Nitrogen Fertilization Requirements for No-tillage and Minimum Tillage Wheat

R. P. Schneider, B. E. Johnson, and F. Sobolik

• Small grains planted in reduced tillage or no-tillage systems often exhibit severe N deficiencies. Yield responses due to N fertilization provide information related to N rates and N source selection. Data from northwestern North Dakota showed dramatic N source differences when rainfall did not occur soon after N applications.

INTRODUCTION

The practice of no-tillage or reduced tillage crop production has stimulated a great deal of interest and questions in recent years. No-tillage is a method of planting crops without seedbed preparation. The only soil disturbance is that which occurs when the seed is planted. Changes in farming practices in the soybean and corn growing areas have indicated a tendency for the farm community to reduce tillage operations and energy demands. Many articles related to no-tillage production of corn and soybeans have been published (3, 4, 5, 6). So intense has the no-tillage concept become that a book has also been published related to the production techniques of no-tillage (8).

Recent articles related to no-tillage (2, 7, 9) and others related to soil water and summerfallow (1) show the concern of research people toward evaluating small grain production practices in North Dakota.

At present limited information is available dealing with surface applications of N fertilizers in no-tillage wheat production. The studies discussed deal with two systems. The first, a no-tillage spring wheat system and the second a minimum tillage winter wheat system.

PROCEDURE

The no-tillage spring wheat system compared N rates and sources over 3 residue heights of 0, 6, and 12 inches (0, 15, 30 cm). The initial work was reported earlier (9). Blocks of residue were 100 ft x 200 ft (30.5 m x 71 m). Within each block of residue, N treatments were imposed in a randomized complete block design, with three replications. In 1978 ammonium nitrate (34-0-0) and urea (46-0-0) were broadcast applied immediately after no-tillage planting Olaf spring wheat at a rate of 70 lb/a (80 kg/ha). In 1979 the above sources were included as well as urea ammonium phosphate (33-11-0-4 (S). Nitrogen rates applied in both years were 0, 18, 36, 54, 71 and 89 lb/a (0, 20, 40, 60, 80, 100 kg/ha). Grain was harvested at maturity with a small plot combine. Samples were cleaned, weighed, and yields calculated. Protein and test weight were determined on the cleaned samples.

The minimum tillage winter wheat study consisted of N rates of 0, 25, 50, 75, and 100 lb/a (0, 28, 56, 84, 112 kg/ha) broadcast applied in the spring. The winter wheat had been planted with a hoe drill after an initial tillage procedure. Nitrogen sources used were ammonium nitrate and urea. A randomized complete block design with four replications was employed to evaluate treatment effects. Harvest and yield determinations were made as previously described.

Coteau spring wheat planted in standing grain residue without prior tillage, Williston, ND, 1979.

Dr. Schneider is assistant professor and Johnson is an assistant in Soils; Sobolik is Extension area soils agent, Williston, ND.

RESULTS

One question often asked is whether soil test data will adequately predict N needs under no-tillage systems. Given the soil test values shown (Table 1), 75 lb N/a (85 kg/ha) would have been recommended for a 40 bu/a yield (2700 kg/ha). Yield response was essentially equal with applications from 54 to 89 lb N/a (60 to 100 kg/ha). It appears that the soil test calibration work on conventional tillage systems applies to no-tillage systems as well, exemplifying the relationship between soil test, N application, and yield.

The source of N fertilizer used was an important factor in relation to N loss, yield, and soil moisture.

Yield of spring wheat increased as rates of N increased to 54 lb/a (60 kg/ha). The observation was only true for those areas where ammonium nitrate was applied. At N rates exceeding 36 lb/a (40 kg/ha) the urea treated areas were less productive. Lack of precipitation for a period of two weeks following N application apparently caused N losses from the soil surface when urea was applied. The soil-residue-urea interaction associated with the urease enzyme and hydrolysis of urea enhanced the loss of N from urea as ammonia (NH_3). Such reactions are less of a factor when applying ammonium nitrate.

Yield reduction was associated with an increase in per cent protein (Table 1). Apparently, the earlier loss of N prohibited lush vegetative growth and tillering, but once seed set occurred the remaining N was utilized in protein production. Even though per cent protein was higher where urea had been applied, total protein production was greater due to increased yields where ammonium nitrate was applied.

Table 1. The effect of N rate and source on the yield and protein of Olaf spring wheat planted no-tillage, Williston, ND, 1978.1/

N Rate			Yield		
lb/a	kg/ha	N Source2/	bu/a	kg/ha	% Protein
0	0	--	15.6	1047	14.8
18	20	AN	23.9	1606	14.5
18	20	UR	27.6	1857	14.2
36	40	AN	28.5	1918	14.4
36	40	UR	30.7	2062	14.1
54	60	AN	37.9	2548	14.2
54	60	UR	27.1	1824	14.7
71	80	AN	37.8	2541	14.6
71	80	UR	23.6	1584	15.9
89	100	AN	37.5	2519	15.0
89	100	UR	25.3	1698	16.1
LSD (.05)			4.5	303	0.3

1/ Soil Test: 40 kg NO_3^--N/ha-60 cm (36 lb NO_3^--N/a-2 ft)
88 kg NO_3^--N/ha-120 cm (79 lb NO_3^--N/a-4 ft)

2/ AN = ammonium nitrate (34-0-0)
UR = urea (46-0-0)

The 1979 data obtained under no-tillage production at Williston (Table 2) indicates the severity of moisture stress during the growing season. A total of 4.5 inches (11.4 cm) of rain fell between May 1 and August 20. Even though 1979 yields were somewhat lower than 1978, a definite N response was obtained, regardless of N source. A 40 bu/a (2700 kg/ha) yield would have been expected from soil test information plus 70 lb N/a (80 kg N/ha) applied as fertilizer. The dry season adversely reduced grain yields even though yields were comparable to fallow at the Williston station.

Table 2. The effect of N rate on the yield and protein of Coteau spring wheat planted no-tillage, Williston, ND, 1979.1/

N Rate		Yield		
lb/a	kg/ha	bu/a	kg/ha	% Protein
0	0	16.3	1096	13.7
18	20	19.6	1316	13.9
36	40	20.7	1388	14.5
54	60	20.7	1388	15.4
71	80	22.3	1496	15.9
89	100	20.8	1396	16.4
LSD (.05)		2.0	133	.6

1/ Soil Test: 38 kg NO_3^--N/ha-60 cm (34 lb NO_3^--N/a-2 ft)
100 kg NO_3^--N/ha-120 cm (90 lb NO_3^--N/a-4 ft)

Grain protein was significantly increased from 13.7% to 16.4% as N rates increased. The increase in protein was also related to the dry growing season. Protein increases can be expected when soil test levels are as low as those indicated.

Results from the winter wheat trial are of considerable significance. The winter wheat was planted in residue which had been worked, but significant amounts of residue remained standing. Within 4 hours of fertilizer material application one inch (2.5 cm) of rainfall occurred, which acted as a means of nutrient incorporation. Data indicated a dramatic response to N fertilization (Table 3). As rates of N increased, yields also increased. The only significant difference between sources occurred at the 75 lb N rate (84 kg/ha). The areas receiving urea N were significantly better than those receiving ammonium nitrate. The yield difference may be due to the large amounts of NH_4^+-N present early in the growing season where urea was applied.

Protein data (Table 3) indicated no dramatic differences. The decreased protein per cent associated with the first increment of N has been shown many times and is due to a lack of N at the time of protein formation. The decrease is also related to a dilution effect associated with increased carbohydrate production.

Soil test recommendations for the area would have been from 80 to 100 lb N/a (90-115 kg N/ha) depending on the yield goals of the producer. The 1978 yields may have been high due to above normal seasonal precipitation.

Table 3. The effect of N rate and source on the yield and protein of Roughrider winter wheat, under minimum tillage, Zahl, ND, 1978.1/

N Rate		N Source2/	Yield		% Protein
lb/a	kg/ha		bu/a	kg/ha	
0	0	--	25.6	1720	11.2
28	25	AN	34.7	2332	10.4
28	25	UR	36.0	2419	10.1
56	50	AN	48.3	3246	10.7
56	50	UR	47.0	3158	11.3
84	75	AN	50.4	3389	11.2
84	75	UR	60.2	4045	11.4
112	100	AN	57.9	3891	11.5
112	100	UR	62.0	4170	11.4
LSD (.05)			6.4	430	0.8

1/ Soil Test: 34 kg NO_3^--N/ha-60 cm (30 lb NO_3^--N/a-2 ft)

84 kg NO_3^--N/ha-120 cm (75 lb NO_3^--N/a-4 ft)

2/ AN = ammonium nitrate (34-0-0)

UR = urea (46-0-0)

CONCLUSION

Data indicate the importance of precipitation when selecting N fertilizer materials. If a no-tillage or reduced tillage system is being employed and surface application of N is anticipated, precautions in selection of N sources are suggested. Under dry conditions, surface application of ammonium nitrate is superior to urea. Given adequate moisture within 24-48 hours of application, urea and ammonium nitrate appear to be comparable sources of N under reduced tillage systems.

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North Dakota State University has, scattered in several departments, quite a number of scientists who, as it relates to their specific disciplines, have considerable interest and expertise in various aspects of nitrogen. If these persons were put together in a single unit they could by virtue of their number or scientific man years of effort constitute a department of their own. However, being scattered about the campus, the impact of this expertise and interest in the many areas of crop production, range management and animal science, has been far greater than if we were a self-contained unit. At the same time, by virtue of being physically scattered and sometimes under different administrative units, we are not always fully aware of each other's work.

With the apparent success and appeal of some of the previous issues of Farm Research which were based on a single theme, the idea was conceived to put together an issue on nitrogen. This would be an issue which would deal with various aspects of nitrogen as they fit into the agricultural scene of North Dakota.

The articles finally included in this issue of Farm Research are by no means exhaustive of the subject, as there is not space for such a complete treatment. The topics and authors chosen were selected so as to be representative, dealing with nitrogen requirements and utilization by specific crops, the status of nitrogen in North Dakota soils, the cycling of this element through our plant-soil and water systems, the possible sources of nitrogen available to the producer and their use over the years with an evaluation of the present economics of using supplemental nitrogen in our management programs, the economics of production, marketing and applying nitrogen fertilizers, and a look toward future availability, cost and use in North Dakota.

The purpose of this issue, then, is to bring together contributions by various scientists working with nitrogen, to limelight the total amount of work being done with nitrogen, and to inform the agricultural community of our state that the Experiment Station is concerned with and working on various problems relating to the use of too much, too little and the appropriate forms of nitrogen in agriculture. Also it is to make each of us working with nitrogen more cognizant of our colleagues' interests and efforts.

It is our hope that you will find this single-theme issue of Farm Research on "Nitrogen in North Dakota Agriculture" both interesting and informative. We hope the information pertains not only to your particular operation, but also will make you aware of how nitrogen relates to other forms of agriculture throughout the state. It is our interest to illustrate that the use of nitrogen has a pronounced effect upon the quality of life in both our urban and rural settings through its influence on the nutritional quality as well as quantity of agricultural goods produced, the economics of our agricultural industry and the quality of our environment.