SAFENING SEED PLACED UREA WITH AGROTAIN®

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INTRODUCTION

The introduction of no-till and direct seeding in the western Canadian prairies has necessitated placing urea N fertilizer with the seed in the majority of cases. Plant stand reduction due to seed-placement of high rates of urea N fertilizers is attributed to the toxic effects of ammonia/ammonium. Current guidelines for seed-row placement of nitrogen in general and urea in particular to avert seedling damage are based on seedbed utilization, soil texture (Saskatchewan Agriculture, Food and Rural Revitalization 2001) and seedbed moisture (Western Cooperative Fertilizers Limited 2002) and are summarized in Tables 1 and 2.

Table 1. Guidelines for applying seedrow urea N with cereals.

		Maximum Seed-placed rate (lb N/acre as urea) (Based on soil texture and seedbed moisture)					
		Light Texture (S to SL)		Medium Texture (L to CL)		Heavy Texture (C to HvC)	
Type of implement	SBU[a]	Dry	Wet	Dry	Wet	Dry	Wet
Disk openers and knives	10%	5	15	10	25	15	30
	20%	10	20	15	35	20	40
Hoe openers, spoons, small sweeps	30%	15	30	20	45	25	50
	40%	20	40	25	50	30	60
	50%	25	45	30	60	35	70
Large sweeps, diskers	60%	30	55	35	65	40	80
	70%	35	65	40	75	45	90
	80%	40	75	45	85	50	100

[a] SBU = seedbed utilization.

Table 2. Guidelines for applying seedrow urea N with canola and flax.

		Maximum Seed-placed rate (lb N/acre as urea) (Based on soil texture and seedbed moisture)					
		Light Texture (S to SL)		Medium Texture (L to CL)		Heavy Texture (C to HvC)	
Type of implement	SBU[a]	Dry	Wet	Dry	Wet	Dry	Wet
Disk openers and knives	10%	0	5	5	10	5	15
	20%	5	15	10	15	15	25
Hoe openers, spoons, small sweeps	30%	10	20	15	25	20	35
	40%	15	30	20	35	25	45
	50%	20	35	25	45	30	55
Large sweeps, diskers	60%	25	40	30	55	35	55
	70%	30	45	35	55	40	75
	80%	35	55	40	75	50	85

[a] SBU = seedbed utilization.

However, crop requirements often exceed these guidelines, which results either in reduction of potential yield through application of lower than recommended N rates or application of fertilizer in a less efficient manner.

An extensive research program was carried out determine the benefit of using urease inhibitor Agrotain® (N-(*n*-butyl)thiophosphoric triamide or NBPT) with seed-placed urea and to develop guidelines for the safe seed-placed application of NBPT-treated urea.

MATERIALS AND METHODS

Four experiments involving a total of 39 trials were carried out between 1997 and 1999 (Table 3). All trials of Experiment 1 were arranged as a split-plot design with N rates (0, 20, 40, 60 and 80 kg N ha^{-1}) as a main plot and four rates of Agrotain® (0, 0.046, 0.093 and 0.14% by weight, representing 33, 66 and 100 % of the recommended rate) as sub-plots. Experiment 2 consisted of seventeen trials with six rates of N (0, 20, 30, 40, 60, 80 kg N ha^{-1} for barley and wheat and 0, 15, 22.5, 30, 45 and 60 kg N ha^{-1} for canola) as main plots and three rates NBPT urease inhibitor (0 and 0.046, and 0.14 % by weight) as sub-plots. Experiment 3 contained twelve trials. Six rates of Agrotain® (0, 0.14, 0.28, 0.42, 0.56 and 0.84 % by weight, representing 25, 50, 75, 100 and 150% of the recommended rate) were applied to one rate of N that was double the recommended for safe seed-placement (30 and 60 kg N ha^{-1} for canola and cereals, respectively) and was compared to an unfertilized control. Phosphorus in all experiments was applied to all treatments in the seed row as triple super phosphate (0-45-0) at a rate of 30 kg P_2O_5 ha^{-1}. Experiment 4 was conducted in 1999 and was similar to Experiment 3 except only three rates of NBPT urease inhibitor were used, namely, 0, 0.28, and 0.56 by weight or 0, 50, and 100% of the recommended rate, respectively. A rain gauge was placed at each site, except at Herronton in 1998, and readings were taken from each site 7 days after seeding and at regular intervals, thereafter.

Emergence counts were determined at the 2 to 4 leaf growth stage as the average of two counts, each consisting of two 1-m row lengths, per plot. Crops were harvested at early maturity using a Wintersteiger Nurserymaster Elite experimental plot combine. The seed weight per plot was measured immediately following harvest and again after being dried by forced air at 60 °C to constant weight. The seed yield per plot was calculated with moisture content corrected to 13.5 and 10 % for cereals and canola, respectively. Days to maturity (DTM) were calculated assuming an average dry down rate of 2.5 % per day using the following equation:

$$DTM = [(\text{moisture at harvest} - 35)/2.5] + \text{Days from seeding to harvest} \qquad \text{equ. [1]}$$

Seed yield and emergence counts from individual trials were subject to ANOVA for a split-plot or a randomized complete block design as required using SYSTAT 8.0 and effects were separated via orthogonal contrasts. The mean over all Agrotain® rates was used for regression analysis to compare the effect of Agrotain® treated versus untreated urea on stand density, days to maturity and/or yield.

RESULTS AND DISCUSSION

The following criteria were established for assessing the impact of Agrotain® treatment on the safety of placing urea with the seed:

1. Trials that received 5-10 mm of precipitation within 48 hours of seeding (or more than 40 mm of precipitation within seven days after seeding) were excluded from the population, since there was no damage from seed-placement of N.

2. A safe N rate was defined as the one that resulted in less than 15% reduction in the stand density of plants and no delay in days to maturity.

Table 3. Experimental parameters of the trials contained in the four experiments

Year	Test No.	Crop	Cultivar	Previous Crop	No. of Blocks	Row Spacing (cm)	Plot Length (m)	Seeding Date	Harvest Date
Experiment 1									
1997	1194	Barley	Stander	Wheat	6	17.8	6.1	3-Jun	3-Sep
	1208	Barley	Stander	Wheat	6	17.8	6.1	3-Jun	2-Sep
	1219	Wheat	Roblin	Wheat	6	17.8	6.1	15-May	2-Sep
	1235	Wheat	Roblin	Barley	6	17.8	6.1	16-May	21-Sep
Experiment 2									
1998	1345	Barley	Kasota	Barley	4	17.8	7	8-Jun	9-Sep
	1354	Barley	Harrington	Barley	6	17.8	7	13-May	21-Aug
	1385	Barley	Lacombe	Barley	6	17.8	7	9-Jun	27-Aug
	1387	Barley	B1602	Wheat	5	17.8	7	9-Jun	28-Aug
	1395	Barley	Lacombe	Canola	6	17.8	7	8-Jun	31-Aug
	1397	Barley	B1602	Canola	6	17.8	7	8-Jun	31-Aug
	1425	Barley	Lacombe	Pea	5	17.8	7	9-Jun	8-Sep
	1435	Barley	TR133	Canola	6	22.9	7.6	5-May	11-Aug
	1348	Canola	Maverick	Barley	4	17.8	7	10-Jun	10-Sep
	1357	Canola	Quest	Barley	6	17.8	7	13-May	28-Sep
	1442	Canola	Quest	Barley	6	22.9	7.6	4-May	31-Aug
	1325	Durum	Malita	Beets	4	17.8	7	2-May	11-Aug
	1332	Wheat	McKenzie	Wheat	6	17.8	7	3-May	27-Aug
	1343	Wheat	McKenzie	Wheat	6	17.8	7	1-May	n/h[z]
	1383	Wheat	McKenzie	Barley	6	17.8	7	29-Apr	13-Aug
	1392	Wheat	McKenzie	Wheat	6	17.8	7	30-Apr	20-Aug
	1421	Wheat	AC Barrie	Pea	6	17.8	7	4-May	25-Aug
Experiment 3									
1998	1353	Barley	Harrington	Barley	6	17.8	7	13-May	21-Aug
	1396	Barley	Lacombe	Canola	6	17.8	7	8-Jun	31-Aug
	1398	Barley	B1602	Canola	6	17.8	7	8-Jun	31-Aug
	1436	Barley	TR133	Canola	6	22.9	7	5-May	10-Aug
	1356	Canola	Quest	Barley	6	17.8	7	13-May	28-Sep
	1394	Canola	Invigor	Wheat	6	17.8	7	30-Apr	26-Aug
	1326	Durum	Malita	Beets	6	17.8	7	2-May	11-Aug
	1333	Wheat	McKenzie	Wheat	6	17.8	7	3-May	27-Aug
	1342	Wheat	McKenzie	Wheat	6	17.8	7	1-May	n/h
	1384	Wheat	McKenzie	Barley	6	17.8	7	29-Apr	13-Aug
	1393	Wheat	McKenzie	Wheat	6	17.8	7	30-Apr	20-Aug
	1422	Wheat	AC Barrie	Pea	6	17.8	7	4-May	25-Aug
Experiment 4									
1999	1510	Barley	Harrington	Barley	7	17.8	7	9-Jun	29-Sep
	1511	Barley	Harrington	Barley	7	17.8	7	27-May	09-Sep
	1548	Barley	Harrington	Wheat	7	17.8	7	15-Jun	29-Sep
	1549	Barley	Harrington	Wheat	7	17.8	7	15-Jun	n/h
	1493	Wheat	McKenzie	Wheat	6	22.9	7.6	12-May	02-Sep
	1512	Wheat	McKenzie	Barley	7	17.8	7	6-May	17-Sep

[z] n/h = not harvested.

Reduction in stand density due to N application was observed in 80% (31 of the 39) of the trials; Agrotain® resulted in a significant improvement of stand density in two out of every three (20 of the 31) trials, where a significant reduction of stand density due to N application was observed. There were no cases where an increase in seedling damage was observed as a result of Agrotain® treatment of urea.

Reductions in stand density with the application of 40 to 60 kg N ha^{-1} resulted in no yield change in five and in a significant yield increase in 23 of a total of 28 trials that were harvested. Hence, the response to N was likely the dominating mechanism for yield increases in spite of the decrease in stand density. Only in eight of these trials was there a significant yield improvement through application of Agrotain®.

Grant and Bailey (1999) observed that seedling damage reduced seedling vigor and delayed maturity in addition to a reduction in stand density. Maturity calculated in this study from equation [1] was delayed for up to 5.1 d yr^{-1} in barley and 1.8 d yr^{-1} in wheat. Treatment of urea with Agrotain® resulted in an overall reduction in days to maturity (DTM) depending on the rate of N applied in the seedrow. The higher the rate of seed-row placed N the greater the benefit from treating urea with Agrotain® (Figure 1). Proportionally, a greater benefit was observed with barley (Figure 1a) compared to wheat (Figure 1b), which is not surprising considering the difference in the magnitude of the delay in DTM between these two crops.

Over the three years of this study with all three crops, seed-placed of urea treated with Agrotain® consistently reduced seedling damage. Reduction in seedling damage has been attributed to an increase in the duration of urea diffusion away from the seedrow as a result of the reduction in urea hydrolysis with application of Agrotain® (Malhi et al 2003); it has been shown to occur with a number of crops, such as barley (Grant and Bailey 1999; Pauly et al. 1996), wheat (Xiaobin et al. 1995; Pauly et al. 1996; Malhi et al. 2003), canola (Pauly et al. 1996; Malhi et al. 2003) and corn (Schlegel 1991). Grant and Bailey (1999) observed that improvement in seed-placed urea safety with Agrotain® was dependent on the environmental conditions occurring after seeding. This was verified in this study; however, increase in stand density as a result of less seedling damage was greater in barley (Figure 2) than wheat (Figure 3) or canola (Figure 4). Treating urea with Agrotain® at rates as low as one third of the recommended rate overall produced similar results to those of the recommended rate.

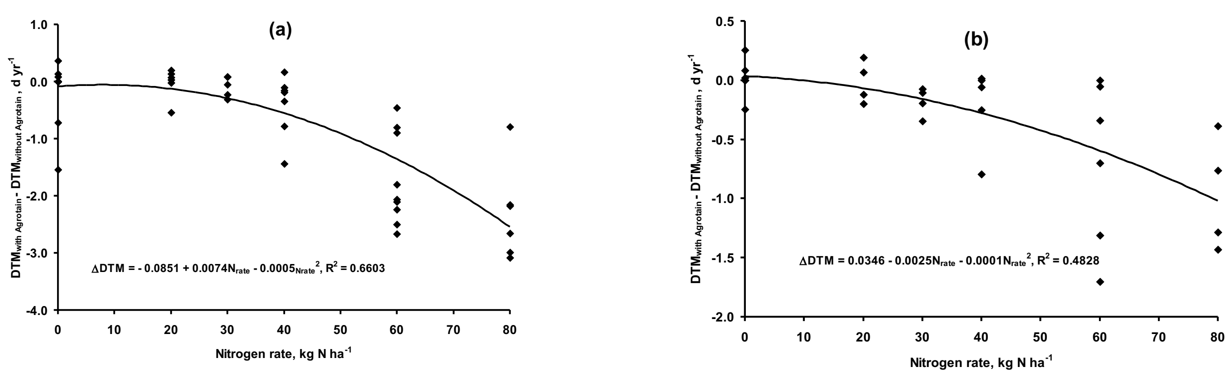

Figure 1. Effect of Agrotain® treated urea on days to maturity (DTM) of barley (a) and wheat (b).

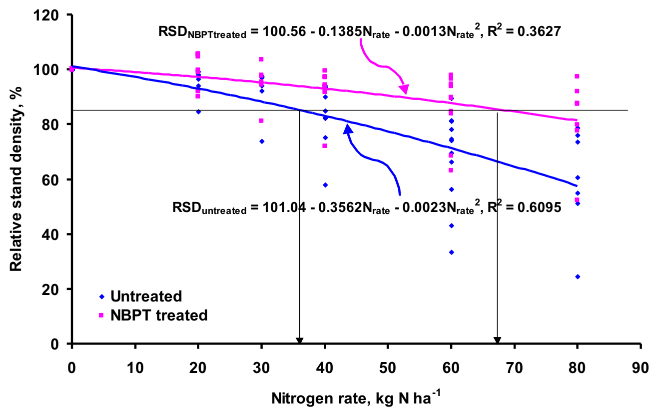

Figure 2. Effect of Agrotain® treatment of urea on the stand density of barley.

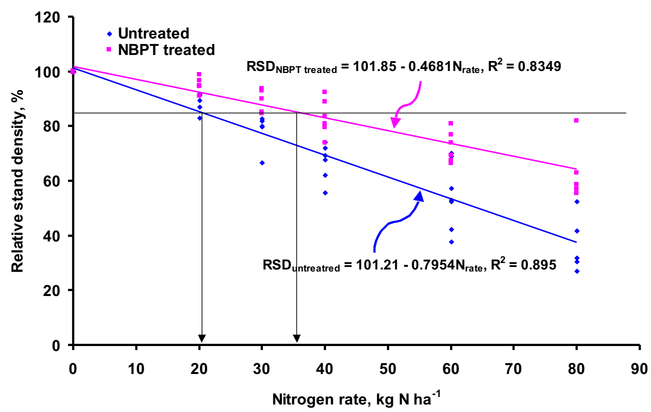

Figure 3. Effect of Agrotain® treatment of urea on the stand density of wheat.

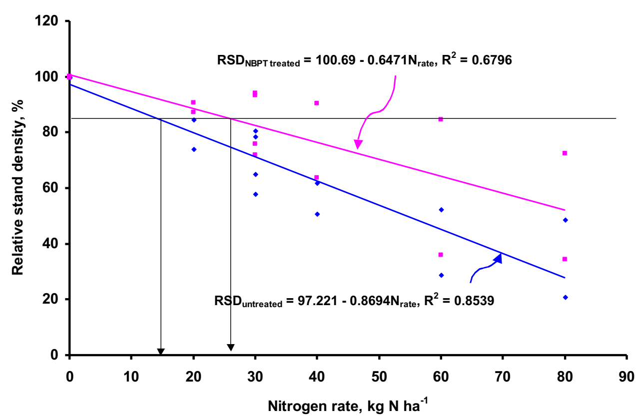

Figure 4. Effect of Agrotain® treatment of urea on the stand density of canola.

The criteria selected to derive a safe seedrow placed urea N in this study were based solely on plant stand density and days to maturity. Any attempt to extrapolate the results of this study to lighter textured soils or wider seedbed utilization rates must be done with caution. The results from this study also suggest that when guidelines are formulated for safe rates of urea fertilizer applied with the seed, placing barley and wheat in the same group may result in underrecommending for the former or over-recommending for the latter crop as far as the maximum safe rate is concerned.

Table 4. Guidelines for applying seedrow Agrotain® treated urea N with cereals (except hulless barley).

	Maximum Seed-placed rate (lb N/acre as urea)					
	Light Texture S to SL		Medium Texture L to SL		Heavy Texture C to HvC	
SBU	No Agrotain	+Agrotain	No Agrotain	+Agrotain	No Agrotain	+Agrotain
10%	15	25	25	40	30	50
20%	20	30	35	50	40	60
30%	30	40	45	60	50	70

Table 5. Guidelines for applying seedrow Agrotain® treated urea N with canola, flax and hulless barley.

	Maximum Seed-placed rate (lb N/acre as urea)					
	Light Texture S to SL		Medium Texture L to CL		Heavy Texture C to HvC	
SBU	No Agrotain	+Agrotain	No Agrotain	+Agrotain	No Agrotain	+Agrotain
10%	5	15	10	20	15	25
20%	15	25	15	25	25	35
30%	20	35	25	35	35	55

CONCLUSIONS

Preliminary guidelines (Tables 4 and 5) were developed for applying seedrow Agrotain® treated urea N based on the following conditions: (a) an application rate of 5.2 liters of Agrotain® per tonne of urea, (b) optimum seedbed preparation, (c) less than 15% seedling damage and (d) no impact on days to maturity. Proper application of Agrotain™ on urea is predicated on following these guidelines.

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