# MANAGING DROUGHT RISK WITH POST-EMERGENT N APPLIACTIONS IN SPRING WHEAT AND CANOLA

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## ABSTRACT

Fertilizer nitrogen accounts for the largest portion of total fertilizer costs. Unlike other nutrients like P and K, nitrogen is more prone to losses from leaching, nitrous oxide emission and denitrification. Producers are interested in more effective ways of managing the risks associated with N management, especially in the drier areas of the Canadian Prairies. Two separate studies were conducted. The first one examined the feasibility of post-emergent applications of liquid UAN either as a surface band or applied with a coulter at different times after seeding and compared to putting all the fertilizer down at seeding using a mid-row band on 40cm spacings. The second study looked at comparing all the fertilizer at seeding vs 33% at seeding and the remainder at different leaf stages vs all the N applied after seeding at different leaf stages. One study included spring wheat and canola at two locations and the other spring wheat at one location. In 2001 and 2002 at Indian Head and 2003 at Scott, the post-emergent applications of N were equivalent to putting all the fertilizer down at seeding in both wheat and canola up to 20 days after seeding where decreases in grain yield were observed at 30 days. In 2003 at Indian Head, the post-emergent applications of N were inferior to all the N applied at time of seeding for grain yield in canola and spring wheat. This was a very dry year with very little meaningful precipitation received after seeding showing that post-emergent applications of N do come with some risk even though the objective is to try and reduce risk. In the second study, even with 33% of the fertilizer applied at seeding, yields were less than when all the fertilizer was applied at seeding, but better than when 100% of the fertilizer was applied after seeding. It may be necessary to include a greater proportion of the fertilizer requirements at time of seeding. The excellent soil moisture conditions in 2003 were such that all fertilizer should have been applied. Developing better risk management strategies for N will require good estimates of spring soil moisture combined with probability estimates of growing season rainfall and accurate estimates of long-term grain yields. As well as more accurate methods of detecting early N deficiency symptoms in crops in order to rescue the yield potential.

## INTRODUCTION

Successful crop production on the Northern Great Plains requires proper correction of any nutrient deficiencies in crops with inorganic forms of fertilizers, principally nitrogen and phosphorus but also potassium and sulfur. Nitrogen is the most limiting nutrient and accounts for the major portion of total fertilizer costs in any given year. With the advent of no-till seeding, numerous fertilizer management strategies have been devised to manage nutrients effectively and make fertilizer more efficient for all kinds of conditions and crops (Lafond et al. 2003). A number of best management practices have also been identified and established for nitrogen fertilizers (Johnston et al. 2004).

The increasing cost of nitrogen fertilizers and the year to year variability in growing season temperature and moisture is forcing the question of whether more can be done to better manage the risks associated with nitrogen fertilizer management. The northern edge of the Northern Great Plains which includes Western Canada is characterized by a short growing season involving limited frost free days. As a result when you consider the pattern of nutrient uptake by crops in Western Canada, we find a period of rapid early accumulation for N and K, while P and S accumulation occurs over the entire growing season. Given that there are only a small proportion of Canadian prairie soils that are severely limited in K supply, most farmers are focused on meeting the large N demand by crops, and ensuring a balance of P and S where required. Based on a previous spring wheat study at Melfort, SK (Johnston, unpublished), crop samples taken on July 7 (42 days after sowing) showed that the crop had taken up 88% of the total N, 90% of total K, 58% of total P, 72% of total S and 47% of its total biomass. The crop development stage on July 7 was 70% head emergence. On June 16, the wheat was in the 5-6 leaf stage with 2 tillers. The 21 day (3 week) period between these two development stages was critical to the N accumulation by the crop, a very short time frame relative to other growing areas of the world. This very short time frame makes it challenging to improve on the current nitrogen management strategies. Work in spring wheat with post-emergent applications involving point injection or the surface broadcast of nitrogen showed that regardless of N application methods, N applications later than the tillering stage in semi-arid regions resulted in a grain yield penalty (Roberts et al. 1992). Studies have demonstrated the benefits of late season N applications for increasing grain protein but not necessarily for increasing grain yield (Lafond and McKell 1998).

However the issue is more than the feasibility of post-emergent N applications. The real issue is whether or not we can manage N more effectively given certain constraints. The major constraints being soil N levels, the soil moisture content and the probability of getting different amounts of precipitation, based on long-term weather records, during the growing season.

The objective of the study was to examine the feasibility of post-emergent N applications in spring wheat and canola using surface bands of UAN solutions and comparing it to the practice of applying all the fertilizer at seeding time.

## MATERIALS AND METHODS

**Study #1** This first study was conducted at two different locations, Indian Head (Heavy clay soil) and Scott (Clay loam soil) over a three year period (2001-2003) using two different crops (canola and spring wheat). The application dates for each location are given in Table 1, the soil N levels and N fertilizer used in Table 2 and the precipitation records in Table 3.

The study evaluated a single rate of N (80% soil test recommendation), applied either as a mid-row band at seeding (dry urea) or solution N (urea ammonium nitrate) applied as a surface dribble (UAN alone and UAN+5% ATS-ammonium thiosulfate) or in-soil coulter band (UAN alone) at some time post-seeding (1 day, 10 day, 20 day, 30 day) on spring wheat and canola. The post-emergent surface and in-soil bands of liquid UAN were spaced 30 cm apart. Below is the actual list of treatments used in the study.

1. Check
2. Mid-row band urea

3. UAN dribble 1 day PS
4. UAN coulter band 1 day PS
5. UAN dribble 10 days PS
6. UAN coulter band 10 days PS
7. UAN dribble 20 days PS
8. UAN coulter band 20 days PS
9. UAN dribble 30 days PS
10. UAN coulter band 30 days PS

**Study # 2** The second study examined the potential of post-emergent applications in spring wheat when combined with 33% of the nitrogen requirement applied at seeding time vs the balance at various leaf stages. This was compared to applying all the fertilizer at time of seeding or after seeding at various leaf stages. This is to try and minimize the chances on limited rainfall following surface application reducing N response. As well the study was conducted on long-term (24 years) and short-term (2 years) no-till fields that have known differences in nitrogen mineralization. This is to verify if fields with good mineralization potential can reduce the negative impact of post-emergent N applications in the case of adverse environmental conditions. Following are the N management treatments used for this study. The amount of soil residual N and N fertilizer applied is given in Table 4. The surface bands were spaced on 20 cm centers. The study was situated on a clay loam soil.

1. Check (no N except for the N with the MAP)
2. Mid-row (MR) band at seeding - all fertilizer N applied
3. 1-1.5 leaf Stage - UAN surface dribbled with 100% of fertilizer N applied
4. 3 - 3.5 leaf stage - UAN surface dribbled with 100% of fertilizer N applied
5. 5 - 5.5 leaf stage - UAN surface dribbled with 100% of fertilizer N applied
6. 33% MR at seeding and the remainder (67%) as UAN surface dribbled at the 1 - 1.5 leaf stage.
7. 33% MR at seeding and the remainder (67%) as UAN surface dribbled at the 3 - 3.5 leaf stage.
8. 33% MR at seeding and the remainder (67%) as UAN surface dribbled at the 5 - 5.5 leaf stage.

Table 1. Dates for nitrogen fertilizer application at Indian Head and Scott for 2001, 2002 and 2003.

| Timing after seeding | 2001 | | 2002 | | 2003 | |
|---|---|---|---|---|---|---|
| | Indian Head | Scott | Indian Head | Scott | Indian Head | Scott |
| 0 | May 23 | May 29 | May 7 | n/a | May 13 | May 14 |
| 1 day | May 24 | May 30 | May 9 | n/a | May 14 | May 15 |
| 10 days | Jun 4 | Jun 8 | May 17 | n/a | May 23 | May 23 |
| 20 days | Jun 14 | Jun 18 | May 27 | n/a | Jun 2 | June 3 |
| 30 days | Jun 25 | Jun 28 | June 6 | n/a | Jun 13 | June 13 |
| n/a: study discontinued due to the drought. | | | | | | |

Table 2. Growing season precipitation at Indian Head and Scott.

| | Indian Head (mm) | | | | Scott (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | Long-term | 2001 | 2002 | 2003 | Long-term |
| May | 2 | 18 | 24 | 49 | 29 | - | 22 | 36 |
| June | 29 | 115 | 18 | 81 | 45 | - | 34 | 60 |
| July | 41 | 49 | 22 | 60 | 33 | - | 66 | 59 |
| August | 13 | 98 | 5 | 52 | 1 | - | 44 | 45 |
| Total | 85 | 280 | 69 | 242 | 108 | - | 166 | 200 |

Table 3. Residual soil nitrogen and fertilizer nitrogen applied on the study areas.

| Year | Crop | Indian Head | | Scott | |
|---|---|---|---|---|---|
| | | Soil Residual N (kg/ha) | Fertilizer N Applied (kg/ha) | Soil Residual N (kg/ha) | Fertilizer N Applied (kg/ha) |
| 2001 | Wheat | 30 | 88 | 27 | 55 |
| | Canola | 30 | 126 | 27 | 55 |
| 2002 | Wheat | 42 | 34 | n/a | n/a |
| | Canola | 35 | 75 | n/a | n/a |
| 2003 | Wheat | 22 | 60 | 31 | 55 |
| | Canola | 22 | 80 | 31 | 55 |

All N rates applied represented 80% of recommended based on soil test results except for 2001 at Indian Head where the full recommended rate was used.
N/a: study discontinued because of drought

Table 4. Soil test levels for $NO_3$-N and $PO_4$ (kg/ha) long-term and short-term no tillage in 2003 and amount of N used in the study.

| Length of No-Till | Soil Test Levels (kg/ha) | | Total N Applied kg/ha |
|---|---|---|---|
| | $NO_3$-N (0-24") | $PO_4$ (0-6") | |
| Short-term | 10 | 9 | 83 |
| Long-term | 16 | 27 | 70 |

## RESULTS AND DISCUSSION

The results from the first study indicate that from a risk management perspective, it may be preferable to apply some N fertilizer during the seeding operation to avoid early season N deficiencies with the crop in situations where there is a delay in getting enough rainfall to move the fertilizer into the soil (Table 5). This was exemplified from the results of 2003 at Indian Head which reinforced the absolute requirement for post-application precipitation to move the fertilizer into the soil. Only in these instances was the coulter superior to the dribble band and yet not as good as when all the fertilizer was applied at seeding. No real advantage was found to using the coulter over that of a surface dribble band with liquid UAN. The results also indicate that there is a need to take into consideration soil moisture conditions at seeding. For example, in 2003 at Indian Head the soil was full of water (3' of moisture on a heavy clay soil) at seeding. The absence of any post-seeding rain meant that the mid-row band treatment was the best, by 5-15 bu/A over post-emergence application. While this was a very dry year, it does indicate that when you have a soil full of water at seeding, you also have the best signal you can get to apply the N requirements to optimize yield and quality – there was no need to hold back at seeding. Given the conditions of the year, all post-emergent treatments resulted in a disadvantage. There is a need to quantify the amount of starter N required to minimize risks with post-emergent N applications as a way to manage N fertilizer application more effectively.

The results of study#2 indicate that with the environmental conditions experienced in 2003, applying 33% of the total N requirement with the remainder as a post-emergent application was still not enough to exploit the full yield potential in 2003 when comparing it to all the fertilizer applied at seeding time. As found in study#1, rainfall was still required to move fertilizer into the soil and capture the full benefit of post-emergence surface dribble bands. The combined yield and protein obtained when all N was mid-row banded indicates that it was the most efficient means of applying N in 2003.

Table 5. Response of spring wheat and canola to post-emergence N application using fluid fertilizer (UAN – 28%) at Indian Head and Scott, SK, 2001-2003.

| WHEAT | | | 1 day | | 10 day | | 20 day | | 30 day | |
|---|---|---|---|---|---|---|---|---|---|---|
| Location | Variable | Midrow[1] | Dribble | Coulter | Dribble | Coulter | Dribble | Coulter | Dribble | Coulter |
| Indian Head'01 | Yield (bu/A) | 38.7 | 36.1 | 39.0 | 38.1 | 39.0 | 37.7 | 39.0 | 37.2 | 35.4 |
| | Protein (%) | 16.1 | 14.7 | 15.8 | 14.7 | 16.0 | 15.7 | 15.2 | 15.3 | 16.0 |
| Indian Head'02 | Yield (bu/A) | 42.0 | 41.0 | 41.0 | 38.0 | 39.0 | 39.0 | 40.0 | 37.0 | 37.0 |
| | Protein (%) | 14.1 | 13.4 | 13.5 | 14.0 | 13.6 | 14.0 | 14.3 | 13.6 | 13.7 |
| Indian Head'03 | Yield (bu/A) | 29.0 | 17.0 | 23.0 | 19.0 | 23.0 | 17.0 | 24.0 | 14.0 | 19.0 |
| | Protein (%) | N/A[2] | | | | | | | | |
| Scott'01 | Yield (bu/A) | 27.0 | 25.2 | 28.3 | 28.0 | 29.3 | 26.6 | 26.6 | 25.6 | 27.0 |
| | Protein (%) | 12.2 | 13.0 | 12.9 | 13.5 | 13.5 | 12.0 | 13.5 | 12.8 | 13.3 |
| Scott'03 | Yield (bu/A) | 20.0 | 21.0 | 19.0 | 20.0 | 20.0 | 21.0 | 22.0 | 20.0 | 20.0 |
| | Protein (%) | 16.5 | 16.1 | 16.4 | 16.2 | 16.4 | 16.3 | 16.2 | 16.3 | 16.5 |
| CANOLA | | | | | | | | | | |
| Indian Head'01 | Yield (bu/A) | 29.0 | 29.7 | 29.4 | 28.6 | 26.2 | 28.8 | 28.0 | 30.1 | 26.9 |
| Indian Head'02 | Yield (bu/A) | 32.0 | 33.0 | 30.0 | 30.0 | 30.0 | 32.0 | 31.0 | 34.0 | 30.0 |
| Indian Head'03 | Yield (bu/A) | 18.0 | 11.0 | 13.0 | 12.0 | 15.0 | 13.0 | 15.0 | 11.0 | 13.0 |
| Scott'01 | Yield (bu/A) | 14.3 | 14.6 | 15.8 | 12.4 | 12.4 | 12.9 | 15.2 | 15.6 | 16.8 |
| Scott'03 | Yield (bu/A) | 12.0 | 16.0 | 13.0 | 16.0 | 14.0 | 12.0 | 12.0 | 10.0 | 14.0 |

[1] Midrow – all N applied as urea in a midrow band at seeding (8" row spacing).

[2] N/S – data not available.

Table 6. Spring wheat response to combinations of N applied at seeding and various post-emergence stages of development near Indian Head in 2003 (Lafond, unpublished data).

| Timing of N | % of N applied mid-row at seeding | % N dribble band applied post-emergence | Long-Term ZT (soil test 16 lb N/A & applied 70 lb N/A) | | Short-Term ZT (soil test 10 lb N/A & applied 83 lb N/A) | |
|---|---|---|---|---|---|---|
| | | | Yield (bu/A) | Protein (%) | Yield (bu/A) | Protein (%) |
| Check | 0 | 0 | 16 | 13.2 | 10 | 11.7 |
| Mid-row | 100 | 0 | 28 | 14.2 | 33 | 12.4 |
| 1-1.5 leaf | 33 | 67 | 25 | 13.4 | 26 | 11.9 |
| 3-3.5 leaf | 33 | 67 | 19 | 13.5 | 25 | 11.9 |
| 5-5.5 leaf | 33 | 67 | 25 | 14.4 | 27 | 12.1 |
| 1-1.5 leaf | 0 | 100 | 19 | 13.7 | 20 | 11.8 |
| 3-3.5 leaf | 0 | 100 | 19 | 14.0 | 18 | 12.2 |
| 5-5.5 leaf | 0 | 100 | 25 | 14.5 | 26 | 12.4 |

## CONCLUSION

-From a risk mgt perspective, it may be preferable to apply some N fertilizer during the seeding operation but the question remains how much is adequate.
-There is a requirement for rain to move the fertilizer into the soil as shown in 2003.
-No real obvious advantage of the coulter over a surface dribble when you consider the costs of the coulter applicator.
-Need to take into consideration soil moisture conditions at seeding and adjust fertilizer N accordingly. If the soil is full of water, apply N to meet your target yield established at seeding.
-Late N applications helps with grain protein.

-Need to consider variability in rainfall timing and intensity.
-Need to consider timeliness of seeding with post-emergent applications.
-Need consider flexibility with UAN.
-Need to consider ease of application of UAN.
-Need to include cost of double shoot openers and single-shoot vs. double-shoot air carts.

## REFERENCES


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