development Center's Northwestern Branch of The Ohio State University, Custar, Ohio. Soil was a Hoytville clay, which had been systematically tiled. The variety 'Hopewell' was planted each year. 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*. Prior to planting, 30 lb/A of N was surface applied as UAN (28-0-0) solution. Three N sources (AMS, urea, and UAN) were applied as a single application late winter or early spring at four different growth stages: Pregreenup (approximately 21 – 28 days before initial greenup), initial greenup (Greenup), early stem elongation (Feekes GS 6) and late stem elongation (Feekes GS 9). Nitrogen was surface applied at a rate of 70 lb/A. An additional two treatments were included in the study as N checks (a zero application of spring N and a 100 lb/A N as UAN surface applied at greenup).

A Minolta Spad 502 chlorophyll meter was used to measure greenness from 30 randomly selected flag leaf blades at flowering. Spike number was calculated from the average of counts observed in a yard-row at three different areas of each plot. Plots were approximately 10 feet wide and 70 feet long. Row spacing was 7.5 inches apart. The center five feet of each plot was harvested to estimate grain yield. Experimental design was a 4 x 3 factorial in a completely randomized block.

Results and Discussion

Soil conditions were relatively dry at planting for the 2001 crop and rainfall was below normal for most of the growing year except for February, April and May (Table 1). Temperatures were near normal until December, at which time temperatures were about ten degrees lower. From January to June, temperatures were above normal, moderating at the end of the growing season. For the 2002 crop, winter monthly averages were approximately six degrees warmer than normal (average monthly temperature never dropped below freezing). In addition, rainfall was above normal for most of the growing season. In 2003 most average monthly temperatures were below normal. Rainfall was near normal to slightly below through April, rainfall was above normal for the rest of the season.

Table 1. Monthly deviations from normal temperature and rainfall averages for the Northwestern Branch, Ohio Agricultural and Research Development Center, Custar, Ohio (2000-2003).

	2000/01		2001/02		2002/03	
	Temperature	Rain	Temperature	Rain	Temperature	Rain
	°F	inch	°F	inch	°F	inch
September	-3.5	-0.90	-2.6	0.71	3.7	0.97
October	2.0	0.20	-1.9	3.69	-2.3	-1.16
November	-1.6	-1.61	5.9	-0.52	-2.2	0.05
December	-10.4	-0.76	5.9	1.01	-0.8	-0.30
January	1.5	-1.42	8.6	0.08	-4.5	-0.80
February	3.9	0.86	6.0	1.00	-4.2	-0.42
March	1.2	-1.60	-1.1	0.31	-2.3	-0.30
April	3.4	0.80	2.0	0.51	0.3	0.22
May	1.7	1.68	-4.2	1.21	-2.2	2.89
June	-0.7	-1.13	2.3	-1.42	-3.0	0.68

Time of spring N application significantly affected grain yield, but only yields from N applied at Feekes GS 9 were significantly different than other times for each year (Table 2). This delayed single N application reduced yields approximately 10% compared to the traditional Greenup treatments. Yields were similar among other application times in 2001, but differences may have been masked from a larger than normal supply of residual nitrogen. Yields were significantly larger for N applied at Feekes GS 6 compared to other application times in 2002, but similar to Greenup applications in 2001 and 2003. Pregreenup N application yields were similar or larger than Greenup applications in 2001 and 2002, but a yield reduction of 19% in 2003.

For all three years, N applied at Feekes GS 9 had approximately 8% fewer spikes than greenup applications (Table 2). Significant differences among remaining treatments were dependent upon the year. No differences occurred from the Pregreenup to Feekes GS 6 in 2001. Spike number was similar between the Pregreenup and Feekes GS 6 in 2002, but Greenup applications were approximately 9% less than Pregreenup or Feekes GS 6. In 2003, spike number was significantly greater for Greenup N applications than other times. Counts were similar for

Feekes GS 6 and GS 9, but Pregreenup applications were approximately 18% less than other times.

Table 2. Grain yield, spike number, and leaf greenness response of winter wheat to spring N (70 lb/A)[†] applied at different growth stages.

Agronomic trait/ Growth stage	Year 2001	2002	2003
Grain Yield		*bu/A*	
Pregreenup	87.7	74.6	57.3
Greenup	87.9	70.6	78.1
Feekes GS 6	86.4	83.8	78.7
Feekes GS 9	79.4	62.2	70.6
Lsd 0.05	1.7	2.4	5.4
Zero Spring N check	73.2	52.1	52.6
Spikes		*yard - row*	
Pregreenup	97	123	98
Greenup	99	113	129
Feekes GS 6	96	126	115
Feekes GS 9	91	107	117
Lsd 0.05	7	5	8
Zero Spring N check	86	87	86
Greenness of flag leaf[‡]			
Pregreenup	45.6	41.9	37.1
Greenup	47.1	40.2	42.9
Feekes GS 6	47.7	44.5	44.5
Feekes GS 9	46.8	47.5	47.1
Lsd 0.05	1.0	1.3	0.9
Zero Spring N check	39.8	34.1	35.8

[†] All treatments received 30 lb/A N as a starter from urea-ammonium nitrate solution prior to planting.
[‡] Leaf greenness measured by a Minolta Spad 502 chlorophyll meter.

Differences were detected among N application time for leaf greenness each year (Table 2). In general, later the application, greener the blades except in 2001, where greenness values were similar except from the Pregreenup application. Also in 2002, greenness was darker for the Pregreenup application than the Greenup time.

Significant yield differences were detected among N sources, but varied each year (Table 3). Yields from AMS were approximately 3% and 12% larger than other N sources in 2001 and

2002. respectively. In 2003, AMS yields were 9% larger than UAN, but similar to urea. Yields from urea were 5% larger than UAN in 2002, but similar in 2001 and 2003. A significant N source x application time occurred in 2002, but not in 2001 and 2003. In 2002, AMS and urea followed the trend of the main effects, but the trend was slightly different for UAN applications where yields were similar between the Pregreenup and Greenup applications (data not shown).

Table 3. Grain yield, spike count, and leaf greenness response of winter wheat to different spring N sources (70 lb N/A)†.

Agronomic traits/ N source	Year 2001	2002	2003
Grain Yield		*bu/A*	
Ammonium sulfate	87.3	78.4	74.4
Urea	85.1	71.7	70.9
Urea-ammonium nitrate	83.6	68.2	68.2
Lsd 0.05	1.5	2.1	4.6
Spikes		*yard - row*	
Ammonium sulfate	98	122	114
Urea	93	117	116
Urea-ammonium nitrate	96	114	115
Lsd 0.05	ns	5	ns
Greenness of flag leaf‡			
Ammonium sulfate	47.6	45.1	43.8
Urea	46.7	43.4	42.5
Urea-ammonium nitrate	46.2	42.1	42.4
Lsd 0.05	0.9	1.1	0.8

† All treatments received 30 lb/A N as a starter from urea-ammonium nitrate solution prior to planting.
‡ Leaf greenness measured by a Minolta Spad 502 chlorophyll meter.

Nitrogen source did not affect spike number in two of the three years (Table 3). In 2002, AMS had approximately 6% more spikes than the other N sources; however, there was a significant interaction between application time and N source. In 2002, AMS treatments had more spikes than other N sources at all application times except for Feekes GS 9, where AMS treatments had 4 and 8% less spikes than urea and UAN, respectively (data not shown). Urea had more spikes than UAN from the Pregreenup and Greenup applications, but fewer spikes from the Feekes GS 6 and 9 applications. Differences among N sources from early application times may be a reflection of N loss.

In all three years, leaves were significantly greener from AMS than other N sources (Table 3). Leaves had similar greenness between urea and UAN for 2001 and 2003, but urea treatments were 3% greener than UAN treatments in 2002. A significant interaction occurred between N application and N source in 2001 and 2003, where leaves were greener from AMS than urea or

UAN when applied before Feekes GS 6. but similar in greenness when applied at Feekes GS 6 or later (data not shown).

The results of this study suggest that grain yields may be significantly reduced when the majority of the N is applied after Feekes GS 6. In all three years, yields were reduced when N was applied at Feekes GS 9 (Table 2). However, greenness of flag leaves was similar or darker for the Feekes GS 9 applications compared to the other times. Even though N applied at Feekes GS 9 was still utilized, soil N levels may have been too low at an earlier time for the plant to obtain optimal yields. Spike number per acre may have been affected, but the data does not indicate a consistent trend between spike number and N application time (Table 2). Spike number was lower from N applied at Feekes GS 9. but this reduction may have been in the number of secondary spikes, which are shorter and smaller than primary spikes and would have less impact on yield. Flag leaves being greener at flowering from Feekes GS 9 applications than earlier times suggest adequate N for grain fill. thus N applied at Feekes GS 9 may have affected the number of spikelets per spike or florets per spikelet.

Spring N may be delayed until Feekes GS 6 without affecting grain yield (Table 2). At Feekes GS 6, wheat generally begins of period of rapid N uptake. Before this stage large rates of N are not necessary for optimum yields and more susceptible to N loss. In 2001, N loss was minimal and/or mineralization greater than the other years as evident by leaf greenness and a relatively high yield from the zero check (Table 2). Yield differences were not detected among application times from Pregreenup to Feekes GS 6 in 2001. 2002 had the greatest potential for N loss since conditions were much different than normal – a relatively warm and wet December through June (Table 1). Greenness values suggest that less N was available from application times prior to Feekes GS 6 (Table 2). Also, treatments that received UAN had lower yields that year compared to other N sources; UAN should have the greatest potential for N loss (Table 3).

Pregreenup applications would be expected to have a greater chance for N loss since the time period from application to crop uptake is longer than other application times. However, in 2002, Greenup applications had lower grain yields than Pregreenup times (Table 2). Greenness values suggest that less N was available from Greenup applications than Pregreenup. Some event allowed greater loss to occur after Greenup applications. and/or abnormally warm conditions in February allowed enough growth that plants were able to utilize some of the N applied at Pregreenup before conditions encouraged N loss.

In 2003, Pregreenup applications were significantly lower in yield than all other application times. Grain yield and leaf greenness was only slightly better than the zero check suggest lack of N. Soil temperatures were much colder in 2003 than the other years and snow and ice were on the soil surface. These conditions may have been more conducive to N loss. Losses were significant regardless of N source.

Nitrogen source may not be an important management consideration for grain yield in years of low N loss potential. If the potential for N loss is high, such as 2002, AMS may have the largest yield advantage. Even when differences were not significant the yield trend was AMS > urea > UAN, largest to smallest. This yield trend may have followed an expected N loss potential trend: UAN > urea > AMS, largest to smallest. Nitrogen loss was not a factor in 2001. but AMS yields were larger than the other N sources, which may suggest a benefit from S. A potential S benefit was not seen in the other two years. Even if a small S benefit occurred, the yield advantage would probably not offset the higher cost of AMS.

Early application of N did not consistently increase number of spikes or increase yields (Table 2). Nitrogen is important for proper tiller development and future spikes as evident with comparison to the zero check, but timing does not appear to affect spike number as long as N is applied by Feekes GS 6. Spike number was not affected by N source, unless N loss was significant.

Summary

Nitrogen application time might be an important management consideration for optimal grain yields in wheat systems that utilize a single N application in late winter or early spring. Depending on the year, N losses may be large enough that a single application at initial greenup may have lower yields than an application at Feekes GS 6. However, if weather or field conditions delay the application at Feekes GS 6 until GS 9, lower yields may be expected than if applications were made at greenup. A split application may lower the risk of N loss, but may be more expensive than increasing the N rate at greenup. In a split spring program, the smaller N fraction should be applied at greenup and the larger fraction at Feekes GS 6. Pregreenup applications of N would not be recommended because of the potential for significant N loss. Urea-ammonium nitrate should not be used for early N applications because of its greater potential for N loss than urea or AMS. A single application of N as late as Feekes GS 6 should not reduce spikes/heads per acre to levels that may reduce yield in programs that apply 20-30 lb/A of starter N.

Reference

Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat & Alfalfa. 1995 Michigan State University Extension Bulletin E-2567.

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