Project title: Long-term effect of nitrogen rates on in corn – 2009 Interim Report

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Executive Summary

This report summarizes results from year 1 of a 10 year field trial designed to evaluate long-term effect of timing and rate of fertilizer N on grain corn yield potential. Any economic results are based on grain corn price of $161/Mg ($4.10/bu) and N cost of $1.00/kg-N ($0.45/lb-N).

Timing of fertilizer N application (at planting or sidedressed 1 month later) had minimal effects on corn uptake patterns and on grain corn yield response. Maximum economic N rates were 162-168 kg-N/ha at Elora in 2009, about 20 to 40 kg-N/ha higher than recommended by Ontario preplant and sidedress recommendations, respectively. Recommended fertilizer N rates resulted in an estimated $8/ha loss for the preplant recommendation and $35/ha for the sidedress recommendation.

The 218 kg-N/ha N rate produced the highest observed corn N uptake with an apparent fertilizer N recovery of about 50%. Similar apparent fertilizer N recovery for corn was observed for the 145 kg-N/ha rate. Grain yield increase per unit of N applied over the 30 kg-N/ha starter rate associated with application of the Maximum Economic N Rates (MERN) was 20.7 kg-grain/kg-N for preplant and 24.9 kg-grain/kg-N for sidedress. Applying non-N limited rates, over the starter rate of 30 kg-N/ha, increased potential yield by a factor of about 1.5 and total plant and grain N uptake by a factor of 2.

End of season residual soil N measurements show that applying fertilizer N in excess of corn requirements will result in higher soil N levels; soil N which is probably subject to environmental losses.

Introduction and Description of Production Practices

A long-term trial was initiated at the Elora Research Station, Elora ON CA to evaluate the effect that timing and rate of nitrogen fertilizer has on long-term corn productivity. The 2009 year represents the first year where the various N treatments were imposed. Information for production practices for 2009 are as follows:

Previous Crop: Grain Corn
Tillage: Fall Chisel plow with spring secondary tillage

Corn: Pioneer 38B14 planted in 0.76 m rows on May 13 at 69,100 seeds/ha
Fertility: Starter 200 kg/ha 15-15-15 starter was banded through planter 5 cm beside, 5 cm below seeding depth (Nutrient rates of 30 kg/ha of N, P2O5 and K2O).
Early (Preplant) N was banded mid-row as UAN 1 week after planting (May 20) at treatment related rates of 0, 28, 57, 115, 188, and 230 kg-N/ha.
The late (sidedress) application date was June 24 with N application treatments that were the same as described for the early date.

Site Fertility

Soil fertility sampling to a depth of 15 cm was taken prior to corn planting in April and also after corn planting in May. The results are presented in Table 1. The site in 2009 has soil test P and K levels that are in the medium range and efforts will continue in 2010 to increase P and K fertility at this site.

Spring soil NO_3-N concentration in the surface 30cm was 8.1ppm (Standard Error=0.43, Sample Number=24) on the day of planting (May 16) and 9.9 ppm (Standard Error=0.41, Sample Number=24) for the presidedress sample date (June 24). Soil NO_3-N test recommendations for Ontario are 124 kg-N/ha for the Preplant sample and 130 kg-N/ha for the Presidedress sample.

Grain Corn Yield and Economic Response to Fertilizer N

This was the first year that N timing and rate treatments were imposed, so results for 2009 were not affected by differences in N application history. Ontario Corn general N recommendations for this site following corn with a 10 Mg/ha expected yield and when N is applied preplant is 145 kg-N/ha when the Nitrogen:Corn price ratio is 6.1. Corn price of $161/tonne ($4.10/bu) and N cost of $1.00/kg-N ($0.45/lb-N) results in a Nitrogen:Corn price ratio of 6.1. Economic assumptions reported in this summary are based on $4.10/bu corn and $0.45/lb-N nitrogen

This trial consists of 2 distinct sets of plots. One set of plots have the various N timing and rate treatments imposed onto plots where the previous year N rate is the same and is used to develop yield response equations to fertilizer N and establish estimates of Maximum Economic Rates of Nitrogen (MERN) for the site. The second series of plots are designed to examine long-term effects of continuously applying the same rate of N fertilizer.

Timing of N application had minimal effect on corn yield response to applied N fertilizer in 2009. Yield response equations are presented in Table 2 and the sidedress regression is illustrated in Figure 1. The non-N limited yield (i.e. plateau yield) was estimated to occur at a preplant N rate of 197 kg-N/ha and at a sidedress N rate of 184 kg-N/ha. Plateau yields for the sidedress application are estimated at 9.75 Mg/ha; about 0.3 Mg/ha higher than the estimated preplant plateau yield.

The economic rates of fertilizer N are estimated to be about 85% of the fertilizer N rates that maximize yield response (Table2). The yields produced by applying economic rates of N are estimated to be 99% of the non-N limited (plateau) yields. The rate of grain yield increase per unit of applied fertilizer N over the starter rate when the MERN rate was applied was 20.7 kg-grain/kg-N for preplant and 24.9 kg-grain/kg-N for sidedress.

The OMAFRA N recommendations were less than calculated MERN for 2009 (Table 2). When N was applied preplant, recommended N rate was 22 kg-N/ha less than was required which produced a yield that was 98% of the maximum economic yield. Following the preplant recommendation resulted in economic returns that were about $8/ha less than estimated maximum potential returns. The sidedress recommendation was 39 kg-N/ha less than was

required to maximize economic returns; which produced a yield that was 95% of the estimated sidedress maximum economic yield. Following the sidedress N recommendations resulted in an estimated net loss of about $35/ha.

Ontario soil NO_3-N test recommendations also were less than maximum economic N rates observed for 2009 (Table 2). On Average, soil NO_3-N test recommendations were about 38 kg-N/ha less than required, producing yields that were about 95% of the estimated maximum economic yield and resulting in a net loss of about $29/ha.

Impact on Timing and Rate of Fertilizer N on Corn Development, Yield and N Uptake
Corn response data summarized in this section are from the series of plots designed to evaluate long-term impact to continuously applying similar rates of fertilizer N. Since this was the first year that N rate treatments were imposed, the corn results discussed in this section did not have a history of different previous year fertilizer application.

Timing of fertilizer N application did not significantly affect corn development, yield and N uptake patterns observed for the various rates of fertilizer N applied in 2009. Therefore, discussion of results will focus on fertilizer N rate effects on corn development, yield and N uptake averaged across N timing treatments.

The various fertilizer N rates had minimal effects on rates of corn development. Days required to achieve 50% silking did not differ by more than 1 day and grain moisture at harvest did not differ by more than 1% (Table 3).

Grain corn yield response to fertilizer N (Table 3) was similar to those observed for plots used to develop yield response equations. Grain corn yields for the 145 kg-N/ha treatment were 95% of the highest yield treatment (218 kg-N/ha); a relative yield difference that was similar to the yield differences predicted by the yield response equations.

Harvest index, which is the percentage of the above ground corn plant mass that is grain, increased slightly with increasing N rate to a maximum value of 51.44% for the 145 kg-N/ha rate. Total above ground biomass in Table 3 was estimated based on a calculation using the dry grain corn yield (0% moisture) and harvest index. The Stover yield in Table 3 represents the mass, at 0% moisture) of the above ground plant material not including the grain or cobs. Essentially, grain, Stover and total yield were increased up to the 218 kg-N/ha rate. Applying 260 kg-N/ha did not increase grain, Stover or total biomass over those obtained for the 218 kg-N/ha rate.

Grain and Stover N concentration increased with increasing rate of fertilizer N from 30 to 218 kg-N/ha (Table 4). When N availability to corn was not limiting (i.e. 218 kg-N/ha rate), grain and Stover N concentrations were increased by a factor of about 1.5 over where just the 30 kg-N/ha starter rate was applied. Applying 260 kg-N/ha did not increase grain or Stover N concentrations over those observed for the 218 kg-N/ha rate.

Grain and Stover N content for the 218 kg-N/ha rate was doubled over N content for the 30 kg-N/ha N rate (Table 4). Applying 260 kg-N/ha did not increase grain or Stover N content over the 218 kg-N/ha rate.

Applying recommended fertilizer N rate increased total N content (Grain & Stover) by about 60 kg-N/ha; which is about 53% of the 115 kg-N/ha of additional fertilizer N applied (Table 4). Applying 188 kg-N/ha over the 30 kg-N/ha starter rate (218 kg-N/ha) increased total N content by about 90 kg-N/ha with an apparent fertilizer N recovery for corn of 49%.

End of Season Residual Soil N.

Applying rates of fertilizer N that were clearly less then required to maximize economic returns (<160 kg-N/ha) resulted in residual mineral soil N levels in the surface 60cm that averaged about 41 kg-N/ha (Table 5). Applying fertilizer N rates in excess of 145 kg-N/ha increased residual mineral soil N levels in the surface 60cm; especially for the later (sidedress) application timing. Yield response and N uptake patterns were not significantly affected by timing of N application and can not explain observed differences in end of season residual soil N levels for the early (preplant) and sidedress application dates. The site did receive about 90mm of rain between the 2 application dates which may have provided more opportunity for N leaching below the 60cm sample depth for the early (preplant) sample date resulting in lower end of season residual N levels in the surface 60cm when compared to the sidedress date.

Table 1. Soil nutrient test results for IPNI Elora ON CA site in spring 2009.

Nutrient Test	Apr-09	May-09
pH	7.7	7.7
Total salts (mmhos/cm)	0.315	n.a.
OM ()%	4.5	4.1
P (ppm)	13.3	19.0
K (ppm)	71.3	82.3
Mg (ppm)	407	399
Ca (ppm)	3711	3673
Zn (ppm)	1.2	1.4
Zn Index	15.5	16.3
Mn (ppm)	11.7	14.5
Mn Index	17.6	17.9
Cu (ppm)	0.95	0.88
Fe (ppm)	18.8	21.2
B (ppm)	0.58	0.61
Cation Exchange	23.3	23.1
K Base Saturation (%)	0.78	0.90
Mg Base Saturation (%)	14.53	14.38
Ca Base Saturation (%)	79.58	79.50
H Base Saturation (%)	5.13	5.18
K/Mg Ratio	0.18	0.20
CEC from OM (%)	62.18	55.41

Table 2. Summary of corn yield response equations to preplant and sidedress applied fertilizer N and estimated corn yield and economic returns associated with following Ontario General and Soil NO3-N test recommendations at Elora (2009).

Parameter	Unit	Early (Preplant)	Late (Sidedress)
Regression (Pr>F)			
C.V.	%	4.7	4.3
Model	Pr>F	<0.0001	<0.0001
Intercept		5351	4977
Linear		41.7	52.1
Quadratic		-0.106	-0.142
Max N	kg-N/ha	197	184
Plateau Yield	kg/ha	9460	9760
Maximum Economic N Rate	kg-N/ha	168	162
Maximum Economic Yield	kg/ha	9370	9690
Net Return+	$/ha	325	399
OMAFRA Recommendations			x
N Rate	kg-N/ha	146	123
Yield	kg/ha	9190	9240
Net Return+	$/ha	317	364
Loss++	$/ha	-8	-35
Soil N Test			
N Rate	kg-N/ha	124	130
Yield	kg/ha	8890	9350
Net Return+	$/ha	291	375
Loss++	$/ha	-34	-24

+ Net return is calculated as the value of the yield ($161/Mg, $4.10/bu) increase associated with applying fertilizer N in excess of the 30 kg-N/ha starter rate less the cost of the nitrogen fertilizer ($1.00/kg-N, $0.45/lb-N).

++ Loss represents an estimate of the reduction in profit associated with applying recommended rates instead of the maximum economic rate of N.

Table 3. Application timing and rate of fertilizer N effect on days required to reach 50% silking, harvest grain moisture, and final yields at Elora in 2009.

Treatment N Rate	50% Silking days	Harvest Moisture %	Grain Yield (@ 15.5%) Mg/ha	Harvest Index %	Total Biomass+ Mg/ha	Stover Biomass++ Mg/ha
30 kg-N/ha	88.9	30.9	6.50	49.3	11.11	4.57
58 kg-N/ha	88.6	30.8	7.58	50.2	12.78	5.08
85 kg-N/ha	88.3	30.3	8.29	51.4	13.64	5.21
145 kg-N/ha	88.4	31.2	8.96	51.6	14.66	5.49
218 kg-N/ha	88.1	31.5	9.38	50.5	15.69	6.03
260 kg-N/ha	87.9	32.1	9.26	50.3	15.56	6.00
Std. Error	0.40	0.32	0.159	0.49	0.329	0.146
LSD (5% level)	1.1	0.8	0.44	1.4	0.81	0.35
Timing						
Preplant	88.4	30.9	8.46	50.3	13.90	5.43
Sidedress	88.3	31.0	8.61	50.8	13.91	5.36
Std. Error	0.23	0.17	0.062	0.28	0.291	0.133
LSD (5% level)	ns	ns	ns	Ns	ns	ns

+ Total biomass yields (at 0% moisture content) were calculated by dividing grain yield at 0% moisture by the harvest index expressed as a proportion (50% expressed as a proportion is 0.5).
++ Stover yields at 0% moisture were estimated by subtracting estimate of total ear yield at 0% moisture from the total dry biomass yield. Therefore, Stover yields do not include cobs.

Table 4. Application timing and rate of fertilizer N effect on concentration and total content of N in grain and Stover at Elora (2009).

	Grain N		Stover N+		Total N
Treatment N Rate	**Concentration %**	**Content kg-N/ha**	**Concentration %**	**Content kg-N/ha**	**Content kg-N/ha**
30 kg-N/ha	0.87	48.7	0.68	31.4	80.1
58 kg-N/ha	1.00	64.4	0.73	37.3	101.7
85 kg-N/ha	1.09	76.5	0.78	40.4	116.9
145 kg-N/ha	1.21	92.3	0.90	49.2	141.4
218 kg-N/ha	1.40	110.9	1.02	61.4	172.3
260 kg-N/ha	1.37	107.5	1.04	62.6	170.1
Std. Error	0.034	3.74	0.047	3.29	6.33
LSD (5% level)	0.09	9.2	0.12	8.2	15.1
Timing					
Preplant	1.15	81.9	0.85	46.8	128.7
Sidedress	1.17	84.8	0.86	47.3	132.1
Std. Error	0.026	3.07	0.033	2.33	4.99
LSD (5% level)	ns	ns	ns	ns	ns

+ Stover N concentration and content includes all above ground plant parts except grain and cobs.

Table 5. Application timing and rate of fertilizer N effect on end of season residual soil mineral N in the surface 60cm at Elora (2009).

	Timing	
N Rate	**Early (Preplant)**	**Late (Sidedress)**
	kg-N/ha	
30 kg-N/ha	38+	41
58 kg-N/ha	41	41
85 kg-N/ha	33	40
145 kg-N/ha	43	48
218 kg-N/ha	48	83
260 kg-N/ha	62	109
Std. Error	7.8	
LSD (5% level)	21	

+ Soil mineral N content was calculated by multiplying the total mineral soil N concentration (NO3-N+NH4-N) by 8 to obtain an estimate in kg-N/ha units.

Figure 1. Grain corn yield response to sidedress applied fertilizer N at Elora 2009. Maximum Economic N Rate estimate is based on a Nitrogen:Corn price ratio of 6.1 ($4.10/bu corn, $0.45/lb-N nitrogen).