Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Early Spring 2009
Vol. 17, No. 2, Issue #64

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Study Shows Merits Of In-crop N Applications

Supports the merits of in-crop N applications for all crops measured.

Summary: *This study, conducted in 2007 at the Indian Head Research Farm in Indian Head, SK, supports the merits of in-crop N applications for all crops measured. This N management approach, when combined with optical sensors, offers the possibility of refining N rates to match the crop with soil and growing conditions and also to take into consideration spatial variability in crop production.*

Nitrogen (N) 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 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. In cereal grains this extends from the start of elongation until heading, with peak uptake during flag leaf extension. In canola it extends 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 yield, expected commodity prices, and N fertilizer prices.

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. 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 in the soil at time of seeding with in-crop surface banded applications of UAN at different times after seeding. Though no adverse effects occurred in canola, 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, 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 a N management tool, it is now possible to estimate crop yield potential early in the growing season in cereals (5- to 6-leaf stage) allowing enough time to adjust 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 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

Yield responses

Responses of durum, spring wheat, oat, and barley to N fertilizer rates were linear and overall response tended to be flat given the high values for the y-intercept (Table 1). The rate of yield increase per kg of N applied (bu/kg N) was 0.2, 0.1, 0.2, and 0.3 for durum, spring wheat, oat, and barley, respectively. With winter wheat and canola, the response to N was quadratic in nature and the optimum N rate was estimated as 133 and 172 kg N/ha, respectively (Table 2).

N rate (kg/ha	Bu/A			
	Durum	Spring wheat	Oat	Barley
0	38.6	30.8	95.1	41.0
25	40.5	32.7	89.7	52.2
50	52.3	36.5	115.0	70.4
75	52.5	40.2	112.7	62.5
100	59.7	42.5	113.7	85.8
125	60.1	39.2	117.5	81.8
cv (%)	15.3	13.2	5.4	22.7
Contrasts	p-values			
linear	0.0001	0.0022	0.0001	0.0003
quadratic	Ns	ns	ns	ns
cubic	Ns	ns	ns	ns
Linear Regression				
Y intercept	38.8	31.7	94.3	44.6
Slope	0.1889	0.0858	0.2077	0.3376
R^2	0.92	0.79	0.68	0.85

Table 1. The response of durum, spring wheat, oat, and barley to different rates of N fertilizer.

N rate (kg/ha)	**Winter Wheat**		**N rate (kg/ha)**	**Canola**
0	33.2		**0**	20.4
25	38.8		**25**	27.8
50	51.2		**50**	31.0
75	56.7		**100**	37.1
100	57.9		**150**	38.3
125	59.9		**200**	41.4
150	61.0		**cv (%)**	22.3
cv (%)	10.7		**p-value**	**<0.0001**
p-value	**<0.0001**		**Y intercept**	21.7
Y intercept	32.1		**x^2**	-0.0006
X2	-0.0016		**X**	0.2064
X	0.4264		**R^2**	0.98
R^2	0.98			

Table 2. The response of winter wheat and canola to different rates of N fertilizer on grain yield bu/A

The results for grain yield and grain protein regarding the evaluation of the optical sensor for refining N rates in durum, spring wheat, oat, and barley are presented in Tables 3 and 4.

With spring wheat and oat, all N management treatments yielded the same and the sensor was able to reduce the N rates used by an average of 33 percent in spring wheat and 28 percent in oat (Table 3).

With barley, the split application of N gave similar yields to FP and yielded more than the reduced N rate treatment (#4 in Table 3), indicating a response to post-emergent applications of UAN. Treatment #7 yielded less than treatment #3 (FP) where 50 percent of the recommended N rate was applied at seeding and the balance determined with the sensor. This was not observed in treatment #8 where 66 percent of the N was applied at seeding and the balance with the optical sensor. However, it should be noted that the N applied was 95 kg/ha for treatment #8 vs. 64 kg/ha for treatment #7. More refinements are required for the barley algorithm.

With durum, applying 50 percent of the recommended N rate at seeding and the balance in-crop yielded less than FP as well as when 66 percent of the N was applied at seeding, regardless of whether or not a uniform rate was used or a rate determined with GreenSeeker®. The results suggest that the level of starter N required for durum to maintain grain yields with post-emergent N applications is at least 66 percent of the targeted rate. The spring wheat algorithm was used for durum and this may have affected the results with the optical sensor. Although the N Rich (#2) and the FP (#3) treatments yielded the same, the yields were lower than N Rich for all other treatments. More refinements to N management in durum are required.

Treatments	Durum	Spring wheat	Barley	Oat
1. Check	20.8e	22.3a	38.7d	93.1b
2. N Rich	50.3a	39.1b	76.9a	104.5a
3. Farmer Practice (FP)	46.8ab	36.4b	76.1a	103.5a
4. 66% of FP (RR)	42.7bc	31.8b	63.4c	103.3a
5. 50% N at Seeding + 50% at 6 leaf stage	38.5cd	36.1b	73.0ab	104.4a
6. 66% N at Seeding + 34% at 6 leaf stage	43.9b	35.4b	71.8ab	105.7a
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	36.9d	37.9b	66.4bc	101.6a
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	42.8bc	38.8b	69.9abc	106.0a
LSD(05)	5.3	7.4	8.1	7.4
Cv(%)	9.0	14.6	8.2	4.9
Contrasts	***p*-values**			
Check vs Rest (1 vs 2-8)	<0.0001	<0.0001	<0.0001	0.00015
N Rich vs Remaining N treatments (2 vs 3-8)	0.0004	ns	0.032	Ns
N Rich vs FP (2 vs 3)	ns	ns	ns	Ns
FP vs RR (3 vs 4)	ns	ns	0.004	Ns
FP vs Split (3 vs 5+6)	0.0196	ns	ns	Ns
FP vs GS (3 vs 7+8)	0.005	ns	0.029	Ns
FP vs Split 50% (3 vs 5)	0.004	ns	ns	Ns
FP vs Split 66% (3 vs 6)	ns	ns	ns	Ns
FP vs GS 50% (3 vs 7)	0.009	ns	0.021	Ns
FP vs GS 66% (3 vs 8)	ns	ns	ns	Ns
Split vs GS (5+6 vs 7+8)	ns	ns	ns	Ns
Split 50% vs GS 50% (5 vs 7)	ns	ns	ns	Ns
Split 66% vs GS 66% (6 vs 8)	ns	ns	ns	Ns
Split 50% vs Split 66% (5 vs 6)	0.049	ns	ns	Ns
GS 50% vs GS 66% (7 vs 8)	0.032	ns	ns	Ns
RR vs Split (4 vs 5+6)	ns	ns	0.015	Ns
RR vs GS (4 vs 7+8)	ns	0.047	ns	Ns

Table 3. The evaluation of different N management strategies on the grain yield (bu/A) of durum, spring wheat, oat, and barley in 2007 at Indian Head.

Treatments	Durum	Spring wheat	Barley	Oat[1]
1. Check	12.8de	14.7c	12.3e	-
2. N Rich	14.9a	16.2a	14.4a	-
3. Farmer Practice (FP)	14.2b	15.8a	13.5bc	-
4. 66% of FP (RR)	12.6b	14.8bc	13.2cd	-
5. 50% N at Seeding + 50% at 6 leaf stage	13.3cd	15.7ab	13.6bc	-
6. 66% N at Seeding + 34% at 6 leaf stage	13.9bc	15.5abc	13.7b	-
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	12.6e	15.5abc	12.8de	-
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	12.8de	15.4abc	13.5bc	-
LSD(05)	0.7	0.9	0.5	-
cv(%)	3.3	4.2	2.3	-
Contrasts	*p*-**values**			
Check vs Rest (1 vs 2-8)	0.011	0.022	<0.0001	-
N Rich vs Remaining N treatments (2 vs 3-8)	<0.0001	0.036	<0.0001	-
N Rich vs FP (2 vs 3)	0.037	ns	0.0008	-
FP vs RR (3 vs 4)	<0.0001	0.036	ns	-
FP vs Split (3 vs 5+6)	0.043	ns	ns	-
FP vs GS (3 vs 7+8)	<0.0001	ns	ns	-
FP vs Split 50% (3 vs 5)	0.009	ns	ns	-
FP vs Split 66% (3 vs 6)	ns	ns	ns	-
FP vs GS 50% (3 vs 7)	<0.0001	ns	0.005	-
FP vs GS 66% (3 vs 8)	0.0003	ns	ns	-
Split vs GS (5+6 vs 7+8)	0.0008	ns	0.008	-
Split 50% vs GS 50% (5 vs 7)	0.044	ns	0.002	-
Split 66% vs GS 66% (6 vs 8)	0.0026	ns	ns	-
Split 50% vs Split 66% (5 vs 6)	ns	ns	ns	-
GS 50% vs GS 66% (7 vs 8)	ns	ns	0.005	-
RR vs Split (4 vs 5+6)	0.002	00053	0.023	-
RR vs GS (4 vs 7+8)	ns	ns	ns	-
[1] Lab analysis of grain protein not complete.				

Table 4. The evaluation of different N management strategies on the grain protein concentration (%) in durum, spring wheat, oat, and barley in 2007 at Indian Head.

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