The Effect of Foliar Application of Urea Ammonium Nitrate On Yield and Protein Content of Wheat

L.J. Swenson, W.C. Dahnke and **Arlyce Johnson**

Nitrogen is the nutrient most often lacking in North Dakota's production program. Historically, nitrogen fertilization has been accomplished by applying required nitrogen to the soil in the fall or in the spring before or during planting.

Hanson (4), Doll (2), Welch (9) and others generally have shown more efficient use of nitrogen when it was applied in the spring. Malhi (6) found that over-winter loss of nitrogen in Alberta was due to denitrification and not to leaching. The denitrification process likely took place in early spring when soils were wet from snow melt. Bundy (1) attributed the greater efficiency of spring-applied nitrogen to less loss by leaching and/or denitrification. Several workers (Varsa (9), Hanson (4), Huber (5)) have shown that use of nitrification inhibitors can increase the efficiency of fall-applied nitrogen on soils subject to leaching or denitrification. Fall application of nitrogen works best on well drained, fine to medium textured soils in low rainfall areas.

Recently growers have become interested in maximizing the efficiency of each input required to produce the highest economic yield. This has raised the question of whether or not traditional fertilization methods are the most efficient.

Malzar (7) stated that most researchers agree the best time to apply nitrogen is just prior to crop need. Split applications, where part of the needed nitrogen is applied during the growing season, is often used in corn production.

Researchers in Wisconsin (3) have used three nitrogen applications on wheat during the growing season. Twenty-five to 30 percent is applied at planting with additional applications during the tillering and grain-filling stages. Spratt (8) found applications of nitrate-nitrogen (NO_3-N) when wheat was in the boot stage increased protein level of the grain. Application of ammonium-nitrogen early in the growing season increased yields of leaves and stems. Increased leaves and stems, however, did not result in a larger grain yield.

Growers interested in split application find foliar applied nitrogen solution to be the most efficient way to apply extra fertilizer. In North Dakota, urea-ammonium nitrate (28-0-0) is the most commonly used liquid nitrogen solution and a form that can be used for foliar application.

This study evaluates using urea-ammonium nitrate (28-0-0) as a nitrogen source for split foliar application on wheat. The objectives were: a) determine the amount of 28-0-0 that can be applied without causing permanent damage to the wheat and b) determine the most suitable stage of growth for application of 28-0-0 to increase yield and/or protein content.

Swenson is research associate, Dahnke is professor, and Johnson is agricultural research technologist, Department of Soil Science.

Field trials were established in 1985 and 1986 to test the effect of foliar application of urea ammonium nitrate (28-0-0) in yield and protein content of wheat. The trials were conducted at Fargo on a Fargo silty clay soil. Table 1 contains soil test levels and other data regarding these trials. Phosphorus and potassium levels were sufficient and application of these was not necessary. The nitrogen fertilizer treatments were all combinations of six application rates and four growth stage application periods. The nitrogen rates were 0, 20, 40, 60, 80 and 100 pounds per acre. The growth stage applications were tillering, jointing, boot and heading in 1985. In 1986, application were made in the two-leaf, tillering, boot and heading stages.

Wheat was planted each year at rate of 90 pounds per acre using a press drill with double disk openers and 6-inch row spacing.

RESULTS AND DISCUSSION

Yield

Yield data for the two years are shown in Tables 2 and 3. Grain yields in 1985 were much greater than in 1986 due to a longer, more favorable growing season. Foliar application

Table 1. Soil test levels, and other agronomic conditions used pertinent to the foliar application study.

	Year	
Variable	**1985**	**1986**
NO_3-N, lb/acre 2'	160	83
Soil test phosphorus, lb/a	75	48
Soil test potassium, lb/a	1090	1000
pH	7.1	7.0
Fertilizer N rates, lb/a	0, 20, 40, 60, 80, 100	0, 20, 40, 60, 80, 100
Crop	Wheat	Wheat
Variety	Len	Stoa
Planting date	April 30	May 14
Harvest date	August 20	August 12
Fertilizer type	UAN (28-0-0)	UAN (28-0-0)

Table 2. Influence of rate and time of foliar N application of nitrogen on wheat yield in 1985.

Growth stage at time of application	Application Rate*						
	lb N/acre						
	0	20	40	60	80	100	AVG.
	bu/ac						
Tillering (Feekes 5)	65	62	65	62	60	64	63 A
Stem extension (Feekes 6-7)	67	62	61	59	61	63	62 A
Boot (Feekes 9-10)	64	59	59	58	61	63	61 A
Flowering (Feekes 10.5)	62	52	60	54	50	54	55 B
AVERAGE	64 A	59 AB	61 AB	58 B	58 B	61 AB	

* Similar letters indicate no significant difference between treatments at 95% level.

Table 3. Influence of rate and time of foliar N application of nitrogen on wheat yield in 1986.

Growing stage of wheat at time of application	Application Rate*						
	lb N/acre						
	0	20	40	60	80	100	AVG.
	bu/acre						
2 leaf (Feekes 2)	26	28	38	33	38	33	33 A
Tillering (Feekes 2-3)	28	36	37	34	36	40	35 A
Boot (Feekes 10)	24	28	28	31	26	28	28 B
Flowering (Feekes 10.5)	25	26	30	25	30	30	28 B
AVERAGE	26 A	30 AB	33 B	31 AB	33 B	33 B	

* Similar letters indicate no significant difference between treatments at 95% level.

caused yield reductions in 1985. The yield reductions were not significantly different from the check when less than 60 pounds of nitrogen was applied. In 1986, yield was increased by foliar application. The yield increases were significant at application rates of 20 and 40 pounds of nitrogen per acre. Application of more than 40 pounds of nitrogen had no effect on yield. A slight decrease in yield resulted from the application of 60 pounds of nitrogen per acre.

In 1985, the plot area contained a high level of residual nitrate nitrogen and plants were adequately supplied with nitrogen. Any damage to the wheat foliage caused by the foliar application resulted in yield reductions. Yield reductions were not as rate dependent as expected since the yield on areas receiving 40 pounds of nitrogen wasn't significantly different from areas that received 100 pounds of nitrogen. In 1986, however, residual nitrate nitrogen levels were much lower and foliar nitrogen application resulted in yield increases. Grain yields in 1986 occurred at the 20 and 40 pound rates. Additional nitrogen had no effect on yield.

Stage of growth of the wheat plant when foliar application was made affected grain yield. In 1985, yields were significantly decreased when foliar nitrogen was applied after the wheat was headed. In 1986, foliar application before the boot stage resulted in significantly higher yields. The reduced yields that occurred when applications were made in the later growth stages were probably a result of damage to the flag leaf.

Protein Content

The protein data are contained in Tables 4 and 5. In both years protein content was increased with foliar nitrogen application. In 1985, when the residual nitrate level was high, protein content was not significantly different from the check at nitrogen rates below 100 pounds. Protein levels of the grain in 1986 increased significantly with nitrogen rate; increases were approximately 0.25% for each 20 pounds of nitrogen applied. In 1985, stage of growth of the wheat when applications were made had no effect on protein content. In 1986, a significant increase in protein content occurred when foliar application was made during the flowering stage.

Table 4. Influence of rate and time of foliar NO_3-N application on protein content of wheat in 1985.

Growth stage of wheat at time of application	Application Rate*						
	lb N/acre						
	0	20	40	60	80	100	AVG.
	% protein						
Tillering (Feekes 5)	13.7	14.6	13.2	13.8	13.7	15.0	14.0 A
Stem extension (Feekes 6-7)	13.2	12.9	13.6	14.5	15.0	14.7	14.0 A
Boot (Feekes 9-10)	14.6	13.9	14.1	14.5	14.1	15.5	14.6 A
Flowering (Feekes 10.5)	14.2	13.1	14.1	14.2	15.5	14.8	14.3 A
AVERAGE	**13.9 AB**	**13.6 A**	**13.8 A**	**14.3 ABC**	**14.8 BC**	**15.0 C**	

* Similar letters indicate no significant difference between treatments at 95% level.

Table 5. Influence of rate and time of foliar NO_3-N application on protein content of wheat in 1986.

Growth stage of wheat at time of application	Application Rate*						
	lb N/acre						
	0	20	40	60	80	100	AVG.
	% protein						
2 leaf (Feekes 2)	14.0	14.0	14.3	14.1	14.8	14.7	14.3 A
Tillering (Feekes 2-3)	14.1	13.9	14.1	14.3	14.6	14.6	14.3 A
Boot (Feekes 10)	13.6	14.4	14.5	14.3	14.3	14.4	14.2 A
Flowering (Feekes 10.5)	13.7	14.2	14.9	14.8	15.1	15.8	14.7 B
AVERAGE	13.8 A	14.1 AB	14.4 BC	14.3 CD	14.7 CD	14.9 E	

* Similar letters indicate no significant difference between treatments at 95% level.

Leaf Damage

The plots were evaluted for leaf damage approximately three days after application and once a week during the growing season. Foliar application of 28-0-0 caused leaf burn both years of the trial. Leaf burn was slight, often not noticeable, at the 20 pound per acre rate. Leaf damage became increasingly severe at the 40 to 80 pound nitrogen rates. Plots that received rates of 80 and 100 pounds nitrogen per acre looked similar. At these rates, approximately 70 percent of the leaf area was damaged.

When foliar application was made during or before the jointing stages, leaf burn symptoms usually disappeared within seven to 10 days. At this time the plants were actively growing and new leaves developed that covered the older damaged leaves. Leaf damage caused by application during the boot stage or later was visable until the crop matured. Yield reductions were greater when application was made from the boot stage to maturity. When plants were at boot stage the flag leaf had developed and damage to the flag leaf caused by foliar application resulted in yield loss.

The only application which caused no visable plant damage regardless of rate was made when the plants were in the two-leaf stage. At this stage, the leaves covered only a small portion of the soil surface and little of the fertilizer actually made contact with the plants.

CONCLUSIONS

Foliar applications of nitrogen did result in yield increases if levels of nitrate nitrogen in the soil were not sufficient for maximum yield. Data from this study indicate nitrogen fertilization is most efficient when all the fertilizer needed for a realistic yield goal is in the soil at planting time.

Grain protein was increased by foliar application of nitrogen each year. In 1985, the soil had a high level of residual nitrate nitrogen and 80 to 100 pounds of foliar-applied nitrogen were required to cause a statistically significant increase in protein content. The soil in 1986 had low residual nitrate nitrogen and signficant protein increases occurred with 20 to 40 pounds of applied nitrogen. In both years, 80 to 100 pounds of nitrogen per acre increased protein levels by about 1 percent.

Foliar application probably should not exceed 40 pounds of nitrogen per acre and should be applied before the wheat plants reach the boot stage to avoid lasting damage to the foliage and possible yield decrease.

Foliar application can be combined with other operations such as herbicide application to keep costs down. (Before mixing a herbicide with 28-0-0 be certain the chemicals are compatible.)

Foliar application of nitrogen may increase or decrease yield and/or protein. The result will depend on the nitrogen status of the soil, the plant, and climatic conditions during and following foliar applications. When foliar applications are made when climatic conditions favor drying, such as high temperatures and low humidity, greater leaf damage will likely occur, resulting in lower yields.

LITERATURE CITED

1. Bundy, L.G. 1986. Timing nitrogen applications to maximize fertilizer efficiency and crop response in conventional corn production. J. of Fert. Issues 3(3):99-106.
2. Doll, E.C. 1962. Effects of fall-applied nitrogen and winter rainfall on yield of wheat. Agronomy J. 54:471-473.
3. 1986. Extra nitrogen: Does it pay? Farm Forum 13(4):14-16.
4. Hanson, R.G., S.R. Maledy, R.D. Hoette, N.W. Watchinski, and C.E. Jentes. 1984. Nitrogen source, time of application, and nitrification inhibitor effect on yield of winter wheat. J. of Fert. Issues 1(2):54-61.
5. Huber, D.M., H.L. Warren, D.W. Nelson, C.Y. Tsai, G.E. Shaner. 1980. Response of winter wheat to inhibiting nitrification of fall applied nitrogen. Agronomy J. 72:632-637.
6. Malhi, S.S., and M. Nyborg. 1983. Field study of the fate of fall applied N labeled fertilizers in three Alberta soils. Agronomy J 75:71-74.
7. Malzer G.L., G.W. Randall, and G.W. Rehm. 1986. Split applications: no set rules. Solutions 30(2):44-52.
8. Spratt, E.D. 1974. Effect of ammonium and nitrate forms of fertilizer-N and their time of application on utilization of N by wheat. Agronomy J. 66:57-61.
9. Varsa, E.C., S.L. Liu, and G. Kapueta. 1984. Use of nitrification inhibitors with Urea and Urea-ammonium nitrate (VAN) solution in wheat production. J. of Fert. Issues 1(4):118 124.
10. Welch, L.F., P.E. Johnson, J.W. Pendelton, and L.B. Miller. 1966. Efficiency of fall vs. spring-applied nitrogen for winter wheat. Agronomy J. 58:271-274.

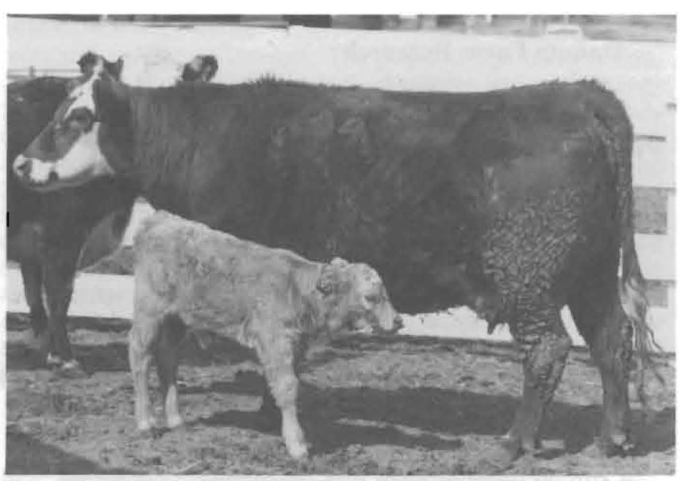
CORRECTION

In the July-August issue (Vol. 46, No. 1), photos and cutlines were switched in the article "The Brood Cow Efficiency Study--A Progress Report."

The photos with their correct cutlines appear below.

Hereford dam; Charolais sire; Calf = H × C

Angus × Hereford dam; Charolais sire; Calf = AH × C



Milking Shorthorn × Angus × Hereford; Charolais sire; Calf = MS × AH × Charolais

Simmental × Hereford dam; Charolais sire; Calf = SH × C