# Urea Treatment Affects Safe Rates of Seed Placed Nitrogen in Saskatchewan.

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**Key Words:** urea, agrotain, polymer coated, seed placed, side banded, dribble banded, wheat, canola, plant density, yield response

**Abstract**

Placing urea in close proximity to seed can cause seedling damage resulting in poor crop establishment. Plant densities are often well below the optimum, and plants that do emerge can exhibit poor vigor. Several strategies have been developed to reduce risk of seed damage from urea. Restricting the amount that is seed placed, placing urea at a safe distance and placement before or after seeding are effective but may not allow for application of adequate N or increase equipment and operating costs. Recently treatments applied to the urea granule such as Agrotain and polymer coating have been developed to slow the conversion to ammonium. Research suggests that the safe rate of N can be increased by 50% where Agrotain is used and are less clear when polymer coatings are used. To demonstrate how Agrotain and polymer treated urea affect crop establishment and yield, rates of 0, 1, 1.5, 2 and 4 times the recommended safe rate were seed placed at Scott, Swift Current, Canora and Redvers, Saskatchewan. Trials were conducted with wheat at all locations, and canola at Scott. Seed placed untreated urea was used as a check. As well, an alternate option using seed placed untreated urea followed by liquid urea ammonium nitrate dribble banded 20 to 35 days after seeding was investigated. Impact of treatments on plant density varied with rainfall across locations. Sites with lower precipitation after seeding indicated more severe damage to seedlings. Untreated urea placed with the seed had the greatest impact on plant density but, Agrotain and polymer treatments also led to decreases at high N rates. The improvement of Agrotain over untreated urea generally confirmed manufacturer recommendations that safe rates of seed placed urea can be increased by about 50%. The polymer was very effective at reducing damage from seed placed urea, but still generally resulted in fewer plants than side band at 4 times the recommended rate of N. Grain yield responses were also variable across locations. At most sites where plant stand reductions were high yield was also affected. Differences between all treatments were small at N rates up to 2 times the recommended rate but at 4 times, yield was reduced for Agrotain treated and untreated seed placed N. For treatments where liquid dribble band was compared to side banding little difference in yield was observed when soil residual N was high and precipitation was low. A reduction in yield was found when soil N and precipitation were low. Where

the N supply from soil was large and precipitation higher, yield of dribble banded crop continued to respond after side banded crops had peaked.

## Introduction

Fertilizer nutrients placed in close proximity to seed can cause seedling damage resulting in poor crop establishment. Plant densities are often well below the optimum, and plants that do emerge can exhibit poor vigor. Such damage results from either a salt or a toxic effect from the fertilizer material.

The salt effect restricts water movement into the seed, slowing or halting germination. When seedbed conditions are very dry, fertilizer salt concentrations in the soil solution are high, causing greater damage. Rain if sufficient, will dilute fertilizer salts and leach them away from the seed, allowing germination to resume. The toxic effect results from damage to enzymes needed for germination and early growth. This damage can weaken or prevent seed from germinating. Nitrogen in the form of ammonium is particularly toxic to most seeds. Nitrogen in other forms like urea can be readily converted to ammonium in the soil.

Since urea is the most commonly used form of dry nitrogen fertilizer, considerable effort has been directed to finding ways to apply this form safely and efficiently. Several strategies have been developed to reduce risk of seed damage from urea. Restricting the amount that is seed placed is effective but usually does not allow for application of adequate N.  Placing urea at a safe distance away as in side-banding normally overcomes the rate restriction. This option increases equipment and operating costs and causes more soil disturbance, but usually provides good yield responses. Placement before or after seeding usually has a good margin of safety, but requires added operations and costs, and may not provide optimal yield response.

Recently treatments applied to the urea granule have been developed. Agrotain is a commercial treatment that affects how rapidly urea is converted to ammonium. Research suggests that the safe rate of N can be increased by 50% where Agrotain is used. Currently Agrotain is available through Westo Fertilizers, and Agrocore United. Another option is to use polymer coatings to prevent rapid release of nitrogen from granules, thereby slowing conversion to ammonium. The polymer should allow N to become available early enough to avoid restricting yield. The technology is well developed in terms of knowing how quickly it will release, but not how it affects safe rates when seed placed is less clear. At present, Agrium is working with an experimental product that shows some promise, and it is that product that has been used in this research.

## Materials and Methods

To demonstrate how Agrotain and polymer treatments affect crop establishment and yield seed placed N rates of 0, 1.0, 1.5, 2.0 and 4.0 times the recommended safe rate for seed placed untreated urea were used. Experiments were conducted at Scott [2003 and 2004], Swift Current [2004], Canora [2004] and Redvers [2004]. Trials were conducted with wheat at all locations, and at Scott a duplicate trial was run with canola. Because similar seeding equipment was used at all sites, the rates for wheat as kg/ha were identical across locations at 0, 25, 37.5, 50 and 100. For canola at Scott, the rates were 10, 15, 20 and 40 kg/ha. Seed placed untreated urea was used as a check, as well as untreated urea side band for comparison at the same N rates. As well, an alternate option was investigated where untreated urea was applied at zero or 25 kg/ha [10 kg/ha for canola] at seeding followed by liquid urea ammonium nitrate dribble banded 20 to 35 days after seeding to give combined rates of 1, 1.5, 2 and 4X the safe rate. Treatments are shown in table 1.

Table 1. Treatments for all sites.

| | Treatments | Placement | N rate (kg/ha) |
|---|---|---|---|
| 1 | no N | | 0 |
| 2 | urea -1.0 x | seed placed | 25 |
| 3 | urea -1.5x | seed placed | 37.5 |
| 4 | urea - 2x | seed placed | 50 |
| 5 | urea - 4x | seed placed | 100 |
| 6 | Polymer coated urea - 1x | seed placed | 25 |
| 7 | polymer coated urea - 1.5x | seed placed | 37.5 |
| 8 | polymer coated urea - 2x | seed placed | 50 |
| 9 | polymer coated urea - 4x | seed placed | 100 |
| 10 | Agrotain coated urea - 1x | seed placed | 25 |
| 11 | Agrotain coated urea - 1.5x | seed placed | 37.5 |
| 12 | Agrotain coated urea - 2x | seed placed | 50 |
| 13 | Agrotain coated urea - 4x | seed placed | 100 |
| 14 | urea -1.0 x | side banded | 25 |
| 15 | urea -1.5x | side banded | 37.5 |
| 16 | urea - 2x | side banded | 50 |
| 17 | urea - 4x | side banded | 100 |
| 18 | urea - 0x & 1.0x liquid split | dribble banded | 25 |
| 19 | urea - 0x & 1.5x liquid split | dribble banded | 37.5 |
| 20 | urea - 1.0x & 1.0x liquid split | seed placed/dribble banded | 50 |
| 21 | urea - 1.0x & 3.0x liquid split | seed placed/dribble banded | 100 |

Emerged seedlings were counted at 10 to 20 days after seeding [DAS] as a means of evaluating treatment effects on crop establishment. At Scott in 2003, and at Canora in 2004 digital photos were also taken of plants at 26 and 32 DAS and computer software was used to estimate the percentage of the soil surface that was covered by green plant material. Grain yield was also measured to evaluate treatment performance, as was grain protein.

## Results and Discussion

Impact of treatments on plant density varied considerably across locations. At Scott in 2003 and 2004, as well as Swift Current 2004, less than 5 mm of rain fell during the 5 days following seeding. At those locations damage to seedlings was severe for seed placed urea [Figure 1]. Untreated urea placed with the seed had the greatest impact on plant density. Agrotain and polymer treatment also led to decreases at high N rates. The improvement of Agrotain over untreated urea generally confirmed what the manufacturer and distributors of this product suggest. That is; that safe rates of seed placed urea can be increased by about 50% if Agrotain is used [emergence with untreated at 25kg/ha was similar to Agrotain at 37.5 kg/ha]. The polymer was very effective at reducing damage from seed placed urea, and damage at 100 kg/ha was similar to untreated seed placed urea at 25 kg/ha. Polymer coated urea still resulted in fewer plants than side band at high 100 kg/ha.

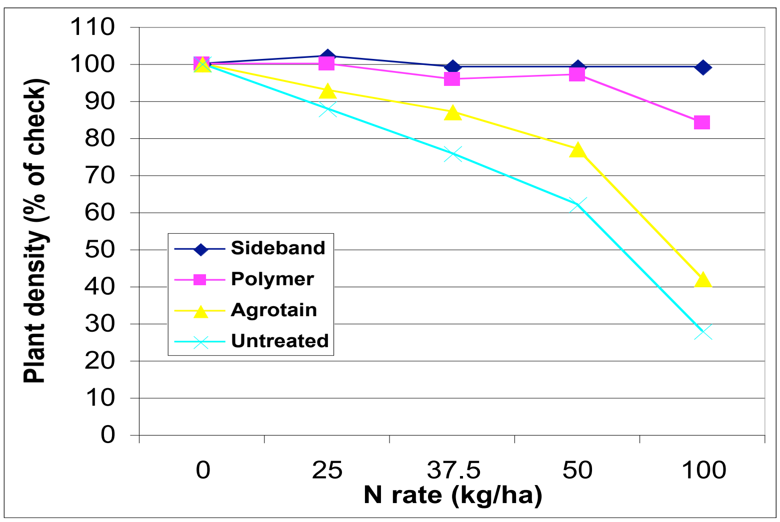


Figure 1. Plant densities [% of the unfertilized check] as influenced by urea treatment, placement and rate for wheat at Scott 2003, 2004 and Swift Current 2004.

At Canora and Redvers, significant rain [27 and 55 mm] occurred within 5 days after seeding, and seedling damage was minimal [Figure 2]. At these locations, none of the treatments had a significant impact on emergence. These results serve as a caution with seed placed N. Quite often growers exceed the guidelines for seed placed N, and don't experience damage. Usually it is because damage is either not severe enough to be noted, or it has not occurred because moisture was sufficient to minimize damage. However, the risk is that conditions between seeding and crop emergence will be dry, and damage will be much higher. The fact that damage was minimal at the 2 Black soil zone locations, and extensive at the Brown and Dark Brown soil zone sites should not be taken to mean that there is no risk of damage on Black soils. There is considerable previous work demonstrating damage on Black soils. However it is true that the probability of rain is higher for the Black soil zone.

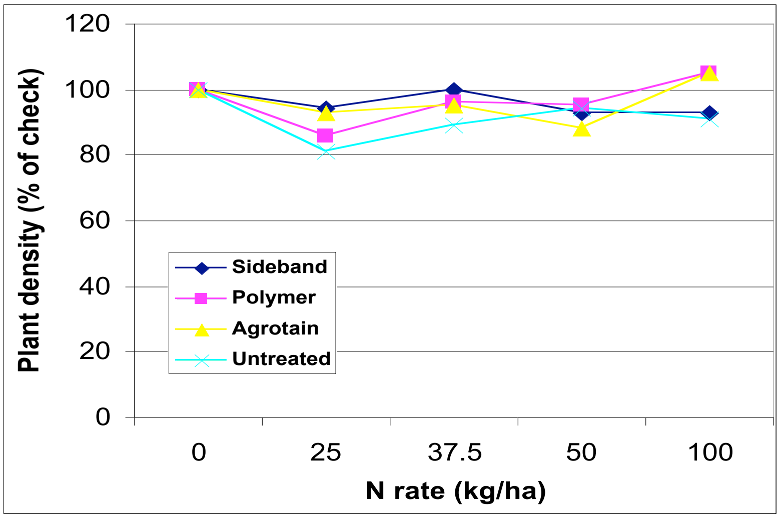


Figure 2. Plant densities [% of the unfertilized check] as influenced by urea treatment, placement and rate for wheat at Canora and Redvers 2004.

With Canola at Scott, damage was highest for untreated seed placed urea followed by Agrotain [Figure 3]. Polymer treatment resulted in no reduction in plant density of canola at Scott. Where split applications of up to 25 kg/ha of urea was seed placed, followed by liquid UAN dribble banded after emergence, there was no significant effect of treatment on plant density [data not shown].

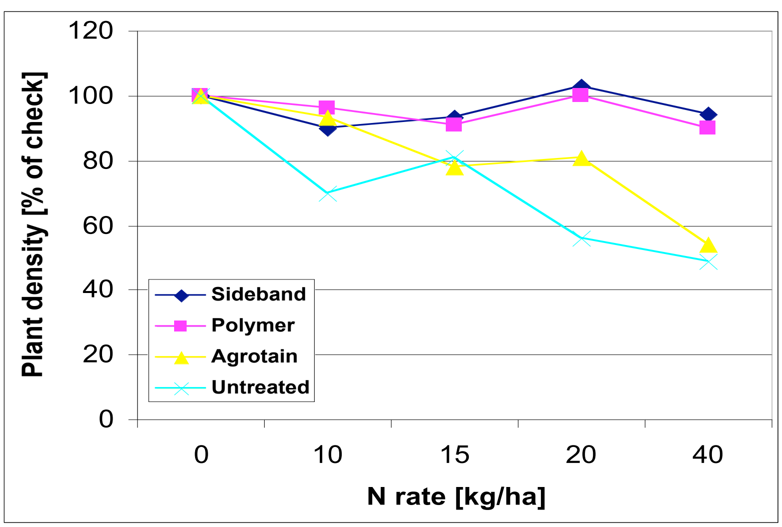


Figure 3. Plant densities [% of the unfertilized check] as influenced by urea treatment, placement and rate for canola at Scott 2004.

Results of digital photography generally agree with those for plant density, and tended to rank the treatments similarly [Figure 4]. This technology measures the proportion of the area covered by green crop, and reflects not only the number of plants per unit area, but also their size. Thus, digital photography did tend to show some of the nutrient N response by the crop, as well as damage to seed or seedlings. Under the dry conditions that prevailed at Scott in 2003, nutrient responses were smaller than normal, but were still visible. Technology that can quantify such treatment effects could be quite useful, particularly where there is initial damage from fertilizer followed by a nutrient response. As we attempt to develop practices that increase nutrient use efficiencies, it becomes critical that we fully understand the nature of nutrient responses.

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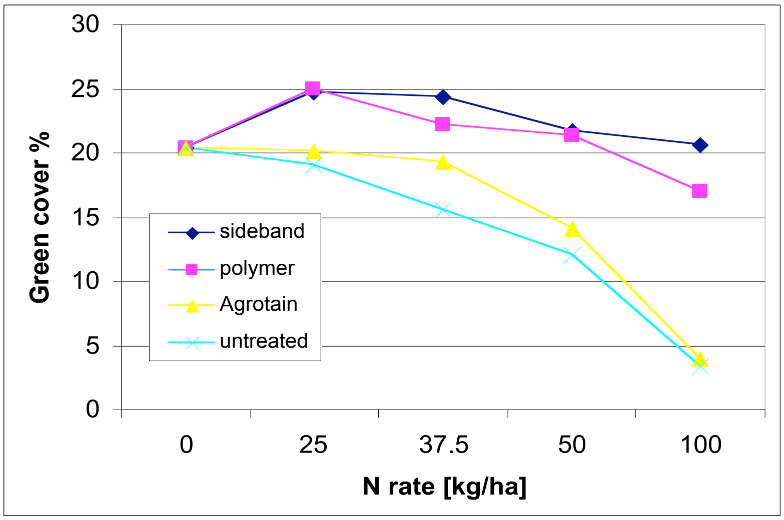


Figure 4. Green cover [%] for wheat [average for readings at 26 and 32 days after seeding] as influenced by urea treatment, placement and rate at Scott, 2003.

Grain yield responses were also quite variable across locations. At Scott in 2003, and at Swift Current in 2004, where plant stand reductions were high, damage to seedlings carried over and affected yield [Figure 5]. At these locations, yield at 25 and 37.5 and 50 kg/ha N and were similar for untreated side band, polymer seed placed, Agrotain seed placed and untreated seed placed. At 100 kg/ha, side band and polymer seed placed provided greater yield than Agrotain seed placed or untreated seed placed. At 100 kg/ha, yield was lower than for 50 kg/ha for untreated seed placed or Agrotain seed placed, while where polymer seed placed or untreated side band were used yield was higher for the 100 than 50 kg/ha of N.

Damage to plant density was also high at Scott in 2004, but it was not evident in final yield [Figure 6]. At this site, plant densities without N were very high relative to other sites, and even with severe damage at high rates of seed placed N, densities were not critically low. In addition, the study was planted on stubble of a bearded wheat variety that had considerable sawfly damage. Treatments with low plant densities had higher incidence of volunteer wheat [the study was seeded to a non-bearded variety], which likely compensated.

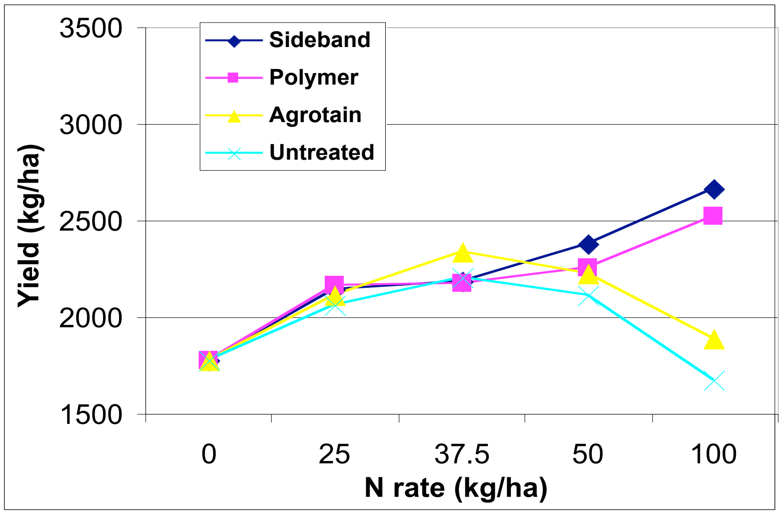


Figure 5. Grain yield as influenced by urea treatment, placement and rate for wheat at Scott 2003 and Swift Current 2004.

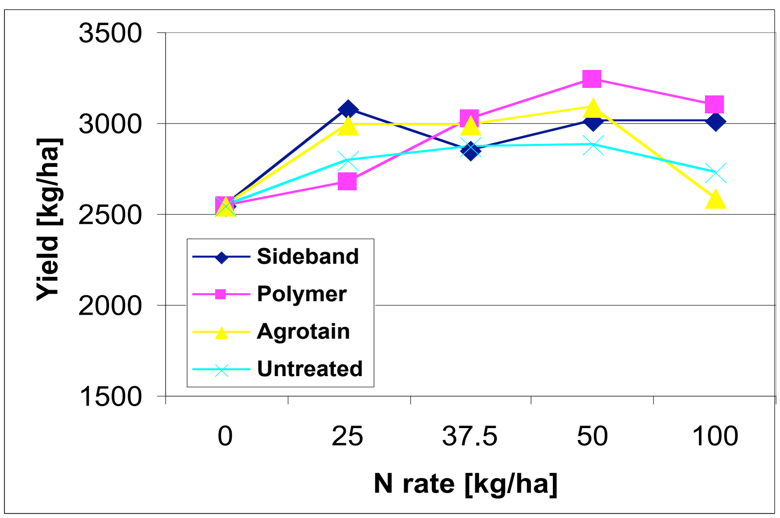


Figure 6. Grain yield as influenced by urea treatment, placement and rate for wheat at Scott 2004.

At Canora and Redvers with little damage to plant density from any treatment, it was not surprising to find that the only factor influencing yield was N rate [Figure 7]. These sites both showed large responses to N. With the polymer there was some concern that the polymer would not allow N to release from the granule early enough to optimize yield. Results from these 2 sites, as well as Swift Current where there was a strong N response should provide some insight into this issue. At all three sites, the yield response over N rates was similar for polymer seed placed and untreated side band, providing support to the contention that N was being released in a manner that optimized yield.

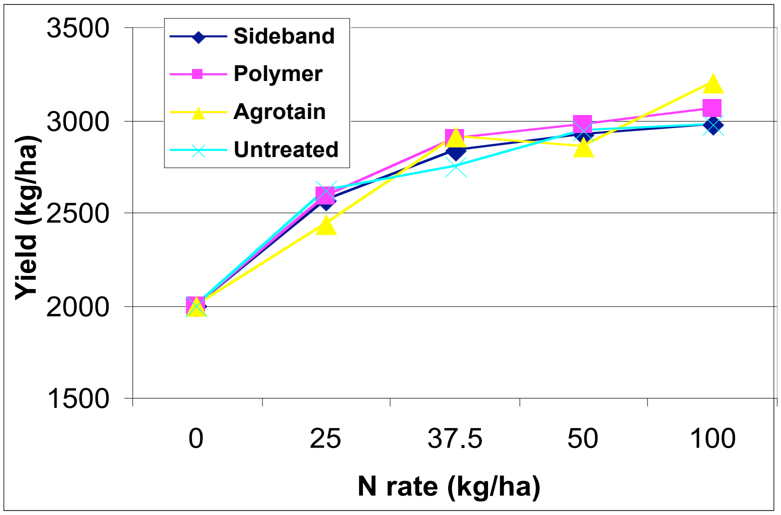


Figure 7. Grain yield as influenced by urea treatment, placement and rate for wheat at Canora 2004 and Redvers 2004

Despite causing serious reductions in plant stand of canola at Scott, seed placing N with or without Agrotain or polymer treatment provided yields that were similar to side band [Figure 8]. This likely reflects the very high canola plant densities that emerged at Scott in 2004. For the zero N treatment, almost 200 plants per square meter emerged. With untreated urea seed placed, emergence was reduced by over 50%, but that still left over 90 plants, more than enough to produce a crop capable of producing much higher yields than the 2000 kg/ha produced by the most productive treatments.

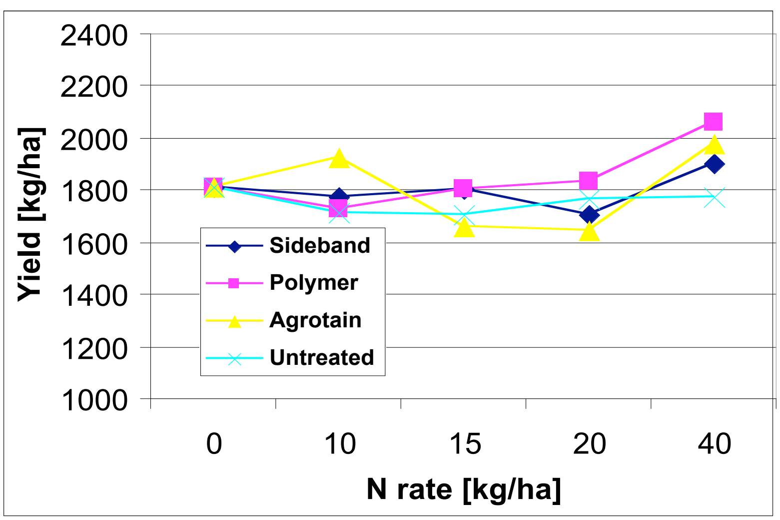


Figure 8. Grain yield as influenced by urea treatment, placement and rate for canola at Scott 2004

Canola is a difficult crop to establish, and is often reseeded because plant densities are too low. For this reason, seed rates usually build in a larger margin of safety than for other crops. When emergence is very high, plant densities greatly exceed the minimum needed. However, where emergence percentage is low [a frequent occurrence], any added reduction due to fertilizer damage can be particularly damaging. Canola is very responsive to N, and optimum rates are often quite high. Considering the limited amounts of untreated N that can be safely placed with seed, any treatment that makes seed placement less risky must be highly effective to allow sufficient N to be applied. Responses to N rates were relatively small, and reflect the low rates of N used in this experiment.

Other options investigated were to apply all N as a liquid dribble band after crop emergence where low N rates are used, or to apply the safe rate with seed and additional N as a liquid dribble band after emergence. At Scott in 2004, there was little difference between the 2 options with wheat [Figure 9] or canola [data not shown]. At this location, the supply of N from the soil was quite high, as evidenced by relatively high yield from the zero N treatment. Responses to N were moderate, indicting that the crop did not have to rely heavily on fertilizer N. Consequently the supply of N was adequate to meet early crop needs. Delaying application of some or all N as with dribble banding did not restrict yield.

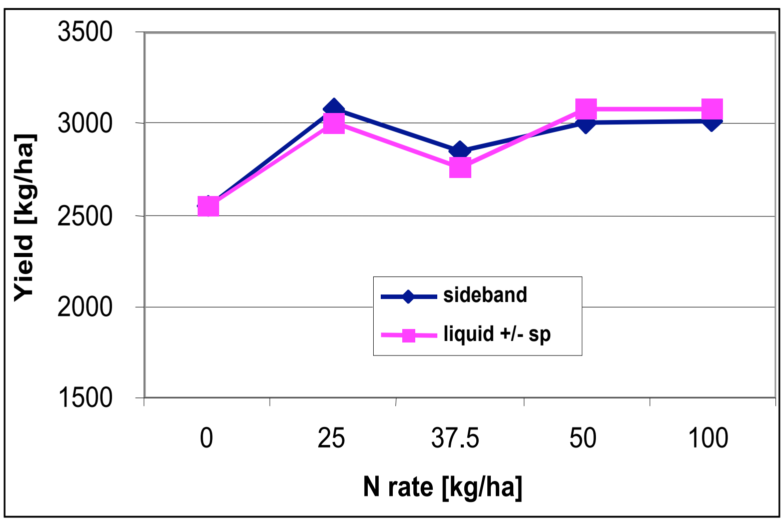


Figure 9. Grain yield as influenced by side banding or liquid dribble banding after emergence +/- seed placed for wheat at Scott 2004.

By contrast, at Swift Current the supply of N was smaller as indicated by low yield at zero fertilizer N [Figure 10]. In this instance, dribble banding some or all N resulted in a reduction in yield compared with side banding, particularly where no N was seed placed. Where soil N is very limited, dribble banding after emergence likely results in N deficiency at early growth stages of the crop causing reduced yield potential that cannot be recovered by later N applications.

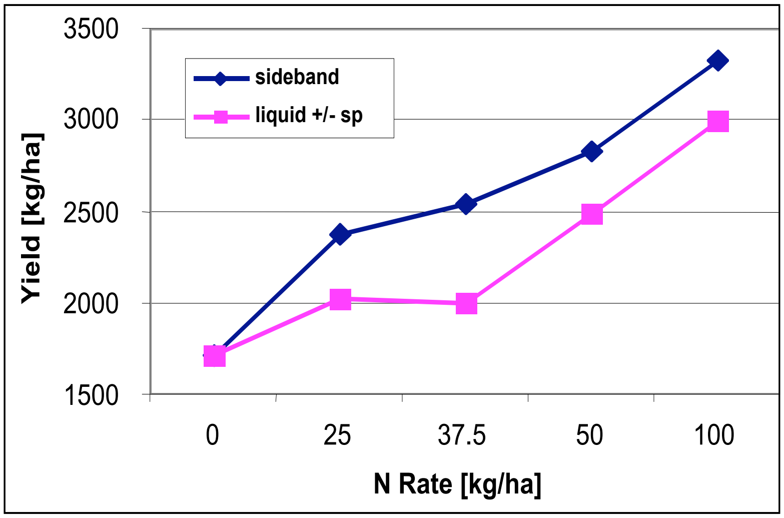


Figure 10. Grain yield as influenced by side banding or liquid dribble banding after emergence +/- seed placed for wheat at Swift Current 2004.

A different response was noted at Canora where the N supply from soil was large [high yield at zero fertilizer N] [Figure 11]. Side band N increased yield at rates up to 37.5 kg/ha with little added yield at 50 and 100 kg/ha. However where some was dribble banded, yields were higher at 50 and 100 kg/ha. Moisture was very favorable at this site, and it is possible that side band or seed placed N not taken up by the crop early was either leached below the root zone or was lost to denitrification. Where higher rates of N were dribble banded, such losses may have been avoided leading to increased yield.

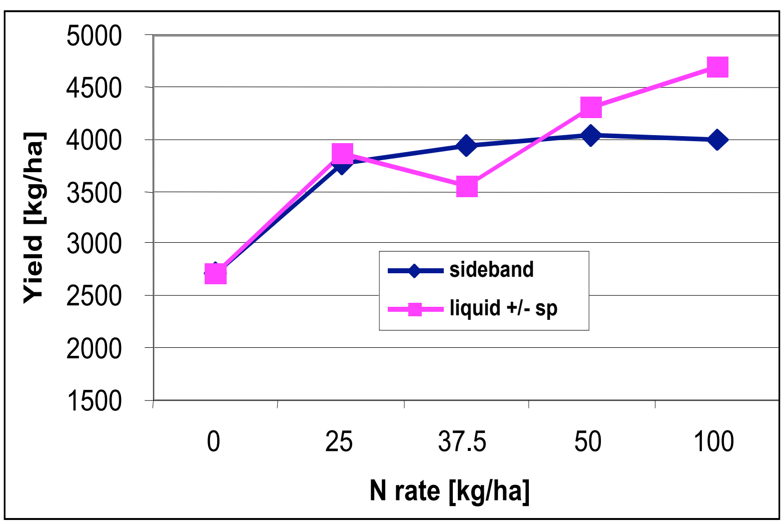


Figure 11. Grain yield as influenced by side banding or liquid dribble banding after emergence +/- seed placed for wheat at Canora 2004.

To verify the responses noted at Swift Current would require additional and more comprehensive study that included data collection on the supply and fate of N in the soil throughout the growing season. As we attempt to fine tune N use to provide optimal economic returns and reduce environmental risk, this knowledge will be crucial. Practices like dribble banding certainly hold potential to achieve optimum yield without compromising the environment.

**Conclusions**

Overall, where emergence was reduced by seed placed untreated or Agrotain treated urea, yield declined as N rate increased. The effect was greater for untreated than Agrotain treated. Results confirm what the suppliers of Agrotain suggest that the rate of seed placed N can be increased by 50% over untreated. With polymer treated urea, yield at high N rates was reduced compared with side band, but substantially higher than for untreated or Agrotain. The Polymer showed a great deal of promise as a means of making seed placed N safer. Results suggest that the safe rate for the polymer is four times as much as for untreated N. In addition, it does not appear that the polymer interferes with release of N in a way that restricts yield response compared with side band, which is typically considered to be the most suitable placement option. Additional work is warranted to determine if these results can be applied over a broad range of soil and climatic conditions, and to evaluate the economic implications.

Results do suggest that any reduction in plant density generally reduced grain yield even under dry conditions. This may challenge conventional thinking that under dry conditions there is a benefit to lower plant densities. However there is growing evidence that having sufficient plant density is critical to ensure that limited water in dry conditions is used for crop growth and not lost to evaporation.

Results also suggest that it may be possible to apply the safe rate of untreated urea with the seed and provide additional N as liquid UAN dribble banded after seeding. However, to fully utilize this option requires improved understanding of fertilizer N dynamics. For instance, where residual soil N is low, is there a need for fertilizer N placed at seeding? Where rain is usually plentiful, does liquid dribble banding consistently increase yield and/or reduce N losses? How long can the liquid application be delayed, and is it dependent upon growing season conditions and soil N status?

**Appendix**

Table A1. Influence of N rate [0 to 4X safe seed placed rate] and various N treatments or placements on plant densities [plants/$m^2$] at 7 location years [6 wheat, 1 canola] in SK.

| | Nitrogen treatment or placement | | | | |
|---|---|---|---|---|---|
| N rate [kg/ha] | Untreated seed placed | Agrotain seed placed | Polymer seed placed | Untreated seed placed | Split seed placed + liquid |
| *Scott wheat 2003* | *Significant N rate by N treatment/placement effects* | | | | |
| 0 | 189 | 189 | 189 | 189 | n/a |
| 25 | 150 | 168 | 186 | 205 | n/a |
| 37.5 | 126 | 154 | 187 | 212 | n/a |
| 50 | 97 | 130 | 184 | 204 | n/a |
| 100 | 11 | 29 | 155 | 190 | n/a |
| *Scott canola 2004* | *Significant N rate effects* | | | | |
| 0 | 193 | 193 | 193 | 193 | 193 |
| 10 | 133 | 179 | 185 | 174 | 178 |
| 15 | 157 | 151 | 175 | 180 | 178 |
| 20 | 108 | 156 | 193 | 199 | 146 |
| 40 | 95 | 105 | 173 | 182 | 137 |
| *Scott wheat 2004* | *Significant N rate effects* | | | | |
| 0 | 308 | 308 | 308 | 308 | 308 |
| 25 | 260 | 279 | 303 | 293 | 288 |
| 37.5 | 245 | 272 | 288 | 279 | 296 |
| 50 | 203 | 247 | 289 | 284 | 276 |
| 100 | 102 | 163 | 273 | 289 | 284 |
| *Swift Current wheat 2004* | *Significant N rate effects* | | | | |
| 0 | 120 | 120 | 120 | 120 | 120 |
| 25 | 134 | 124 | 126 | 134 | 124 |
| 37.5 | 100 | 108 | 115 | 120 | 111 |
| 50 | 83 | 99 | 124 | 125 | 105 |
| 100 | 59 | 66 | 92 | 129 | 112 |
| *Canora wheat 2004* | *No significant effects* | | | | |
| 0 | 168 | 168 | 168 | 168 | 168 |
| 25 | 138 | 154 | 139 | 180 | 161 |
| 37.5 | 152 | 152 | 146 | 163 | 142 |
| 50 | 144 | 160 | 168 | 169 | 148 |
| 100 | 138 | 179 | 154 | 152 | 144 |
| *Redvers wheat 2004* | *Significant N treatment/placement effect** | | | | |
| 0 | 136 | 136 | 136 | 136 | 136 |
| 25 | 108 | 129 | 121 | 105 | 168 |
| 37.5 | 117 | 137 | 145 | **n/a*** | 148 |
| 50 | 142 | 108 | 120 | **n/a*** | 181 |
| 100 | 144 | 138 | 125 | **n/a*** | 164 |

* Side band treatments at Redvers were seeded later than other treatments, and some plugging of seeding equipment occurred, therefore the data is not reported here.

Table A2. Influence of N rate [0 to 4X safe seed placed rate] and various N treatments or placements on grain yield [kg/ha] at 7 location years [6 wheat, 1 canola] in SK.

| | Nitrogen treatment or placement | | | | |
|---|---|---|---|---|---|
| N rate [kg/ha] | Untreated seed placed | Agrotain seed placed | Polymer seed placed | Untreated seed placed | Split seed placed + liquid |
| *Scott wheat 2003* | *Significant N rate by N treatment/placement effect* | | | | |
| 0 | 1850 | 1850 | 1850 | 1850 | n/a |
| 25 | 1989 | 1999 | 1862 | 1916 | n/a |
| 37.5 | 1905 | 2072 | 1769 | 1819 | n/a |
| 50 | 1675 | 1748 | 1586 | 1935 | n/a |
| 100 | 1126 | 1321 | 1796 | 2000 | n/a |
| *Scott canola 2004* | *Significant N rate effect* | | | | |
| 0 | 1808 | 1808 | 1808 | 1808 | 1808 |
| 10 | 1714 | 1922 | 1730 | 1772 | 1814 |
| 15 | 1703 | 1657 | 1800 | 1799 | 1792 |
| 20 | 1768 | 1643 | 1930 | 1704 | 1720 |
| 40 | 1771 | 1975 | 2062 | 1902 | 1962 |
| *Scott wheat 2004* | *Significant N rate effect* | | | | |
| 0 | 1710 | 1710 | 1710 | 1710 | 1710 |
| 25 | 2124 | 2234 | 2468 | 2368 | 3005 |
| 37.5 | 2496 | 2594 | 2580 | 2541 | 2761 |
| 50 | 2555 | 2700 | 2915 | 2826 | 3079 |
| 100 | 2225 | 2456 | 3243 | 3327 | 3080 |
| *Swift Current wheat 2004* | *Significant N rate by N treatment/placement effect* | | | | |
| 0 | 1710 | 1710 | 1710 | 1710 | 1710 |
| 25 | 2124 | 2234 | 2468 | 2368 | 2024 |
| 37.5 | 2496 | 2594 | 2580 | 2541 | 1995 |
| 50 | 2555 | 2700 | 2915 | 2826 | 2483 |
| 100 | 2225 | 2456 | 3243 | 3327 | 2988 |
| *Canora wheat 2004* | *Significant N rate effect* | | | | |
| 0 | 2715 | 2715 | 2751 | 2715 | 2715 |
| 25 | 3736 | 3466 | 3653 | 3765 | 3850 |
| 37.5 | 4073 | 4035 | 4128 | 3937 | 3558 |
| 50 | 4108 | 3888 | 4172 | 4039 | 4297 |
| 100 | 4024 | 4360 | 4241 | 3994 | 4683 |
| *Redvers wheat 2004* | *Significant N rate by N treatment/placement effect* | | | | |
| 0 | 1266 | 1266 | 1266 | 1266 | 1266 |
| 25 | 1491 | 1414 | 1526 | 1365 | 1818 |
| 37.5 | 1429 | 1791 | 1668 | **n/a*** | 1491 |
| 50 | 1768 | 1822 | 1782 | **n/a*** | 1983 |
| 100 | 1911 | 2041 | 1877 | **n/a*** | 1906 |

* * Side band treatments at Redvers were seeded later than other treatments, and some plugging of seeding equipment occurred, therefore the data is not reported here.