Project title: Long-term effect of nitrogen rates on corn – 2011 Interim Report

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Date: January 4, 2011

Executive Summary

This report summarizes results from year 3 of a 10 year field trial designed to evaluate the long-term effect of timing and rate of fertilizer N on grain corn yield and associated economics. The trial also evaluates the long-term impact of duration (over years) of various fertilizer N rates on corn yield potential, natural N supply and soil organic matter levels. The 2011 growing season represented the third year that the various N rate treatments were imposed on this trial. Economic estimates presented in this summary are based on a grain corn price of $220/Mg ($5.60/bu) and N cost of $1.54/kg-N ($0.70/lb-N) (Nitrogen:Corn price ratio of 7).

Fertilizer N rate history (uniform 145 kg-N/ha applied the previous year or the same fertilizer N rate applied starting in 2009) had small and inconsistent effects on corn response to the various fertilizer N rates applied. This may suggest that short-term history of less than adequate fertilizer N application does not substantially affect current year's corn fertilizer N requirements in Ontario.

Maximum economic rate of nitrogen (MERN) in 2011 was about 25 kg-N/ha (12%) less when applied sidedress 1 month after planting compared to when N was applied on the day of planting. Maximum economic rate of N in 2011 was estimated at 205 kg-N/ha with a grain yield of 11.0 Mg/ha when applied on the day of planting and 180 kg-N/ha with a yield of 10.8 Mg/ha when applied sidedress 1 month after planting. In 2010, applying N sidedress reduced MERN by 20% (Planting MERN was 226 kg-N/ha and sidedress MERN was 181 kg-N/ha). In 2009, application timing had small effects on MERN, averaging about 165 kg-N/ha. For each of the 3 years of this study, applying MERN produced yields that were 99% of the non-N limited yields.

Timing of N application had small effects on grain yield increase per unit of N applied between the starter and maximum economic rates of N in 2011, averaging 29 kg-grain/kg-N. In 2010, timing of N application affected grain yield increase per unit of N applied between the starter and maximum economic rates which were 28 kg-grain/kg-N when applied close to the day of planting and 33 kg-grain/kg-N when applied sidedress 1 month after planting. Timing of N application had minimal effect on grain yield increase per unit of N applied in 2009, averaging 23 kg-grain/kg-N between the starter and maximum economic N rates.

Applying 115 kg-N/ha over the starter rate increased total above-ground corn N uptake by 70 kg-N/ha in 2011 with an apparent fertilizer N recovery of 61%. Applying 115 kg-N/ha over the starter rate was associated with fertilizer N recoveries of 59% in 2010 and 53% in 2009. Similarly, applying 188 kg-N/ha over the starter rate increased total above-ground N uptake by 106 kg-N/ha in 2011 with an apparent fertilizer N recovery of 56%. Fertilizer N recoveries associated with applying 188 kg-N/ha over the starter rate were 50% in 2010 and 49% in 2009.

Fertilizer N requirements in 2011 were about 60 kg-N/ha higher than Ontario's general N recommendations based on a 10 Mg/ha yield goal for a silt-loam soil in a 2650 CHU area following grain corn. Similarly, fertilizer N rates recommended by the soil N test were about 65 kg-N/ha less than required to produce maximum economic yields in 2011. Similar under predictions were observed in 2010. Applying recommended N rates in 2011 would have resulted in significant economic losses estimated at about $105/ha to $135/ha. When more years of data are available from this site, attempts to correlate fertilizer N requirements to weather events will be made to determine if recommendation models can be improved based on known, and perhaps, anticipated weather events or trends.

Introduction and Description of Production Practices

A long-term trial was initiated at the Elora Research Station (Elora ON CA) in 2008 to evaluate the effect that duration (over years), timing of application (close to date of planting or sidedress about 1 month after planting) and rate of nitrogen fertilizer has on long-term corn productivity and associated economics. The actual N fertilizer treatments were first imposed in 2009, so 2011 results represent the third year of corn response to the various N fertilizer treatments. The fertilizer N treatments were duplicated so that the same application rate and timing combination is applied on some plots continuously for the entire duration of the trial and on other plots the fertilizer N rate treatments are applied on plots which received a uniform 145 kg-N/ha rate the previous year. Comparison of the continuous fertilizer N treatments to those imposed on plots with uniform 145 kg-N/ha application the previous year will enable the evaluation of long-term effects of various fertilizer N application rates and timings on organic matter levels, natural N supply and corn yield response. Continuous fertilizer N treatments (including the continuous starter N only treatments) received the same fertilizer N rate for the third consecutive year in 2011.

2011 production practices:

Previous Crop: Grain Corn

Tillage: Fall Moldboard plow with spring secondary tillage (switched from Fall Chisel plow used in 2009 and 2010 production years)

Corn: Pioneer 38B14 planted in 0.76 m rows on May 12 at 79,000 seeds/ha

Fertility: On May 10, 46 kg-P_2O_5/ha as 0-46-0 and 60 kg-K_2O/ha as 0-0-60 was broadcast applied and incorporated just prior to planting using a field cultivator.

Starter 200 kg/ha of 15-15-15-2Zn starter was banded through planter 5 cm beside, 5 cm below seeding depth (Nutrient rates of 30 kg/ha of N, P2O5 and K2O plus 4 kg-Zn/ha).

Early application timing (planting) of fertilizer N was banded mid-row as UAN on May 12 at treatment related rates of 0, 28, 57, 115, 188, and 230 kg-N/ha.

The late application timing (sidedress) was June 15 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 last taken on April 15, 2010. The results are presented in Table 1. At this time the site had soil test P and K levels that were in the "moderately responsive" range and efforts will continue in 2012 to increase P and K fertility at this site.

Soil ammonium and nitrate concentrations in the surface 30cm for the May 12 and June 14 sample dates were not affected by the length of time (duration) that fertilizer N treatments had been imposed (data not shown). Site average spring soil NO_3-N concentration in the surface 30cm for the planting sample date (May 12) averaged 7.0ppm (Standard Error=0.12, Sample Number=38) and for the sidedress sample date (June 14) soil nitrate-N concentration averaged 11.3 ppm (Standard Error=0.42, Sample Number=40). Soil NO_3-N test recommendations for Ontario are 138 kg-N/ha preplant based on the planting sample and 116 kg-N/ha sidedress based on the sidedress sample. The 2011 planting soil NO_3-N concentrations, and associated preplant soil NO_3-N Test recommendations, were similar to those observed for 2009 and 2010. However, the 2011 sidedress soil NO_3-N concentrations were higher than observed for earlier years,

resulting in a sidedress fertilizer N recommendation in 2011 that was about 20 kg-N/ha lower than earlier years.

Grain Corn Yield and Economic Response to Fertilizer N

Ontario Corn general N recommendations for this site following grain corn with a 10 Mg/ha expected yield and a Nitrogen:Corn price ratio of 7 are 143 kg-N/ha preplant and 120 kg-N/ha sidedress. Economic estimates presented in this summary are based on a Nitrogen:Corn price ratio of 7 with a corn price of $220/tonne ($5.60/bu) and fertilizer N cost of $1.54/kg-N ($0.70/lb-N).

Four yield response equations to applied fertilizer N were initially fitted to the 2011 grain corn yield data which were based on fertilizer N application timing (planting or sidedress) and previous year fertilizer N rate (uniform 145 kg-N/ha rate applied in 2010 or continuous application of the same rate over years).

Previous year fertilizer N rate history had minimal effects on grain corn yield response to fertilizer N rates applied in 2011. The impact that fertilizer N history had on grain corn yield response to various N rates applied at planting is shown in Figure 1 and at sidedress is shown in Figure 2. Fertilizer N rate history effects on grain corn yields were inconsistent when fertilizer N was applied at planting (Fig. 1) and generally small when fertilizer N was applied sidedress (Fig. 2). Previous year N history also had small effect on grain corn yields in 2010. Over time, continuous applications of less than adequate fertilizer N rates may reduce grain corn yield because of reduced residual (carry over) N and/or readily mineralizable organic N. The lack of consistent and significant yield reductions associated with continuous application of less than adequate fertilizer N rates at this trial in 2010 and 2011 suggest that shorter-term (1-2 years) of less than adequate N fertility probably has minimal impact on subsequent corn grain yield potential in Ontario. Since fertilizer N history did not consistently affect grain corn yields, even for lower rates of fertilizer N application, discussion of 2011 grain corn yield response to fertilizer N rates and application timing will be based on development of regression equations using yield data pooled across fertilizer N application history.

The non-N limited (plateau) planting fertilizer N rate in 2011 was 233 kg-N/ha producing grain corn yield of 11.1 Mg/ha (Table 2; Fig. 1). Maximum Economic Rate of Nitrogen (MERN) at price ratio 7 when applied at planting was estimated at 205 kg-N/ha and Maximum Economic Yields (MEY) were 11.0 Mg/ha (99% of the non-N limited (plateau) yields). In 2010 planting MERN was 226 kg-N/ha and MEY was 11.0 Mg/ha. In 2009 planting MERN was 165 kg-N/ha and MEY was 9.3 MG/ha. As in 2011, MEY associated with planting N application in 2009 and 2010 was 99% of the plateau yield.

Sidedress fertilizer N rates required to reach plateau (non-N) limited, and maximum economic, yields were about 12% lower compared to fertilizer N applied at planting (Table 2). Both timings of fertilizer N application produced similar plateau and maximum economic grain corn yields in 2011. In 2010 estimated MERN for sidedress N was 20% less than when N was applied near planting with both application timings producing similar MEY. In 2009 application timing did not affect estimated MERN or MEY.

In 2011 timing of fertilizer N application did not affect the rate of grain yield increase per unit of applied fertilizer N between the starter rate (30 kg-N/ha) and MERN, which averaged 29 kg-grain/kg-N. Application timing had greater effects on grain yield increase per kg-N applied in 2010 which was 28 kg-grain/kg-N for Planting and 33 kg-grain/kg-N for sidedress. In 2009,

planting and sidedress effects on grain yield increase per kg-N applied were small, averaging 23 kg-grain/kg-N. The average rate of grain yield increase was calculated by determining the estimated yield response between the starter N rate (30 kg-N/ha) and MERN and then dividing by the amount of fertilizer N required over the starter rate to obtain MERN.

Applying fertilizer N increased corn yields in 2011 by 5.0 Mg/ha when applied at planting and 4.4 Mg/ha when applied sidedress (Table 2). Net returns to applying fertilizer N, over the starter rate, is estimated at $839/ha when applied at planting and $737/ha when applied sidedress. Similar results were observed in 2010 with maximum economic yield increased by 5.5 Mg/ha with a return of $908/ha for N applied near planting and maximum economic yield increased by 5.1 Mg/ha with a return of $888/ha) for N applied sidedress. Economic yield increases were smaller and not affected by application timing in 2009 with an average yield increase of 2.8Mg/ha and return of $429/ha.

Both the preplant and sidedress OMAFRA N recommendations based on a 10 Mg/ha yield goal using a nitrogen:corn price ratio of 7 were about 60 kg-N/ha less than calculated MERN for 2011 with an estimated loss of potential yield of about 1.0 Mg/ha (9%) and a loss of potential return of about $105 - $117/ha (Table 2). In 2010 general recommendations were 83 kg-N/ha less than required for preplant and 63 kg-N/ha for sidedress with estimated losses of potential yield of 1.2 Mg/ha and returns of $155/ha. In 2009 general fertilizer preplant N recommendation was essentially the same as the planting MERN estimate and the OMAFRA general fertilizer sidedress N recommendation was 39 kg-N/ha less than the sidedress mern with an estimated loss in potential yield of 0.4 Mg/ha (5%) and returns of $38/ha.

Higher than expected yields can partially explain under recommendation of N in 2011, but even when 2011 yields are used to develop general recommendations the estimated losses are $67/ha for Planting and $86/ha for sidedress.

Ontario soil NO_3-N test recommendations also were less than the estimated MERN for 2011, with both the preplant and sidedress test essentially having a similar under prediction of about 65 kg-N/ha with an estimated yield reduction of about 1.1 Mg/ha (10%) and loss of potential returns of about $120/ha to $134/ha (Table 2).

The soil nitrate-N test recommendations in 2011 were similar to 2010 and 2009; and in all three years the soil N test under predicted corn fertilizer N requirements and provided a recommendation that was substantially less than actual N requirements. Failure of the soil nitrate-N test to recommend appropriate fertilizer N rates may suggest that the site may have lower than average capacity to supply natural N and(or) the soil N test is not correctly calibrated.

Impact on Timing and Rate of Fertilizer N on Corn Development, Yield and N Uptake

This section utilizes 2 statistical analyses because of an imbalance in fertilizer N treatments. The trial does contain a balanced assortment of N fertilizer treatments consisting of 1) 5 total N rates (30, 58, 87, 145 and 218 kg-N/ha); 2) 2 application dates (close to when corn was planted or sidedress 1 month after corn planting) and 3) 2 fertilizer N application histories (uniform N application of 145 kg-N/ha the previous year or where the same N rate has been applied continuously starting in 2009). This analysis was used to identify the impact that timing of N application and fertilizer N history has on corn response to the various fertilizer N rates. There also was a continuously applied 260 kg-N/ha rate which was applied close to corn planting or sidedress. Comparisons between the continuously applied 218 and 260 kg-N/ha rates were included in summary tables to evaluate the potential corn response to N rates exceeding 218 kg-

N/ha with significance of corn response to applying 260 kg-N/ha based on a statistical analysis that only included the continuously applied N treatments.

Corn development, yield and N uptake response to rate of fertilizer N application in 2011 was not affected by either Timing (Planting vs. sidedress) or previous N application history (Uniform 145 kg-N/ha in 2010 vs. 3 years of the same fertilizer N rate). This also was observed in 2010. The continuous N treatments in 2011 were imposed for only 3 years and it is anticipated that continuous application of the same fertilizer rates for an extended period of time will result in differences in corn response when compared to where relatively uniform rates of N were applied over the same time period. Since corn development, yield and N uptake response to fertilizer N rate was not affected by timing or history of fertilizer N application in 2011, only overall average effects of N history, application timing and total N rates will be summarized in this progress report for 2011.

Corn development (days to 50% silking, harvest grain moisture) and final biomass (Grain, stover, total above ground and harvest index) were not affected by timing of fertilizer N application or fertilizer N history (Table 3). A similar response was observed in 2010.

Increasing N rate reduced the number of days required for 50% silking (Table 3). When 87 - 218 kg-N/ha of fertilizer N was applied, corn silking occurred about 2 days earlier than where only starter N was applied. Applying 260 kg-N/ha did not significantly change the day requirement for 50% silking when compared to where 218 kg-N/ha was applied continuously. Fertilizer N rate effects on days required for 50% silking observed in 2011 were similar to those observed in 2010.

Applying N rates over 200 kg-N/ha was associated with harvest moisture content that was about 1% higher than when fertilizer N rates were less than 90 kg-N/ha (Table 3). Similarly, the continuous 260 kg-N/ha rate was associated with higher harvest grain moisture compared to the 218 kg-N/ha rate.

Grain yield, total corn biomass and stover biomass responded to increasing fertilizer N rates with the 218 kg-N/ha rate generally producing greater corn biomass and grain yield than the lower N rates (Table 3). Harvest index, the percentage of total corn plant biomass which is grain, also increased as total N rate increased with the highest harvest indices' associated with the 145 and 218 kg-N/ha rate. Again, corn biomass and yield responses to fertilizer N rates observed in 2011 were very similar to those observed in 2010. 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.

Applying 260 kg-N/ha increased grain corn yield by 0.68 Mg/ha (6%), stover yield by 0.54 Mg/ha (10%) and total above ground biomass by 1.18 Mg/ha (7%) over where 218 kg-N/ha was applied continuously (Table 3). In earlier years applying 260 kg-N/ha did not increase corn biomass and yield when compared to the 218 kg-N/ha rate.

Both nitrogen concentration and uptake associated with corn grain and stover was not affected by timing of fertilizer N application or N rate history (table 4). Again, 2011 responses were similar to those observed in 2010.

Grain and Stover N concentration in 2011 steadily increased, as fertilizer N rate increased from the starter rate (30 kg-N/ha) to 218 kg-N/ha (Table 4). Applying 218 kg-N/ha increased grain N

concentration by a factor of about 1.7 and stover N concentration by a factor of about 1.4 over where just the 30 kg-N/ha starter rate was applied. Applying 260 kg-N/ha was associated with slight increases of stover and grain N concentration when compared to where 218 kg-N/ha was applied continuously (not statistically significant at 5% level) (Table 4). The effect of fertilizer N rate on stover and grain N concentration observed in 2011 were similar to those observed in 2010.

Total corn nitrogen content, which represents total N uptake in the above ground portion of the plant, was increased by a factor of about 2.5 at the 218 kg-N/ha rate when compared to the starter only (30 kg-N/ha) rate (Table 4). Grain N content, which represents N removal, increased by a factor of about 2.9 for the 218 kg-N/ha rate when compared to the starter only rate. Stover N content, which represents the amount of N remaining in the corn residue after harvest, increased by a factor of about 1.8 for the 218 kg-N/ha rate when compared to the starter only rate. Applying 260 kg-N/ha increased stover N uptake by 8 kg-N/ha (18%, grain N Uptake by 15 kg-N/ha (12%) and total N uptake by 23 kg-N/ha (13%) over where 218 kg-N/ha was applied continuously (Table 4). Increases in corn N uptake associated with the 260 kg-N/ha rate, compared to 218 kg-N/ha, was about 4 times higher in 2011 compared to 2010.

Applying recommended fertilizer N rate (145 kg-N/ha) increased total N content (Grain & Stover) by about 70 kg-N/ha with an apparent fertilizer N recovery of about 61% for the 115 kg-N/ha that was applied in addition to the starter N. For earlier years, applying 115 kg-N/ha over the 30 kg-N/ha starter rate increased total N uptake by 68 kg-N/ha (apparent fertilizer N recovery of 59%) in 2010 and 60 kg-N/ha (apparent fertilizer N recovery of about 53) in 2009%. The 218 kg-N/rate in 2011 total N uptake was increased by 106 kg-N/ha over the starter rate of 30 kg-N/ha with an apparent fertilizer N recovery of 56%. For earlier years, applying 188 kg-N/ha of fertilizer N over the 30 kg-N/ha starter, increased total N uptake by 94 kg-N/ha (apparent fertilizer N recovery of 50%) in 2010 and 90 kg-N/ha (apparent fertilizer N recovery of 49%) in 2009.

Late Season Soil N.

Soil mineral N content in the surface 30 cm measured shortly following black layering of corn (early October) was not affected by fertilizer N application history, application timing or rate of N applied (Table 5). The soil mineral N levels were low in early October of 2011, ranging between 32 to 38 kg-N/ha for the various N rates applied. Lack of differences in soil mineral N content associated with the various fertilizer N rates in 2011 is likely due to relatively high fertilizer N demand by corn at this site in 2011 as indicated by the estimated MERN of 205 for N applied at planting and 180 kg-N/ha for N applied sidedress. Also, this site received a total of 80 mm of rain during the 4 week period prior to taking soil samples in early October and the low soil mineral N contents could also be partially due to NO_3 leaching into soil depths below 30 cm.

Table 1. Surface 15 cm soil nutrient test results for the IPNI long-term nitrogen response trial located near Elora ON CA which was last sampled on April 15, 2010.

Nutrient Test	Nutrient Value
pH	7.6
P (ppm)	13.8
K (ppm)	82
Mg (ppm)	417
K/Mg Ratio	0.2

Table 2. Summary of corn yield response equations for planting and sidedress fertilizer N applied at a long-term fertilizer N rate trial located at Elora (2011). Summary includes estimates of net returns and losses associated with applying fertilizer N rates based on Ontario general recommendations and the soil nitrate-N test.

Parameter	Unit	Planting	Sidedress
Response Equations			
Intercept	kg/ha	4301	4747
Linear		58.0	60.3
Quadratic		-0.1245	-0.1478
Model C.V.	%	6.5	6.7
Maximum N	kg-N/ha	233	204
Plateau Yield	Mg/ha	11.1	10.9
Maximum Economic N Rate	kg-N/ha	205	180
Maximum Economic Yield	Mg/ha	11.0	10.8
Net Return	$/ha	838.69	737.20
General Recommendations			
Recommended N Rate	kg-N/ha	143	120
Estimated Yield	Mg/ha	10.0	9.9
Estimated Net Return	$/ha	733.94	619.96
Estimated Loss	$/ha	-104.75	-117.24
Nitrate-N Test Recommendations			
Recommended N Rate	kg-N/ha	138	116
Estimated Yield	Mg/ha	9.9	9.8
Estimated Net Return	$/ha	715.60	603.30
Estimated Loss	$/ha	-123.09	-133.89

+ Estimated net return is calculated as the value of the yield ($220/Mg, $5.60/bu) increase associated with applying fertilizer N in excess of the 30 kg-N/ha starter rate less the cost of the nitrogen fertilizer ($1.54/kg-N, $0.70/lb-N).

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

Table 3. Fertilizer nitrogen application history, timing and rate effects on days required to reach 50% silking, harvest grain moisture, and final yields at Elora (2011).

Group	50%	Grain	Grain	Harvest	Total	Stover
Treatment	Silking	Moisture	Yield -Mg/ha @	Index+	Biomass Mg/ha @	Biomass++ Mg/ha @
History	- Days -	- % -	15.5% -	- % -	0% -	0% -
Continuous	75.8	24.1	8.64	53.7	13.56	4.66
Uniform	76.2	24.1	8.73	54.1	13.57	4.60
Se	0.23	0.09	0.096	0.29	0.176	0.083
LSD(P=0.05)+++	ns	ns	ns	ns	ns	ns
Timing						
Planting	75.9	24.1	8.59	53.9	13.41	4.59
Sidedress	76.1	24.1	8.77	53.8	13.73	4.67
Se	0.23	0.11	0.096	0.30	0.176	0.083
LSD(P=0.05)+++	ns	ns	ns	ns	ns	ns
N Rate						
30 kg-N/ha	77.4	23.8	6.29	51.8	10.26	3.82
58 kg-N/ha	76.6	23.8	7.40	52.6	11.94	4.32
87 kg-N/ha	75.1	23.8	8.70	54.1	13.60	4.70
145 kg-N/ha	75.6	24.2	10.19	55.6	15.50	5.00
218 kg-N/ha	75.3	24.9	10.82	55.4	16.54	5.31
Se	0.37	0.11	0.152	0.44	0.279	0.131
LSD(P=0.05)+++	1.0	0.3	0.43	1.2	0.79	0.37
Continuous N Rate++++						
218 kg-N/ha	75.1	25.1	10.63	54.5	16.52	5.42
260 kg-N/ha	74.9	25.5	11.31	54.0	17.70	5.95
Se	0.53	0.15	0.238	0.64	0.422	0.196
LSD(P=0.05)+++	ns	0.4	0.64	ns	1.09	0.51

+ 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.

+++ Least Significant Difference at the 5% level of probability. The symbol ns indicates that differences were not significant.

++++ Comparison of the 218 and 260 kg-N/ha N rates which were applied continuously for the third year in 2011 averaged over Planting and sidedress application timing.

Table 4. Fertilizer nitrogen application history, timing and rate effects on concentration and total content of N in grain and Stover at Elora (2011).

	Stover[+] N		[Grain] N		Total N
Group					
Treatment	Concentration	Content - kg-	Concentration	Content - kg-	Content - kg-
History	- % -	N/ha -	- % -	N/ha -	N/ha -
Continuous	0.66	31	1.12	85	116
Uniform	0.65	30	1.11	85	113
Se	0.021	1.0	0.017	1.6	2.1
LSD(P=0.05)++	ns	ns	ns	ns	ns
Timing					
Planting	0.67	30	1.10	83	112
Sidedress	0.65	31	1.14	87	118
Se	0.021	1.0	0.018	1.7	2.4
LSD(P=0.05)++	ns	ns	ns	ns	ns
N Rate					
30 kg-N/ha	0.58	22	0.89	47	70
58 kg-N/ha	0.62	27	0.94	59	86
87 kg-N/ha	0.63	29	1.03	76	103
145 kg-N/ha	0.67	33	1.24	107	140
218 kg-N/ha	0.79	41	1.49	137	175
Se	0.027	1.4	0.024	2.5	3.0
LSD(P=0.05)++	0.06	3	0.06	7	8
Continuous N Rate+++					
218 kg-N/ha	0.78	42	1.54	138	180
260 kg-N/ha	0.83	50	1.61	153	203
Se	0.034	2.3	0.032	3.4	5.0
LSD(P=0.05)++	ns	5	ns	10	14

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

++ Least Significant Difference at the 5% level of probability. The symbol ns indicates that differences were not significant.

+++ Comparison of the 218 and 260 kg-N/ha N rates which were applied continuously for the third year in 2011 averaged over Planting and sidedress application timing.

Table 5. Fertilizer nitrogen application history, timing and rate effects on total soil mineral N content in the surface 30cm shortly after corn black layer at Elora (early October, 2011).

Group

Treatment	Mineral N^+
History	- kg-N/ha -
Continuous	34
Uniform	35
Se	3.6
LSD(P=0.05)++	ns
Timing	
Planting	34
Sidedress	35
Se	3.6
LSD(P=0.05)++	ns
N Rate	
30 kg-N/ha	38
58 kg-N/ha	35
87 kg-N/ha	35
145 kg-N/ha	32
218 kg-N/ha	33
Se	3.9
LSD(P=0.05)++	Ns
Continuous N Rate+++	
218 kg-N/ha	32
260 kg-N/ha	34
Se	3.7
LSD(P=0.05)++	ns

+ Soil mineral N content was calculated by multiplying the total mineral soil N concentration (NO3-N+NH4-N) by 4 to obtain an estimate in kg-N/ha units.

++ Least Significant Difference at the 5% level of probability. The symbol ns indicates that differences were not significant.

+++ Comparison of the 218 and 260 kg-N/ha N rates which were applied continuously for the third year in 2011 averaged over Planting and sidedress application timing.

Figure 1. Grain corn yield response to fertilizer N applied at planting where the previous year's fertilizer N rate was either uniform at 145 kg-N/ha or the same fertilizer N rate was applied for the third consecutive year at Elora (2011). Maximum Economic N Rate at a nitrogen:corn price ratio of 7 is estimated at 205 kg-N/ha).

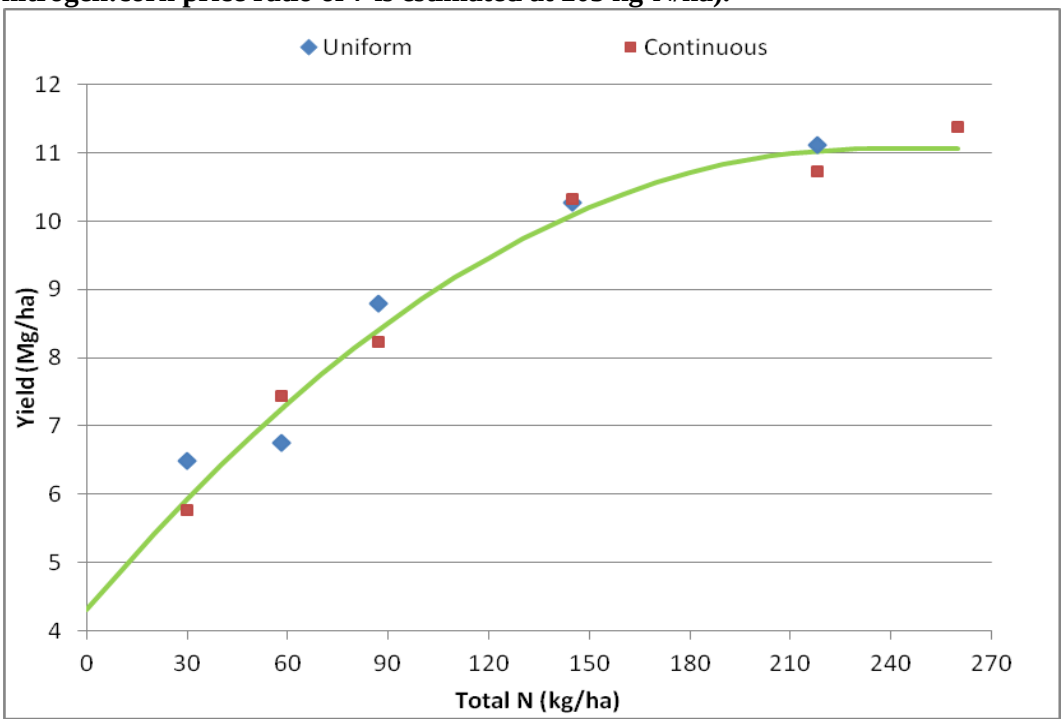

Figure 2. Grain corn yield response to fertilizer N applied sidedress where the previous year's fertilizer N rate was either uniform at 145 kg-N/ha or the same fertilizer N rate was applied for the third consecutive year at Elora (2011). Maximum Economic N Rate at a nitrogen:corn price ratio of 7 is estimated at 180 kg-N/ha).