Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Early Spring 2010
Vol. 18 No. 2, Issue #68

Drs. G. Lafond, C. Holzapfel, and W. May

N Management, Plus Optical Sensors, Helps To Refine N Rates

Matches crop with soil and crop conditions to enhance yields.

***Summary:** The study results in 2008 support the merits of in-crop N applications for all crops except for canola when combined with an optical sensor. With canola, environmental conditions improved greatly after the sensor readings, resulting in an underestimate of yield potential when the sensor readings were taken. This N management approach, when combined with optical sensors, offers the possibility of refining N rates to match crop with soil and crop conditions and also to take into consideration spatial variability in soil nitrogen (N) and yield response.*

Nitrogen fertility management encompasses four major components: source, placement, timing, and rate. Research has demonstrated that there is very little difference between fertilizer forms, providing they are managed appropriately. Placing the fertilizer in the soil, as opposed to on the surface, greatly minimizes losses from volatilization and immobilization and enhances overall N fertilizer recovery. The timing of N application should be such that it is available close to the time of maximum crop uptake, which in cereal grains extends from the start of elongation until heading, with peak uptake during flag leaf extension and in canola from the start of flowering to the end of pod formation.

Current N fertilizer rate recommendations on the Canadian prairies generally consider factors such as:

- Soil texture
- Residual soil nitrate levels
- Soil moisture at seeding
- Average growing season precipitation
- Previous crop grown
- Crop to be grown
- Target grain yield
- Expected commodity prices
- N fertilizer prices.

However, there is much uncertainty with all of these factors due to year-to-year variations in climatic conditions and to spatial variability in soil nutrient levels and inherent fertility of the soil. Nitrogen release during the growing season and the major pathways of N losses (immobilization, volatilization, denitrification, and leaching) are also greatly influenced by climatic conditions, making their amounts very difficult to estimate. Consequently, much uncertainty exists in determining crop N requirements and the rate of application can easily be under- or overestimated with important economic and/or environmental consequences in either case.

There is interest in exploring post-emergent N applications in annual crops to refine our ability to arrive at more optimal rates of N fertilizer. Delaying some or all of the N fertilizer until after crop emergence may allow for a better sense of yield potential and expected growing conditions. Recent research with spring wheat and canola, using post-emergent N applications as an N management tool, compared applying all fertilizer at time of seeding in the soil with in-crop surface banded applications of liquid urea-ammonium-nitrate (UAN) at different times after seeding. Recent research (2007) showed no adverse effects in canola but some yield depression was observed in spring wheat, especially in those years where little precipitation was received after N application. In order to reduce the risks associated with post-emergent N applications, some of our recent research has shown that applying 50 percent or more of the recommended N at seeding enhances the opportunity for in-crop applications of N in spring wheat and canola to better match soil and climatic conditions.

With the recent introduction of commercial optical sensors as an N management tool, it is now possible to estimate crop yield potential early in the growing season (5- to 6-leaf stage), allowing enough time to adjust the N rates to realize that potential.

The objectives of this study were to validate the application algorithms developed to date in spring and winter wheat, durum, oat, malting barley, and canola, using small plots in order to get an accurate assessment of the proposed algorithms. The validation consisted of applying specific amounts of UAN at the 6- to 7-leaf stage in cereals and at the mid-bolting stage of canola, using rates determined by the algorithms. The results were then compared to actual N rate studies for each crop adjacent to the plot studies where the algorithms were tested. This was to verify how well the algorithms were able to predict the best N rate possible, using the N response curves from the adjacent plots as a measure of precision or accuracy.

Overall response

The responses of durum, spring wheat, oat, and barley to N fertilizer rates were linear, except for spring wheat where the quadratic form was significant. The overall responses tended to be flat given the high values for the y-intercept (Table 1). It should be noted that for spring wheat, the quadratic form was also significant (Table 1). The rate of yield increase per kg of N applied (bu/kg) was 0.189, 0.086, 0.208, and 0.3338 for durum, spring wheat, oat, and barley, respectively, when using a linear function. With winter wheat, the response to N was quadratic in nature and the optimum N rate estimated as 133 kg/ha (Table 2). With canola, the linear and quadratic forms were significant and the optimum N rate was calculated at 185 kg/ha, which is much above the economic rate, given the prices of N fertilizers for the 2008 growing season.

Amounts of N

The amount of N used for durum, spring wheat, barley, and oat for the various experiments is provided in Table 3. With spring wheat and durum, there was a response to N observed but no other treatment effects on grain yield (Table 4). Consequently, for those two crops there was a saving of 26 to 44 kg/A in spring wheat and durum when the optical sensor was used to fine-tune N rates based on estimated yield potentials

N rate (kg/ha)	Bu/A			
	Durum	Spring Wheat	Oat	Barley
0	40.6	33.3	105	58.6
25	48.8	38.0	110	58.3
50	46.0	40.4	117	73.3
75	49.1	44.3	126	72.0
100	51.3	41.8	124	71.9
125	53.5	44.2	126	74.6

Table 1. *The response of durum, spring wheat, oat and barley to different rates of nitrogen fertilizer in 2008.*

N rate (kg/ha)	Winter Wheat		N rate (kg/ha)	Canola
0	30.3		0	20.7
25	36.6		25	27.2
50	38.1		50	31.9
75	41.0		75	39.5
100	42.6		100	42.3
125	41.9		125	44.9
150	43.4		cv (%)	6.7

Table 2. *The response of winter wheat and canola to different rates of nitrogen fertilizer on grain yield (bu/A) in 2008.*

Treatments	Durum	Spring Wheat	Barley	Oat
1. Check	0	0	0	0
2. N Rich	130	130	160	112
3. Farmer Practice (FP)	90	90	105	56
4. 66% of FP (RR)	59	59	69	37
5. 50% N at Seeding + 50% at 6 leaf stage	90	90	105	56
6. 66% N at Seeding + 34% at 6 leaf stage	90	90	105	56
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	46	48	52	30
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	64	64	73	37

Table 3. *The evaluation of different N management strategies on the amount of nitrogen fertilizer (kg N/ha) applied in durum, spring wheat, oat and barley in 2008*

Treatments	Durum	Spring Wheat	Barley	Oat
1. Check	31.2	31.0	48.2	97
2. N Rich	46.5	41.0	74.5	119
3. Farmer Practice (FP)	40.1	40.3	70.3	109
4. 66% of FP (RR)	44.4	39.2	68.8	111
5. 50% N at Seeding + 50% at 6 leaf stage	11.9	38.3	75.6	112
6. 66% N at Seeding + 34% at 6 leaf stage	45.5	38.3	73.8	116
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	39.3	38.0	62.0	105
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	39.4	39.7	70.1	115

Table 4. *The evaluation of different N management strategies on the grain yield (bu/A) of durum, spring wheat, oat and barley in 2008.*

in relation to the N rich treatment (Table 3).

Yield by crop

Barley. With barley, N response was observed and the grain yields for the optical sensor were the same as the grower's treatment, even though less overall N was used with the optical sensor. However, the treatment where only 50 percent of the target N was applied at seeding tended to be lower (Tables 3 and 4). It is interesting to note that the split application of N gave higher grain yields than when the optical sensor was used.

Oat. With oat, N response was observed and the N-rich treatment gave the highest grain yields and the yield was also higher than the grower's treatment (Table 4). When the optical sensor was used, the treatment, where 66 percent of the target N rate was applied at seeding, gave a higher yield than when only 50 percent of the target N rate was used at seeding. The sensor treatments gave similar yields to the grower treatments but used less N fertilizer (19 to 26 kg/ha less).

Winter wheat. With winter wheat, a response to N was observed but no other treatment differences were noted (Table 5). Use of the sensor gave grain yields similar to the grower's treatment but with less N (27 to 58 kg/A). The overall grain yields for winter wheat were low due to the dry spring and wide temperature fluctuations in April and early May.

Canola. With canola, N response was observed and the N-rich treatment yielded higher than the average of all other treatments including the check (Table 6). Grower treatments yielded more than the split-applied treatment where only 50 percent of the target N rate was applied at seeding, yet similar to the treatment where 66 percent of the target N rate was applied at seeding. Using the optical sensor resulted not only in lower N fertilizer use but also in lower yields relative to grower treatments. In 2008 the sensor underestimated yield potential, resulting in lower N rates. The weather after application improved significantly, resulting in overall above-average grain yields. In 2008, even adding 66 percent of the target N rate at seeding did not lessen the chances for lower grain yields when the optical sensor was used. Final N rates were much lower than the target N rate when the optical sensor was used.

Treatments	Bu/A	kg N fertilizer /ha
1. Check	28.7	0
2. N Rich	42.4	207
3. Farmer Practice (FP)	40.9	110
4. 66% of FP (RR)	38.2	78
5. 66% N in Early Spring and 34% at Feekes 4-5	43.5	110
6. 66% N in Early Spring + balance with GreenSeeker (GS) at Feekes 4-5	41.3	83
7. 34% N in Early Spring and 66% at Feekes 4-5	41.1	110
8. 34% N in Early Spring + balance with GreenSeeker (GS) at Feekes 4-5	39.4	52

Table 5. *The evaluation of different N management strategies on the grain yield and total nitrogen fertilizer used in winter wheat in 2008.*

Treatments	Grain Yield	N Rate
1. Check	24.5	0
2. N Rich	44.7	148
3. Farmer Practice (FP)	44.4	114
4. 66% of FP (RR)	39.8	75
5. 50% N at Seeding + 50% at 6 leaf stage	40.8	114
6. 66% N at Seeding + 34% at 6 leaf stage	43.0	114
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	38.9	59
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	37.7	75

Table 6. *The evaluation of different N management strategies on the grain yield (kg/ha) and total nitrogen fertilizer (kg/ha) used in canola in 2008.*

Dr. Lafond and Mr. May are research scientists with Agriculture and Agri-Food Canada and Mr. Holzapfel is a research scientist with the Indian Head Agricultural Research Foundation.