The Effect of N Fertilizer Placement, Formulation, Timing and Rate on the agronomic performance in wheat

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Keywords: N fertilizer, placement, Wheat.

Abstract

Increasing the efficiency of nitrogen fertilizer uptake by crops improves the agronomic, economic, and environmental value of fertilizer N. Band placement of urea below the soil surface increased recovery of N in plants in both conventional and no-tillage systems. The latter systems require all fertilizers be applied before or during the seeding operation. In order to avoid seedling damage caused by fertilizer, side banding and mid-row banding opener systems have been developed to separate the seed and fertilizer. The objective of this study was to compare the agronomic performance in wheat between side banding and mid-row banding N fertilizations and estimate effects of fertilizer formulation, timing and rate in an Orthic Brown Chernozem. A three-year experiment (2000-2002) was conducted near Swift Current in the Brown soil zone (Swinton silt loam, Orthic Brown Chernozem) of southern Saskatchewan. Seventeen treatments were arranged in a randomized complete block design in four replications with plot size of 3 m × 9.2 m. A Canada Western Red Spring wheat, AC Barrie, was seeded on a no-tillage management. Results showed that the environment had a major impact on the grain yield and biomass production. In general, the difference in agronomic performance between side banding and mid-row banding treatments was small.

Introduction

Increasing the efficiency of nitrogen (N) fertilizer uptake by crops improves the agronomic, economic, and environmental value of fertilizer N. Malhi and Nyborg (1991) found that band placement of urea below the soil surface increased recovery of N in plants in both conventional and no-tillage systems. The latter systems require all fertilizers be applied before or during the seeding operation. In order to avoid seedling damage caused by fertilizer, side banding and mid-row banding opener systems have been developed to separate the seed and fertilizer. The objective of this study was to compare the agronomic performance in wheat between side banding and mid-row banding N fertilizations and estimate effects of fertilizer formulation, timing and rate in an Orthic Brown Chernozem.

Materials and Methods

This study was a part of a multi-location and multi-crop research program on effects of nitrogen placement on greenhouse gas emissions and agronomic performance. A three-year experiment (2000-2002) was conducted near Swift Current in the Brown soil zone (Swinton silt loam, Orthic Brown Chernozem) of southern Saskatchewan. Seventeen treatments (Table 1) were arranged in a randomized complete block design in four replications with plot size of 3 m × 9.2 m. A Canada Western Red Spring wheat (AC

Barrie in 2000 and 2001 and AC Eatonia in 2002) was seeded on a no-tillage management.

All dependent variables were analyzed for each year with the PROC MIXED procedure of SAS (SAS Institute Inc. 1996) with the REML option with treatments fixed and replications random. Single degree of freedom contrasts were used to determine differences between several treatments (side banding vs. mid-row banding, broadcast vs. banding, urea vs. AA, fall fertilization vs. spring fertilization, etc.). Linear, quadratic and cubic effects of N rate were determined by orthogonal contrasts.

Results and Discussion

In 2000, the temperature was above average in the growing season (May-August) except in June and the precipitation was higher than average (Table 2). In 2001, the temperature was above average during most of the growing season, with very low precipitation. The moisture condition in the early spring of 2002 was poor because of the depletion of soil moisture in 2001 and low precipitation in May, while precipitation was above normal, and temperature was normal in the rest of the growing season. As a result of the varied weather conditions and severe sawfly damage in 2001, the overall average yield was 3.7 t ha^{-1} in 2000, 0.7 t ha^{-1} in 2001 and 1.3 t ha^{-1} in 2002.

Statistical analysis indicated no significant placement × formulation or placement × rate interactions for all agronomic variables in each year. Therefore, overall contrasts between side banding and mid-row banding treatments were presented. The grain yield of side banded treatments did not differ from that of mid-row banded treatments in 2000 or 2001 (Fig. 1). In 2002, side banded treatments achieved higher yield ($P < 0.05$) than mid-row treatments, but the increase was only 0.2 t $ha^{-1.}$ Similarly, the straw production of side banding treatments was higher than that of mid-row banding treatments in 2002. Although a treatment difference in straw was observed in 2001, the amount of difference was very small (0.1 t ha^{-1}).

A considerable crop stress on the medium and high side-banded urea treatments was visually observed in the early growing season in 2000. These symptoms were no longer apparent by the flag leaf stage. In 2001, side banding treatments had lower plant density than mid-row banding treatments ($P < 0.05$). There were no significant differences between side banding and mid-row banding treatments in heads per plant or kernel weight.

The treatment of broadcast application consistently had lower yield than both side banding and mid-row banding treatments (urea at medium rate) although differences were only significant in 2002. Treatment differences in other variables were not significant except that the broadcast treatment had higher plant density ($P < 0.01$), but less heads per plant ($P < 0.05$) than the mid-row banding treatment in 2000.

Treatment differences between urea and AA were in general not significant except that AA treatments had higher plant density ($P < 0.01$) and less heads per plant ($P < 0.05$) than urea treatments in 2000 (Fig. 1). In most cases, differences were not significant for other treatment comparisons.

In summary, the environment had a major impact on the grain yield and biomass production. In general, differences in agronomic performance between side banding and mid-row banding and between urea and AA applications were small.

Acknowledgements

We would like to thank the AAFC Matching Investment Initiative Program, Canadian Fertilizer Institute, Saskatchewan Agricultural Development Fund (ADF), Western Grains Research Foundation, Bourgault Industries, and the Saskatchewan Flax Commission for funding support. We also acknowledge Prairie Agricultural Machinery Institute, Flexi-coil Ltd., Big Quill and Western Ag Innovations for their in-kind contributions.

References

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Table 1. List of treatments.

Treatment	N fertilizer				P fertilizer placement[1]
	Form	Rate	Placement	Timing	
1) Side-banded urea with low rate[2]	Urea	low	side band	spring	side band
2) Side-banded urea with medium rate	Urea	medium	side band	spring	side band
3) Side-banded urea with high rate	Urea	high	side band	spring	side band
4) Mid-row banded urea with low rate	Urea	low	mid-row	spring	with seed
5) Mid-row banded urea with medium rate	Urea	medium	mid-row	spring	with seed
6) Mid-row banded urea with high rate	Urea	high	mid-row	spring	with seed
7) Fall banded urea with medium rate	Urea	medium	band	fall	with seed
8) Broadcasted urea with medium rate	Urea	medium	broadcast	spring	with seed
9) Side-banded AA[3] with low rate	AA	low	side band	spring	with seed
10) Side-banded AA with medium rate	AA	medium	side band	spring	with seed
11) Side-banded AA with high rate	AA	high	side band	spring	with seed
12) Mid-row banded AA with low rate	AA	low	mid-row	spring	with seed
13) Mid-row banded AA with medium rate	AA	medium	mid-row	spring	with seed
14) Mid-row banded AA with high rate	AA	high	mid-row	spring	with seed
15) Fall banded AA with medium rate	AA	medium	band	fall	with seed
16) Very low N	-	-	-	-	with seed
17) Side-banded urea with medium rate + P[4]	Urea	medium	side band	spring	with seed

[1] Mono-ammonium phosphate (11-51-0) applied at rates of 17 kg P2O5 ha-1and 4 kg N ha-1.

[2] Low rate was a half of medium rate, medium rate was the generally recommended rate for the area; high rate was 1.5 times of medium rate and very low rate was no fertilizer applied, except Mono-ammonium phosphate. The recommended rate was 60 kg N ha^{-1}.

[3] Anhydrous ammonia.

[4] Mono-ammonium phosphate was applied with seed.

Table 2. Mean monthly air temperature and precipitation (May-August) at Swift Current, SK.

	Temperature (ºC)				Precipitation (mm)			
	2000	2001	2002	1900-2002	2000	2001	2002	1900-2002
May	18.9	12.2	8.5	10.9	65	23	22	44
June	13.8	15.0	15.7	15.4	54	32	144	73
July	19.1	19.7	19.6	18.6	127	63	73	51
August	18.4	20.9	15.5	17.6	13	3	102	42
Mean for temperature								
Sum for precipitation	15.6	17.0	14.8	15.6	259	121	341	202

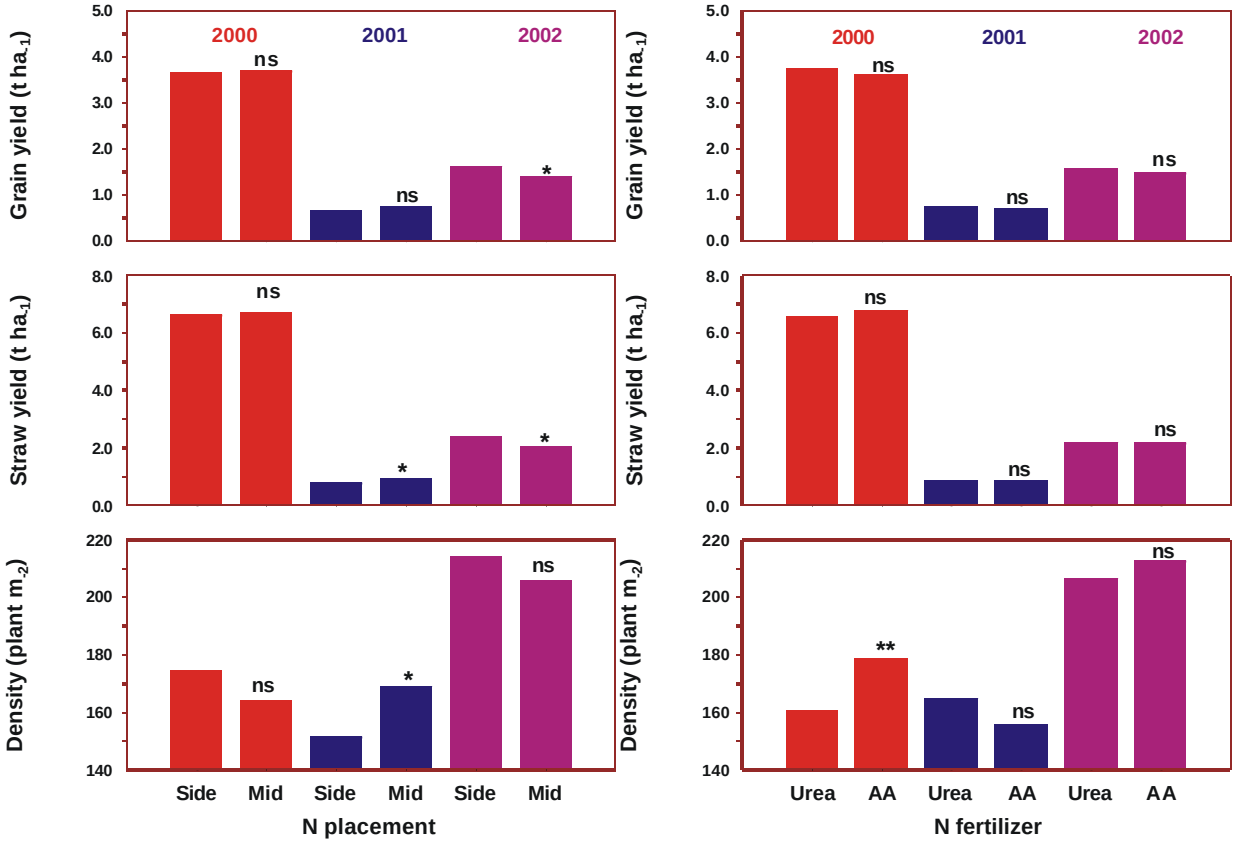

Fig. 1. Comparisons between side banded N (Side) and Mid-row banded N (Mid) treatments and between Urea ad AA treatments in wheat. *, **, ns: significant at 0.05, 0.01 and not significant at 0.05 probability levels, respectively, within the same year.