# In-Season Fertility Management of Annual Crops: Is it for You?

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Fertilizers are the main form of plant nutrients used by farmers in western Canada to correct deficiencies and meet crop requirements. The scientific research conducted in the region supports the fertilizer best management practices (BMPs):

- Fertilizer application rates guided by realistic yield goals and soil test recommendations from labs using regional field trial data bases,
- Spring assessment of plant-available water to guide fertilizer use and seeding decision,
- Minimize the use of seed-row applied fertilizer, and using adequate seed-fertilizer separation with side band openers, to prevent damage to germinating crops,
- In-soil banding of fertilizer for annual crops to improve nutrient-use relative to broadcast application,
- Where fall application is used, that ammonium based fertilizer nitrogen (N) sources (urea and anhydrous ammonia) be in-soil band applied when soil temperatures begin to decline,
- Ensuring that spring and in-crop applications of N are early enough to avoid deficiencies during the period of rapid uptake at stem extension or bolting, and
- Balancing N application with other limiting nutrients, such as phosphorus (P), sulphur (S) and potassium (K).

The annual crops we grow in western Canada are often referred to as "short-season" small grains, oilseed and pulse crops in other parts of North America. This reflects the limitations of our environment in growing crops, limited frost free days. As a result when we look at the pattern of nutrient uptake by our crops we find a period of rapid early accumulation for N and K, while P and S occur over the entire growing season (Figure 1). Given that there are only a small proportion of Saskatchewan 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. The sample information from Julian day 188 (July 7) shows this spring wheat crop having taken up 88% of the total N, 90% of total K, 58% of total P, 72% of total S and 47% of total biomass. The crop development stage on July 7 was 70% head emergence. At day 167 (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.

**Post-Emergence N Application**

There is growing interest in using post-emergence N application as a *means of managing risk* in semi-arid crop production. The basic premise of post-emergence N application is as follows:

- At seeding soil water assessments indicate that you have less than adequate stored soil water to grow a stubble crop (2' on a heavy clay; 3' on a loam; 4' on a sand), assuming average growing season precipitation.
- As a result, the stubble crop is seeded with a reduced rate of N, along with all of the other nutrients (P, K and S) required by soil test. For example, if you have 20 lb N/A in your

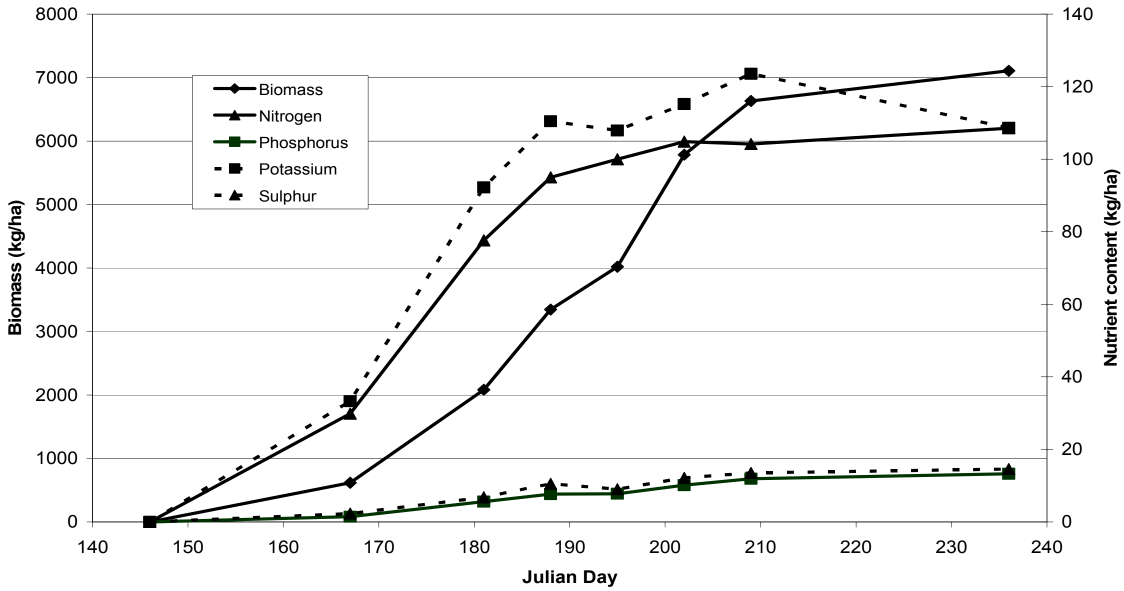


Figure 1. Graphical pattern of biomass accumulation and uptake of N, P, K and S by AC-Barrie spring wheat at Melfort in 1998 (Johnston et al., unpublished data).

soil test you may add 30 lb N/A as fertilizer to give you a total of 50 lb N/A, enough to grow a 20 bu/A wheat crop (using a factor of 2.5 lb N/bu for high protein CWRS).

- You then have approximately 3-4 weeks between seeding and the start of stem elongation to make further additions to the crop N supply. If it remains dry, then you could elect to add no further N and take what you get from the growing season. If moisture conditions improve, you could add more N (using the 2.5 lb N/bu guide) knowing that your *early season plant development has not been restricted by N supply*. It is important to remember that if a wheat plant seedling develops under N deficient conditions, it will set limits on the yield potential – a means of responding to the available resources.
- The concept could also be applied when growing season conditions continue to improve after seeding, and you know that the yield potential will likely out-strip the N applied. For example, using the above soil test of 20 lb N/A, you applied 55 lb fertilizer N to give you a total of 75 lb N/A, with a yield goal of 30 bu/A. However, at the beginning of stem extension your previous experience, and stored soil water measurements, indicate that there is solid potential of 45 bu/A – you could add an additional 35-40 lb N/A to account for the increased yield estimate and maintain your grain protein potential.
- It is important to remember that post-emergence N application is not a suitable means of deferring your entire N application decision to some date of advanced crop development. If you are planning to do this you had better have confirmed sufficient levels of residual soil N to avoid early season crop N requirements for the establishment of high yield potential.
- Post-emergence N is standard practice on most of the area seeded to winter crops (winter wheat and fall rye), and most forages have all their nutrient requirements applied onto established stands. For both winter crops and forages it has been long established that

application as early as possible in the spring is critical to capturing the full yield response of these early growing crops.

## Limitations of Post-Emergence Fertilizer Application

When we consider post-emergence nutrient application to a crop, it is important to clarify where we can effectively use the practice, and where it is likely to be of little use.

- In western Canada we have field trial evidence that crops will respond to delayed N application, as long as they established with sufficient N to build yield potential.
- We also have several examples of how S can be added to a canola crop through to the beginning of flowering to correct a S deficiency. It is important to remember that canola is a crop that had a far superior ability to respond to late-season improvements in growing conditions and still generate a yield response, something cereals are unable to do.
- Capturing cereal yield responses requires that the N get into the plant during the earlier yield building phase (pre-heading), vs late season protein building phase (post-heading).
- Post-emergence application is going to have little or no impact on the response of a deficient crop to nutrients like P or K. For P, while the addition may result in an improvement in the appearance of the crop, the impact of early season P deficiencies on yield formation (tillering and head development) have already occurred. If the K deficiency is severe enough, then the plants ability to take up N will be seriously limited.

## Recent Research on Post-Emergence N in Saskatchewan

To address some of the questions related to post-emergence N application on annual crops in Saskatchewan, Simplot Agri-Business of Brandon, MB has been funding some research with Agriculture and Agri-Food Canada at Indian Head (Guy Lafond) and Scott (Stewart Brandt), Saskatchewan. The main objectives of this work were to establish how late all of the N could be applied to a canola or wheat crop after emergence, and whether using a coulter improved the crop response over dribble band application on the soil surface. Mid-row banded N at seeding was the check treatment.

Table 1. 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.

In summary the results of this project to date indicate:

- 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.
- The results from 2003 at Indian Head indicate 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.
- No real advantage was observed for the use of the coulter over that of a surface dribble band.
- 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-emergence 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, and this will be the focus of future research.

Further research was initiated at Indian Head in 2003 to evaluate N fertilizer timing combinations, including applying all N at seeding, applying a portion (33%) at seeding and the remainder (66%) at various plant development stages, or applying all the N at various plant development stages. The identical trial was run on two adjacent fields South of Indian Head, one that had been in continuous crop and no-till for over 23 years, and the other which was just recently (2001) converted from conventional till fallow-wheat to continuous cropping and no-till.

Table 2. 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 |

The results of this study indicate:

- As found in the previous study in 2003, rainfall is 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.

- While delayed rainfall may reduce yield response to applied N, it will increase grain protein concentration.
- From a risk management perspective, these results indicate that there is a need to look at more than 33% of total N requirements applied at seeding to optimize yield response.
- There is also a need to take into consideration spring soil moisture levels when considering the post-emergence application of N. At this trial location the soil was full of water at seeding, and application of all the N at seeding proved to be the best treatment.
- While delaying N applications until the 5-5.5 leaf stage did not optimize grain yields, it did help to increase grain protein, indicating late uptake of N after yield formation.

**New Technology and Future Opportunities in N Management**

There is considerable excitement in the fertilizer industry with the development of on-the-go optical sensors for evaluating a crops N sufficiency. A company in California, N-Tech, has commercialized technology developed at Oklahoma State University into a field ready sensor called GreenSeeker®. GreenSeeker® is an integrated optical sensing and application system that measures crop N status, and then variably applies the crop's N requirements. Yield potential for a crop is identified using a vegetative index known as NDVI (normalized difference vegetative index) and an environmental factor. Nitrogen is then recommended based on yield potential and the responsiveness of the crop to additional nitrogen, established through previous research and a N-rich strip in the field.

The sensor uses light emitting diodes (LED) to generate red and near infrared (NIR) light. The light generated is reflected off of the crop and measured by a photodiode located at the front of the sensor head. The optical sensor measures nitrogen needs in a 2 by 2 foot area while applying fluid fertilizer from stream nozzles in the previously sensed area. This means that there is a sensor every 20-24" in the application unit. The technology is designed to optimize N fertilizer application by applying only the rate which should adjust for the difference in green color between the established color standard and the plant being sensed.

One of the unique opportunities with the optical sensing technology is that it allows the plant to act as the indicator of N sufficiency, reflecting the plants ability to respond to the soil and fertilizer N applied in combination with the local environmental conditions. It does not rely on soil testing or any other form of satellite based images. A number of researchers currently are using hand-held sensors in western Canada, and we can expect to see some plot and field trial results in the near future.

The Indian Head Agricultural Research Foundation in conjunction with AAFC at Brandon, Swift Current and Indian Head has succeeded in identifying management zones in fields with the use of NDVI calculated from satellite imagery. The zones have been shown to be consistent from one year to the next in terms ranking in yields. This method would allow producers to be more strategic in their soil sampling and general observations in order to try and uncover the reasons for the yield differences between the zones and hopefully capture the potential through different fertilizer regimes.