EVALUATING NITROGEN FERTILIZER SOURCES FOR WINTER WHEAT

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ABSTRACT

A study was conducted to evaluate available and alternate nitrogen (N) forms and application methods compared to broadcast applications of ammonium nitrate (AN) in the early spring. Most of the alternate N sources provided similar yields to spring broadcast AN, except fall banded AN, and spring surface broadcast applied ESN. Different features of some of the N fertilizer sources make them better suited to specific time and placement combinations.

BACKGROUND

AN was the commonly recommended N source for winter wheat fields usually broadcast applied in early spring. This product performed very well for applying N to winter wheat, however, with the general removal of AN from the retail agriculture market in the Northern Great Plains of North America the most available source of granular N fertilizer is urea (46-0-0). Under spring conditions where the surface applied urea is not moved sufficiently into the soil with a timely rain after application there can be unwanted losses through ammonia (NH_3) volatilization due to urease activity in surface residues and soil. Other alternative granular N sources include urea treated with Agrotain a urease inhibitor, urea treated with Agrotain plus DCD a nitrification inhibitor (Super Urea), and ESN or polymer coated urea. Most of these N-urea forms can be side-banded at planting (September), or top-dressed in the spring (mid to late April). The ESN product can also be considered for seed-row placement at planting due to delay of release of soluble urea and little toxicity to germinating seedlings.

MATERIALS AND METHODS

A study was conducted beginning in the fall of 2006 at Beiseker, AB on a silt-loam textured soil with a 4.5 % organic matter content in the Ap horizon. This soil is classified as a Black Chernozemic soil (Canadian Soil Classification) or a Udic Boroll (U.S taxonomy) (McKeague 1978). The previous crop had been canola. The soil was sampled and analyzed for macro-nutrient availability a couple of weeks (15-Sep-2006) before no-till planting on 25-Sep-2006. A paired row opener was used on the research plot planter that had the capability to precision place fertilizer in a band 30 mm (1.2 inches) below and between the paired-row of seed that were 51 mm (2 inches) apart. Shank spacing was 254 mm (10 inches). Planting depth of the winter wheat was 25 mm (1 inch), and the 98% germination grain, cultivar CDC Clair, was seeded at a rate of 134 kg ha^{-1} (120 lb/A), for a target population of 250 plants m^2 (approx 25 plants ft^2). The seed-row fertilizer blend applied supplied 6N, 30 P2O5, 10 K2O, and 5 S kg ha^{-1}. N fertilizer experimental design was a randomized complete block consisting of 4 replicates, with a 0-N check plot, and N fertilizer rates of 30, 60, 90 and 120 kg N ha^{-1}. The forms of N fertilizer evaluated included AN, urea, Agrotain-treated urea, Super Urea, and ESN. Placement-timing combinations included banded at the time of planting and early spring broadcast (26-April-2007) for all N forms, and an additional seed-row placement for ESN. There were a total of 45 treatments in total. Individual research plots were 2 m by 8 m (6.5 ft by 26 ft). An in-crop broadleaf herbicide application (Bromoxynil) was applied on the 20-May-2007. The plots were harvested 20-August-2007 using a research plot-combine, samples were further cleaned of chaff before weighing. Yield data was analyzed using analysis of variance.

RESULTS AND DISCUSSION

The weather experienced at the research site during the period of 25-September-2006 until harvest on 25-Aug-2007 was very compatible to winter wheat growth. The accumulated precipitation during the period was 350 mm (13.8 inches), and accumulated growing degree days (0 C) was 1500 (AARD 2006). These values were very close to long-term 30-year averages for the area.

Response to nitrogen was excellent with the check plot 0-N treatment yielding 2819 kg ha^{-1} (42 bu A^{-1}), and the average yields from N fertilizer rates 30, 60, 90 and 120 kg N ha^{-1} (27, 54, 80 and 107 lb NA^{-1}) for all forms and placement combinations were 4189, 4556, 5239 and 5595 kg ha^{-1} (62, 68, 78 and 83 bu A^{-1}).

Most of the N fertilizer forms had differences between fall and spring application times, except for Super Urea. Fall banded ammonium nitrate, urea, and Agrotain-treated urea did not perform well compared to spring broadcast applications (Table 1). ESN did well as fall-banded or seed-row placement at planting, but did not do as well as a spring broadcast application. Each form of N fertilizer used in this study has features that make it suitable for use as an N source for winter wheat if used at an appropriate time and placement. However if not used at the proper time and placement there can be unwanted losses or inefficiencies. There is a common saying for use of N fertilizer that states the following “A pound of N is a pound of N if used properly”. The key part of this saying is “if used properly”. It is useful to look at each form of N included in this study and compare placement in a precision placed band, or in the case of ESN also in the seed-row, in the fall at the time of planting, to a surface broadcast application in the early spring.

The former common use of AN as a spring broadcast application is a proper use of this product. If used in the fall at the time of planting it can be subject to denitrification and leaching losses over fall, winter and especially in the early spring when thawing and snowmelt can result in saturated surface soils and a low soil oxygen status. Half the N in AN is nitrate and a portion of the other half of N in the ammonium form can be transformed to nitrate depending on the conditions suitable for the soil microbes responsible for nitrification. This is adequately warm temperatures and sufficient moisture. In this study fall applied AN performed poorly compared to spring broadcast application, thus showing that denitrification or leaching losses probably occured (Table 1). Urea and Agrotain-treated urea also resulted in lower fall yields compared to spring broadcast applications. The losses of N for these two N fertilizers due to denitrification and leaching were probably less than the AN because of less difference between fall and spring yields. There is less nitrate N initially and also a delay in ammonium available to be nitrified because the urea molecules require hydrolysis by the action of the urease enzyme present in soil and crop residues.

Table1. Yield of winter wheat in response to various N forms applied in timing and placement combinations, averaged over four different rates, analysis for each N form separately.

Form of N Fertilizer	Placement and Timing	Yield kg ha^{-1}	Yield Bu A^{-1}	Significance α 0.05, within each form of N Fertilizer
Ammonium Nitrate	Broadcast in Spring	5590	83	a
	Side-banded at Planting	3792	57	b
Urea	Broadcast in Spring	5570	83	a
	Side-banded at Planting	4630	70	b
Agrotain Treated Urea	Broadcast in Spring	5486	82	a
	Side-banded at Planting	4509	67	b
Super Urea	Broadcast in Spring	5393	80	a
	Side-banded at Planting	4876	73	a
ESN	Broadcast in Spring	4420	66	c
	Side-banded at Planting	4725	70	b
	Seed-row at Planting	5459	81	a

Super Urea resulted in closer yields comparing fall to spring timing of application, probably due to the action of the DCD nitrification inhibitor that would keep the N in the ammonium form longer and result in less nitrate available for denitrification or leaching compared to urea, Agrotain-treated urea, or the ammonium N in the AN. ESN performed quite differently than all the other N sources as the highest yield was fall placement in the seed-row. Placement in the side-band was intermediate and spring broadcast resulted in the lowest yield. Placing ESN on the surface in the spring may result in a delay of urea release from the polymer coated granule, or may also result in more ammonia volatilzation losses than if the ESN granules are placed in the soil. It is difficult to explain why the seed-row placed ESN gave higher yields than the side-banded ESN both at planting in this experiment.

To compare all the forms of N and the various timing by placement combinations the 90 kg N ha^{-1} rate of application is shown below (Table 2). This is close to the recommended rate of N for this crop in this area based on regional soil-test calibration research. This reinforces that AN, urea and Agrotain-treated urea were best suited to spring application than a fall side-banded application. In this experiment there was no evidence of ammonia volatilization losses in the early spring from surface applications of urea compared to ammonium nitrate, Agrotain-treated urea, or Super Urea. This probably because 44 mm (1.7 in) of precipitation was received within 11 days after application in the spring, and average air temperature was 7.5 degrees C (AARD 2006). Adequate moisture that moved the urea into the soil, and cooler soil temperatures should decrease the level of urease activity resulting in ammonia volatilization losses.

Table2. Yield of winter wheat in response to various N forms applied in timing and placement combinations, at the 90 kg N ha-1 rate, analysis for all N forms together.

Form of N	Placement and Timing	Yield kg ha-1	Yield bu A-1	Significance α 0.05
Ammonium Nitrate	Broadcast in Spring	6145	92	a
Ammonium Nitrate	Side-banded at Planting	3447	51	f
Urea	Broadcast in Spring	6092	91	ab
Urea	Side-banded at Planting	4659	69	e
Agrotain-treated Urea	Broadcast in Spring	6229	93	a
Agrotain-treated Urea	Side-banded at Planting	4515	67	e
Super Urea	Broadcast in Spring	5768	86	bc
Super Urea	Side-banded at Planting	5738	86	c
ESN	Broadcast in Spring	4520	67	e
ESN	Side-banded at Planting	5280	79	d
ESN	Seed-row at Planting	5917	88	abc
Check 0 N	NA	2818	42	NA

CONCLUSIONS AND RECOMMENDATIONS

1. All the N-fertilizer forms compared to AN as a spring broadcast application could be viable alternatives if applied at the appropriate timing and placement combination. AN was confirmed to be an efficient N fertilizer for spring broadcast applications, but is not now generally available in the Northern Great Plains region where this study was done.
2. Urea and Agrotain-treated urea were best applied as a spring broadcast applications rather than side-banded at planting in the fall. Further research is recommended comparing these two forms of N, as spring broadcast applications, to determine the benefit from having the urease inhibitor to reduce potential ammonia volatilization losses.
3. Super Urea could be applied as either a fall side-banded, or spring broadcast application. This was the only N form where differences between fall and spring applications were not observed. The combination of the urease and nitrification inhibitors kept the N in ammonium form and reduced denitrification or leaching losses, compared to AN, urea and Agrotain-treated urea.
4. ESN performed best as a seed-row application at planting and ESN side-banded was intermediate in yield compared to other experimental treatments. More research is recommended to determine whether or not the seed-row and side-banded placement methods are different or not.

REFERENCES

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