General Nitrogen Recommendations for Corn

Purpose:

This project was designed to improve the precision of nitrogen recommendations for Ontario corn growers, improving the economic returns from growing corn and reducing the environmental impact from over-application of nitrogen

Methods:

The Ontario Corn N Database was developed by collecting where ever possible, the original data from nitrogen response trials in corn spanning the 41 year period from 1962-2002. The complete dataset included 1631 site-years of data from 448 unique experimental sites. Out of this total, 1024 experiments included three or more rates of nitrogen, so the data could be used to calculate a value for the Maximum Economic Rate of Nitrogen (MERN).

Figure 1.

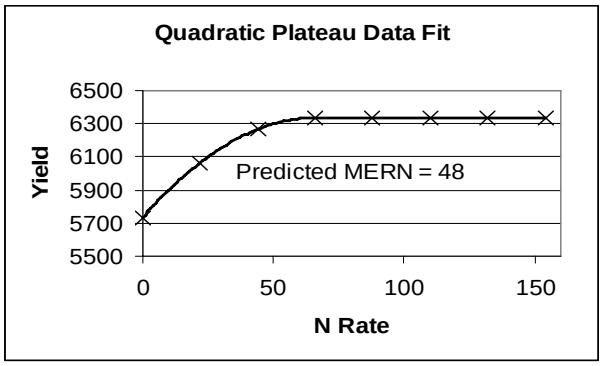
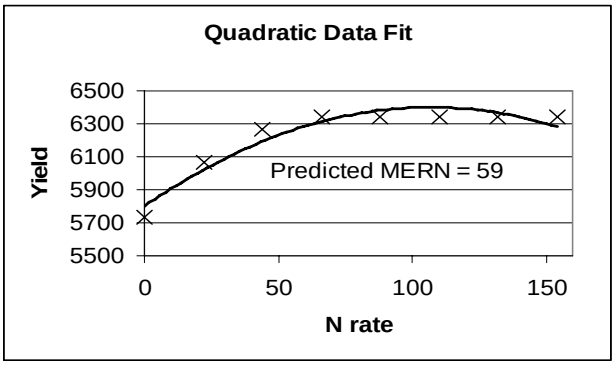


Figure 2.



MERN's were calculated for each experiment by fitting the data to a Quadratic-Plateau equation (Figure 1.). This resulted in a better fit to the data than a quadratic equation (Figure 2.), and predicted a somewhat lower MERN value, particularly on sites with relatively low response to nitrogen. The comparison between the two methods on a sample data set can be seen in the graphs above. MERN's obtained from this process were compared to the characteristics of each site, and the factors that had a significant influence on the nitrogen requirement of corn were determined. These were then assembled into a worksheet for predicting the N requirement for individual fields in Ontario based on these factors.

Results:

Of the 1024 observations with enough data to fit to an equation, 6.2% showed no response to added N, and a further 5.6% showed no economic response to N above the lowest rate applied in the trial. Significant factors in determining yield response to N included soil type, yield, previous crop, tillage (for red clover plowdown, only), Crop Heat Unit (CHU) rating, fertilizer:corn price ratio, and application timing. Factors that were considered, but did not have a significant influence on N requirements, were fertilizer type, tillage system (except for clover), soil organic matter, and hybrid.

Significant factors were assembled into the following worksheet:

Summary:

The new general nitrogen recommendations for corn provide a powerful tool for farmers to fine-tune their nitrogen rates to maximize profitability, and to minimize environmental impacts. These recommendations are also available in the form of a calculator, to do the math automatically.

Next Steps:

The data available did not allow a complete assessment of the relationship between soil nitrate levels, and N recommendations according to the factors in the worksheet. This will require further analysis of the database numbers, as well as additional field work.

Sites that had received livestock manure were excluded from the database that generated the N Recommendation Worksheet for Corn. Work is underway to review the data regarding the availability of nitrogen from manure application. As information from this project becomes available, it will be incorporated into the N recommendations for corn.

Acknowledgements:

This project would not have been possible without the willing participation of numerous researchers at the University of Guelph, Ridgetown College, Kemptville College, and Agriculture and Agri-Food Canada, as well as OMAFRA staff, who shared their plot results. Particular credit has to be given to Ken Janovicek, of the Department of Plant Agriculture, who is responsible for the lion's share of the data collection, analysis and interpretation.

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General Recommended Nitrogen Rates for Corn: Corn N Worksheet (Imperial)

A. Base N Requirement. (choose from Table A)	= ___ A
B. Yield Adjustment. (Yield (bu/ac) _____ X 0.77) =	+ ___ B
C. Heat Unit Adjustment. Your CHU's = _____ Less - 2650 Total = _____ x 0.037 = _____ →	+/- ___ C
D. Previous Crop Adjustment. (Choose from Table D)	- ___ D
E. Price Ratio (PR) Adjustment. (for nitrogen price relative to corn price; choose from Table E)	- ___ E
F. Total N recommendation (F = A+B+C-D-E)	= ___ F (lbs N/ac)
G. Deduct Starter N (lbs N/ac)	- ___ G
H. Deduct Manure N Credits[1] (lbs N/ac)	- ___ H
I. Preplant Additional N (I = F-G-H)	= ___ I (lbs N/ac)
OR	
J. If applying N as Sidedress J =_____(I) x _____ adjustment value from Table J.	= ___ J (lbs N/ac)

[1]Manure N Credits can be found in the Soil Management Section of Publication 811, or the Nutrient Management Workbook.

Table J: Timing Adjustment (South Western and Central Ontario only)

Soil Texture	Adjustment
Clay, Clay Loam, Loam, Silt Loam, Silty Clay, Silty Clay Loam	0.8
Sandy Clay, Sandy Clay Loam, Sandy Loam	0.9
Sand, Loamy Sand	1.0

Table A: Base N Requirement

Soil Texture	Base N Requirement	
	South Western and Central Ontario	Eastern Ontario*
Clay, Heavy Clay	47	1
Clay Loam	36	1
Loam	28	1
Loamy Sand	41	17
Sand	46	17
Sandy Clay, Sandy Clay Loam	38	17
Sandy Loam	34	17
Silt Loam	18	1
Silty Clay Loam	32	1
Silty Clay	44	1

*Eastern Ontario includes Frontenac, Renfrew and counties to the east of them

Table D: Previous Crop Adjustments

Previous Crop	Adjustment
Grain Corn	0
Silage Corn	12
Cereals (straw removed)	11
Cereals (staw not removed)	0
Soybeans	27
Edible Beans	27
Clover cover crop (plowed)	73
Clover cover crop (no-till)	60
Perennial Forages	
Less than 1/3 legume	0
1/3 to 1/2 legume	49
Over 1/2 legume	98
Crops Not Listed	0

Table E: Price Ratio (PR) Adjustment

	Nitrogen Price $/lb N				
Corn Price $/bu	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**
	---------- lbs N/ac ----------				
2.50	24	30	37	44	51
2.60	22	28	35	41	48
2.70	20	26	32	38	45
2.80	18	24	30	36	42
2.90	16	22	28	34	40
3.00	15	20	26	32	40
3.10	13	19	24	32	37
3.20	12	17	23	28	33
3.30	11	16	21	26	31
3.40	10	14	19	24	29

Explanation of Factors in Worksheet:

Note: The fertilizer rates calculated in this worksheet are designed to produce highest economic yields when accompanied by good or above average management. Research data show that higher rates will occasionally produce higher yields but that these increases in yield are not likely to be large enough to pay for the extra fertilizer.

A. Base N Requirement

In most of the province, the medium textured soils (silt loams and loams) provided the greatest amount of nitrogen to the corn crop, as indicated by the lower "Base N Requirement" (Table A). In both coarser and finer textured soils, the nitrogen requirements are higher.

The data showed a significantly lower requirement for nitrogen in Ottawa Valley than in the rest of the province, although the reasons for this are not completely clear. This appears to apply in all of the counties east of the Frontenac Axis (Frontenac, Renfrew, and all the counties to the east of them). The "Base N Requirement" in Table A clearly show the lower N requirements in Eastern Ontario soils.

Because these values are derived from the average responses on a wide range of sites, they will represent the expected requirements for soils with "average" characteristics. Any soil that varies widely from the average for a particular texture class (e.g. much higher or much lower organic matter content) may differ in the optimum N rates for that particular field.

B. Yield Adjustment

There is a weak but consistent relationship between fields with higher yields at optimum N rates and higher nitrogen requirements. The yield factor derived from the N response data (0.77 lb N per bushel of yield) is almost exactly equal to the N removal from the field in the grain portion of the crop.

Use average yields for the previous five years to estimate the productive capacity of the field. Entering an inflated yield goal into this adjustment will not increase the productivity of the field, will cost money for wasted N, and may result in environmental harm. To convert silage yield to an estimate of grain yield, divide the silage yield by 5 for grain yield in tonnes/hectare or tons/acre, or multiply tons per acre by 7 to estimate bushels per acre.

C. Heat Unit Adjustment

The data shows that corn in the long season areas of the province require more nitrogen than the short season areas. This may be due to greater moisture stress on the crop in areas with higher average temperatures, which would decrease N use efficiency, or it could be related to differences in soil organic matter content.

D. Previous Crop Adjustment

The crop that was grown immediately prior to planting corn has a significant impact on the nitrogen requirements. Crops like grain corn immobilize a significant quantity of mineral N from the soil as the high carbon residue decomposes, and this is reflected in higher N requirements. Forage legume crops fix nitrogen out of the air, that is released to the corn crop as the residue breaks down, resulting in reduced N requirements.

For simplicity, the N recommendations in this table have been stated relative to the preceding crop with the highest N requirement (grain corn), so all of the adjustments for previous crop are in the form of a credit.

E. Price Ratio Adjustment

The optimum N rate is the point where the yield increase from the last pound of added nitrogen just pays for the extra N. As the cost of nitrogen fertilizer goes up, or the value of the corn crop goes down, the amount of yield required to pay for a pound of nitrogen increases. This means that the nitrogen rate that provides the maximum return to added fertilizer is reduced. The amount of reduction in N rates for various combinations of corn and nitrogen price is found in Table E.
For prices outside of the ranges provided, you can calculate the adjustment to fertilizer rates by following these steps:

1. Determine the price of a kilogram of nitrogen. This can be calculated by dividing the price per tonne that you are paying for fertilizer by the number of kilograms of nitrogen in each tonne (the %N multiplied by ten). The price per pound can be calculated by multiplying the price per kilogram by 0.45. For example, urea (46% N) at $506 per tonne will have an N price per kilogram of $506/460 kg = $1.10/kg N, or $0.50 per pound of N.
2. Estimate the value of a kilogram (or pound) of corn. The corn price will need to be estimated for the year following harvest (unless the corn has been pre-sold at a fixed price), and should include all stabilization payments, minus costs for drying, trucking and elevation. The value of corn to be fed on-farm should be priced at the replacement cost for the corn if it needs to be purchased from off farm. The price for a kilogram of corn is the expected price per tonne, divided by 1000. The price for a pound of corn is the expected net price per bushel divided by 56.
3. Calculate the N:corn price ratio, by dividing the price of a kilogram (or pound) of nitrogen into the value of a kilogram (or pound) of corn.
4. Subtract 5 from the price ratio, because the N recommendations were developed for a price ratio of 5.
5. Multiply the resulting figure by 6 (imperial), or 6.7 (metric), and enter this figure into the price ratio adjustment.

F. Total N Recommendation

This figure, calculated by summing values A through E, represents the total N requirements for the crop. This is normally supplied by a combination of starter fertilizer, broadcast or side-dressed fertilizer, and manure.

G. Deduct Starter N

Any N that is supplied at planting should be included here.

H. Deduct Manure N Credits

Available nitrogen from manure (or biosolids) should be included on this line. The more accurate the estimate of available N from manure, based on accurate application rates and manure analysis, the more confidence you will have in the manure N credits.

I. Preplant Additional N

The difference between the Total N recommendation, and the credits for starter N and manure N, is the amount of nitrogen that will need to be included in a pre-plant broadcast or banded application.

OR

J. Sidedress Additional N

Nitrogen that is applied just before the crop needs it is utilized more efficiently than N applied pre-plant, because there is less opportunity for loss through denitrification or leaching. This difference is most pronounced in the heavier textured soils. Sandy soils do not normally show a benefit to side-dress N applications. NOTE: This adjustment does not apply in Eastern Ontario, where the N recommendations are already relatively low.