USING A UREASE INHIBITOR, N-BUTYL THIOPHOSPHORIC TRIAMIDE (NBPT) FOR SEED-PLACING NITROGEN WITH WHEAT, BARLEY, AND CANOLA

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Abstract

Comparisons were made between banded urea, seed-placed urea, and seed-placed urea treated with the urease inhibitor N-butyl thiophosphoric triamide (UNBPT) at nitrogen applications of 0, 25, 50, 75, and 100 kg N ha". Seeding equipment used spoon openers and utilized about 25% of the seed-bed area. Yield with seed-placed UNBPT was at least equal to yield from banded urea, and was higher than yield with seed-placed urea at 6 of 8, 5 of 8, and 4 of 14, barley, wheat, and canola sites. Nitrogen from UNBPT could be applied at least 25 kg N ha^{-1} higher than could safely be applied using urea in seed-placed applications.

INTRODUCTION

Urease is an enzyme found in a large number of higher plants and microorganisms (Bremner and Mulvaney, 1978). In soils, urease is an extracellular enzyme that is released from living or decaying microorganisms or plants (Mulvaney and Bremner, 198 1). Urease is abundant in soils and occurs universally (Tisdale et al, 1985). When urea is applied to soil it is rapidly hydrolyzed in a reaction catalyzed by urease.

The chemistry associated with urea hydrolysis affects fertilizer management practices. Surface applied urea potentially could lose nitrogen to the atmosphere through ammonia volatilization, Incorporation of broadcast urea minimizes this N loss potential. Since urea hydrolysis produces ammonia/ammonium creating conditions which can be toxic to seedlings, urea must be physically separated from seeds either by banding urea away from seeds or by scattering seed and fertilizer over a wide seed-row.

N-butyl thiophosphoric triamide (NBPT) has been identified as an effective urease inhibitor by reducing ammonia volatilization from surface applied urea (Bremner et ***al,*** 1991; Christianson et al, 1990; Schlegel et al, 1986; Zhengping et ***al,*** 1991). NBPT has also been found to reduce or eliminate the adverse effects of urea fertilizer on seed germination, seedling growth, and early plant growth (Bremner and Krogmeier, 1988). NBPT or other effective urease inhibitors have the potential to minimize the limitations of urea fertilizer and could alter current urea fertilizer management practices, especially in reduced tillage and direct seeding management systems.

Sherritt's research work with NBPT since 1993 has focused on seed-placed nitrogen fertilization with barley, wheat, and canola. Since NBPT was found to delay urea

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'hydrolysis and reduce the toxic effects of urea near seeds and seedlings, NBPT treated urea (UNBPT) should be much safer than urea for seed-placing. Possibly, seed and UNBPT would not need to be physically separated if rainfall diluted urea concentrations near seeds prior to hydrolysis. Although rainfall would also minimize the toxic effects of conventional urea, the rainfall would have to be within a few days of seeding or else toxic conditions would develop. Delayed urea hydrolysis would minimize toxic conditions allowing for a prolonged rain-free period following seeding. NBPT would not be a guarantee against damage from seed-placed nitrogen, since its effectiveness would still ultimately depend on rainfall. However, NBPT would be like an insurance policy against temporary drought that would allow for the safe use of urea in seed-placed applications.

In 1995 Sherritt performed seed-placed nitrogen experiments with barley, wheat, and canola to determine if NBPT allowed for greater rates of seed-placed nitrogen than urea with wheat, barley, and canola. An overall aim of the research was to determine if NBPT could alleviate some of the problems associated with fertilizer placement in low disturbance, direct seeding situations.

MATERIALS AND METHODS

Seed-placed fertilizer experiments were performed at a number of locations in Alberta and Saskatchewan (Table 1.). The intent was to spread experiments over a large geographic area in order to have a range of agro-climatic conditions at seeding and in the weeks immediately following seeding. Generally each location had both a canola and a cereal experiment. The experiments were arranged in a randomized complete block design with 5 product/placements (banded urea, 10 and 25% SBU[1] seed-placed urea, 10 and 25% SBU seed-placed UNBPT) and 5 N application rates (0. 25, 50, 75, and 100 kg N ha^{-1}) replicated 3 times. In addition to the seed-placed nitrogen, canola and cereal experiments had 25 kg P_2O_5 ha^{-1} applied in the seed-row, and the cereals had a further 15 kg K_2O ha^{-1} seed-placed.

Table 1. Locations for 1995 Seed-placed fertilizer experiments

Crop	Location	Totals
Barley	Dundum, Asquith, Delmas, and Watson, Saskatchewan, Castor, Olds, Innisfail, and Neerlandia Alberta	8
Wheat	Strasbourg , Davidson, Delisle, Delmas, and Watson, Saskatchewan, Calmar, Fort Saskatchewan, and Torrington, Alberta	8
Canola	Dundum, Asquith, Delmas 1 and 2, Strasbourg, Davidson, Watson 1 and 2, and Delisle, Saskatchewan, Castor, Olds, Innisfail, Calmar, Neerlandia-1 and 2, Fort Saskatchewan, and Torrington, Alberta	17

1 SBU or Seed-bed Utilization: (width of individual seed-fertilizer row/row spacing)*100

All seeding was done with a plot air-drill using Bourgault 3" spoon openers and on-row packing (8-inch centers). Custom-made seed/fertilizer boots were supposed to limit the spread of seed and fertilizer to about 2 cm (-10% SBU) and 5 cm (25% SBU), but the seed and fertilizer spread with the 10% boot appeared to be similar to the spread with the 25% boot. Evidently there was considerable seed and fertilizer scatter between the 10% boot and the soil surface behind the spoon opener so the spread with either boot was similar. In the results and discussion there will not be any distinction made between the two SBU's with either urea or UNBPT.

Three canola sites were not harvested. The Torrington site was plagued with excess rainfall that drowned out numerous plots, one site at Neerlandia was decimated by hail, and the treatments at Delisle were mixed when the plots were swathed by the cooperator. Harvest data were collected for all other canola and cereal experiments.

RESULTS AND DISCUSSION

Treatment effects were visible (reduced stand) at most locations throughout the growing season. However, these effects were not always evident in yield data (Table 2.). Early in the 1995 season it was estimated that about 75% of the sites would have been classified as Effective at harvest so the number of sites where there were no differences between product/placements is surprising. This is especially true for canola where few sites were expected to be classified Not Needed. Apparently the canola stand was not reduced below the point where the remaining plants could compensate in yield. The Davidson site had the most severe treatment effects with canola emergence severely impaired even by phosphate fertilizer alone.

Table 2. 1995 Seed-placed experiments where NBPT was effective, ineffective, or not necessary for reducing the toxic effects of seed-placed fertilization+.

Crop	Effective'	Not Needed'	Ineffective[3]	Total
Barley	6	2	0	8
Wheat	5	3	0	8
Canola	4	8	2	14
Total	15	13	2	30

† Product effectiveness is based on yield comparisons between the different product/placements averaged across the N application range.

1 Effective: Average yield from UNBPT>yield from seed-placed urea; UNBPT>banded urea

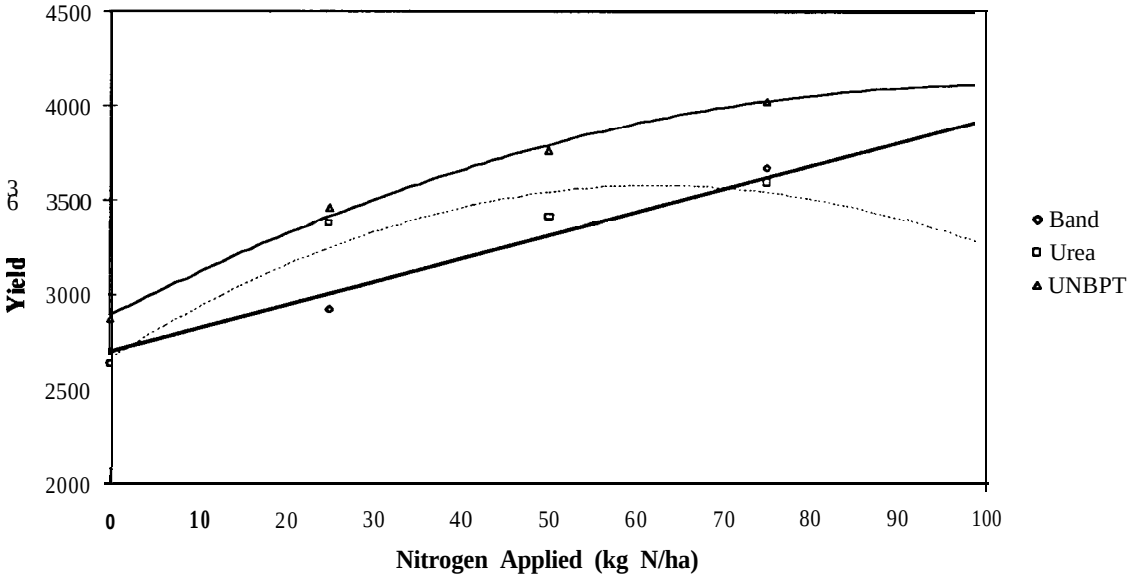
' Not Needed: no yield difference between banded urea, seed-placed urea, and seed-placed UNBPT (and seed-placed ammonium nitrate where applicable).

3 Ineffective: yield from banded urea>seed-placed urea=seed-placed UNBPT

From sites where NBPT was effective, barley yield (averaged across all N application rates) with seed-placed UNBPT was higher than either banded urea or seed-placed urea (Figure 1 and Appendix). Although the average effect of seed placed urea and

banded urea are the same, at 25 kg N ha“ yield was higher from seed-placed urea than banded urea while at 100 kg N ha^{-1} yield was higher with banded than with seed-placed urea. Barley yield at every N application rate was higher or tended to be higher with seed-placed UNBPT than barley yield Seed-placed urea and UNBPT had similar yield at 0 and 25 kg N ha-‘, but toxicity effects probably caused the yield from the two sources to diverge at N rates above 25 kg N ha^{-1}. There were indications from both the seed-placed urea (low N rates) and s UNBPT (all N rates) that seed-placing nitrogen with barley could be a more effective N placement method than banding.

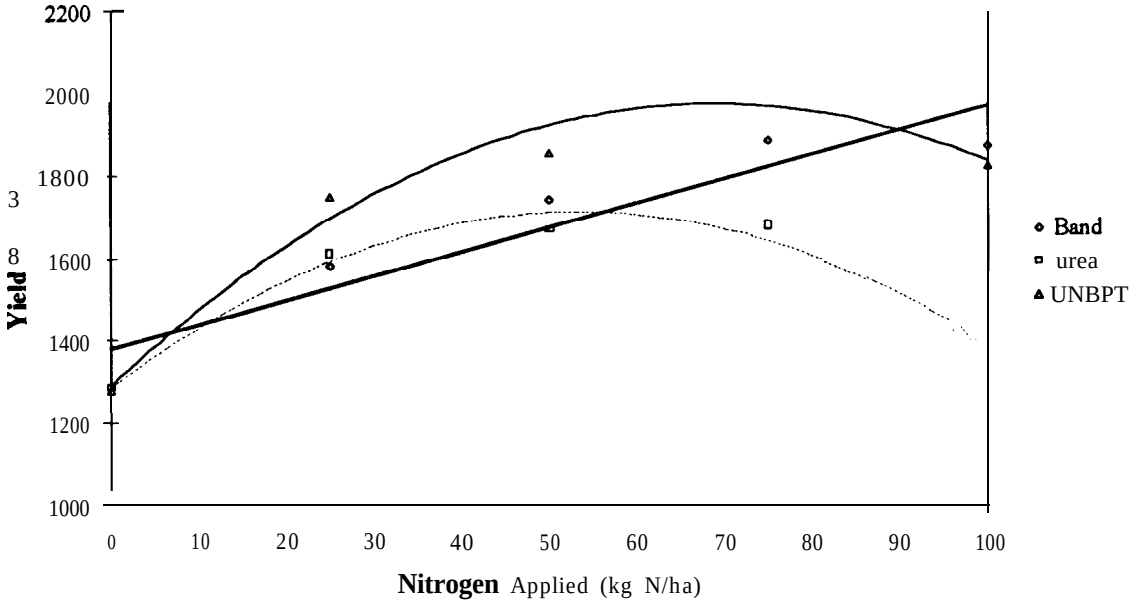
Figure 1. Seed-placed nitrogen with barley: Combined effective sites



The maximum safe seed-placed urea application rate with barley (using banding as the standard) was about 75 kg N ha^{-1}. The maximum safe N application rate for barley with UNBPT was higher than the application rates used in this experiment (at least 100 kg N ha-‘). It must be remembered that these maximum rates were established with seeding equipment that had relatively low soil disturbance yet still had considerable seed and fertilizer scatter (SBU). These rates therefore are not universal since lower or higher SBU would alter maximum allowable rates.

The shape of the wheat yield response curves were similar to the barley yield response curves. However, with wheat there was no overall yield difference between banded urea and seed-placed UNBPT (Figure 2). The maximum safe N application rate with seed-placed UNBPT was therefore 100 kg N ha^{-1}. Like the barley experiments, wheat yield from seed-placed urea was lower than the yield from seed-placed UNBPT. The average wheat yield with seed-placed urea was also lower than the yield with banded urea. The maximum safe seed-placed nitrogen rate using urea appeared to be between 50 and 75 kg N ha^{-1}.

Figure 2. Seed-placed nitrogen with wheat: Combined effective sites



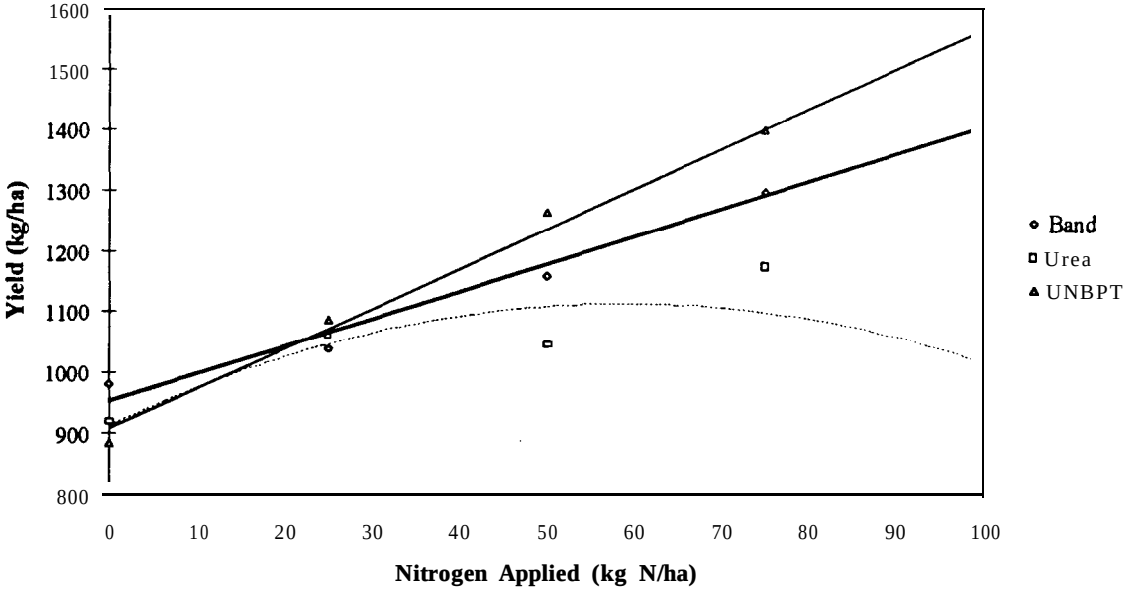
Unlike the barley experiments, there was no evidence to suggest an N use efficiency improvement with seed-placed N compared to banded N. The apparent N efficiency gain with seed-placing in the barley experiments may only be a chance event since one would think that the same effect should occur with wheat. However it should be noted that the relative yield potential of the barley experiments appears to be higher than the yield potential with the wheat experiments. The barley experiments had maximum yield of about 3900 kg ha^{-1} which is relatively high considering the agro-climatic regions for the experimental sites (3 sites on Brown/Dark Brown soils, 2 sites on Black soil, 1 site on Gray soil). On the other hand wheat experiments had maximum yield of about 2000 kg ha^{-1} which would be considered mediocre at best for small plot work (wheat experiments were in similar agro-climatic regions as the barley). The yield potential is probably an indication of moisture conditions (and the potential toxicity of seed-placed nitrogen) at the sites. The toxic effects of seed-placed urea restricted wheat yield at a lower N application rate than occurred with barley. Therefore the wheat experiments probably had higher potential for yield losses from seed-placed nitrogen than the barley experiments. With these conditions a wheat yield improvement due to increased nitrogen use efficiency from seed-placing would be small or unlikely. Yield improvements from seed-placing compared to banding nitrogen probably only occur when the potential for seed-placed N toxicity is low and the yield potential is relatively high.

Canola yield with seed-placed urea was lower than the yield from either seed-placed UNBPT or banded urea (Figure 3). Canola yield with seed-placed UNBPT and banded urea were similar. The maximum safe rate of seed-placed UNBPT was higher than the N application range used in this experiment (at least 100 kg N ha^{-1}). The maximum safe rate

of seed-placed urea appears to be about 75 kg N ha-‘. It must again be noted that the seeding equipment produced considerable seed and fertilizer scatter (utilized about 25% of the seed-bed) so safe seed-placed urea and UNBPT rates are not universally applicable to all seeding operations.

The overall canola yield was lower than expected for small plots with adequate fertilization and is a concern. It is possible that higher overall yield would have revealed differences between banded urea and seed-placed UNBPT (either higher yield with banded urea or higher yield with seed-placed UNBPT). As with the wheat, there was no evidence that seed-placed N was more efficient than banded N but this could also be due to the low yield potential.

Figure 3. Seed-placed nitrogen with canola: Combined effective sites



CONCLUSIONS

Seed-placed experiments in 1995 were seeded with a plot air-drill using Bourgault 3” spoon openers. Although the seeding equipment disturbed a small portion of the seed-bed, yield results should be equated with about 20-25% SBU and not generalized for all low disturbance seeding situations. It should also be noted that the air drill utilized on-row packing. This equipment had excellent depth control and generated a good quality finished seed-bed even in high trash conditions.

NBPT was effective (overall yield with seed-placed UNBPT higher than seed-placed urea and sometimes higher than banded urea) at 6 of 8, 5 of 8, and 4 of 14, barley, wheat, and canola sites harvested in 1995. At 2 of 30 sites (both canola) seed-placed urea and seed-placed UNBPT had similar yield and both yielded lower than banded urea. At 13 of

30 sites (2 barley, 3 wheat, and 14 canola) there was no difference between banded urea, seed-placed urea, and seed-placed UNBPT. NBPT effectively reduced the toxic effects associated with seed-placed nitrogen fertilization with granular urea.

On sites where UNBPT was effective, seed-placed UNBPT produced yield equal to or higher than banded urea across the entire N application range. The maximum safe seed-placed N application rate with UNBPT was 100 kg N ha^{-1} for barley, wheat, and canola. This was at least 25 kg N ha^{-1} higher than could safely be applied with seed-placed urea.

Barley yield at NBPT effective sites was higher when UNBPT, 25 kg P_2O_5 ha^{-1}, and 15 kg K_2O ha^{-1}, were seed-placed than when urea was banded and the P and K were seed-placed. These results possibly are indicating some increased fertilizer use effkiency due to the fertilizer placement method. With wheat and canola there was no yield improvement due to this possible effective fertilizer use. At this point in time there is insufficient evidence to determine if seed-placing results in more effective nitrogen fertilizer use than banding.

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APPENDIX

Contrasts performed on combined UNBPT effective barley, wheat, and canola sites

	Band vs Urea	Band vs UNBPT	UNBPT vs Urea
Barley	**ns†**	**p = 0.001**	**p = 0.000**
Wheat	**p = 0.033**	**ns**	p = 0.000
Canola	**p = 0.007**	ns	p = 0.000

ns: not significant **ns†**: no yield difference when averaged across N application range, but seed-placed urea had higher yield at **25** kg N ha^{-1} (p = 0.049), and banded urea had higher yield at 100 kg N ha^{-1} (p = **0.007).**