Evaluation of different Nitrogen decision guides in fertilizing Corn

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Background and Objectives

Manitoba Agriculture nitrogen rate guidelines for corn were developed before 1990 and are out-of-date for current yield levels. Recently North Dakota State University (NDSU) has released N rate guidelines for corn and a number of in-crop scouting measures can be used to assess sufficiency and need for more N. The following study was initiated with the objective to evaluate a number of N decision guides for suitability in fertilizing corn in Manitoba.

Materials and Methods

These trials were done at five different sites and Diversification Centres staff managed three (Melita, Carberry and Arborg) out of these five sites. Additional sites were at St Adolphe (Kelburn farm) and a farm field north of Morden and were managed by Crops Branch, University of Manitoba staff and Richardson staff.

Different nitrogen treatments (0-200 lb N/acre – Table 4)) were applied as post plant surface broadcast using Super U (46-0-0). To simulate the Y-drop application of side-dress stage N, liquid UAN (28-0-0) was applied at the 6 leaf stage of corn on each side of the corn plant (treatments 7 and 8). Site description and field activities are listed in Tables 1-3.

Table 1. Site cropping history, soil characteristics and 2016 growing conditions.

Site	***Kelburn***	***Carberry***	***Arborg***	***Morden***	***Melita***
Soil type	*Scanterbury clay*	*Ramada clay loam*	*Peguis clay*	*Neuenberg sand loam*	*Ryerson loam*
Previous crop	*Soybean*	*Canola*	*Wheat*	*Potatoes, Rye cover C*	*Wheat*
Soil analysis					
Nitrate-N (lb/ac in 0-24")	*71*	*55*	*106*	*35*	*57*
PSNT nitrate-N (lb/ac in 0-12")	*170*	*74*	*254*	*63*	*95*
Organic Matter (%)	*7.7%*	*4.9%*	*8.6%*	*2.9%*	*4.0%*
P ppm Olsen	*28*	*8*	*47*	*33*	*7*
K ppm	*507*	*225*	*480*	*179*	*341*
pH	*7.1*	*6.0*	*8.0*	*7.8*	*8.0*
May-Sept weather					
Crop heat units (% of normal)	*112*	*109*	*106*	*107*	*108*
Precipitation (inches)	*16.1*	*12.2*	*11.7*	*18.1*	*14.2*
% of normal	*122*	*101*	*93*	*139*	*106*

Table 2. Field Practices.

Site	*Kelburn*	*Carberry*	*Arborg*	*Morden*	*Melita*
Planting Date	*May 13/16*	*17-May*	*20-May*	*04-May*	*13-May*
Hybrid	*DEC 26-28*	*DKC26-28*	*DKC 23-17*	*Pioneer 7958AM*	*DKC 26-28*
Population ('000/ac)	*32*	*32*	*32*	*31*	*32*
Side banded fertilizer					
MAP (lb P_2O_5/acre)	*40*	*54*	*90*	*40*	*40*
Potash (lb K_2O/acre)	*0*	*0*	*0*	*10*	*0*
Weed Control					
Herbicide 1	*post plant Glyphosate and Heat + Merge*	*Glyphosate on 14-Jun*	*Glyphosate on 10-Jun*	*Glyphosate and Heat + Merge on 09-May*	*Glyphosate and Heat + Merge on 21-May*
Herbicide 2	*Glyphosate on June 14*		*Glyphosate on 15-Jul*	*Glyphosate on 10-Jun*	*Maverick on 17-Jun*
Herbicide 3	*Basagran on July 08*			*Glyphosate on 20-Jun*	
Harvest	*11-Oct*	*09-Nov*	*04-Nov*	*04-Oct*	*21-Oct*

Table 3. Treatment applications and crop observations.

Site	*Kelburn*	*Carberry*	*Arborg*	*Morden*	*Melita*
Nitrogen Treatments					
Treatments 1-6	*20-May*	*15-Jun*	*08-Jul*	*09-May*	*13-May*
Treatments 7-8	*27-Jun*	*08-Jul*	*14-Jul*	*27-Jun*	*29-Jun*
Observations					
PSNT	*27-Jun*	*08-Jul*	*14-Jul*	*27-Jun*	*11-Jul*
SPAD	*nd*	*08-Jul*	*14-Jul*	*28-Jun*	*29-Jun*
GreenSeeker1	*27-Jun*	*08-Jul*	*14-Jul*	*28-Jun*	*29-Jun*
GreenSeeker2	*nd*	*18-Jul*	*nd*	*nd*	*20-Jul*
N Deficiency Leaf rating	*03-Aug*	*09-Aug*	*04-Aug*	*28-Jul*	*nd*
Stalk N	*11-Oct*	*nd*	*nd*	*nd*	*03-Oct*

- nd = not determined at this site
- PSNT (pre side dress nitrate-N test) soil sample is taken between the rows to a depth of 12” (values reported in Table 1)
- SPAD chlorophyll readings are taken mid-leaf of the earliest leaf with a developed collar. SPAD values are referenced as an index of those measured at full N rates.
- GreenSeeker readings of NDVI are taken with the pocket GreenSeeker.
- N deficiency ratings are the number of lower corn leaves with visible N deficiency (yellowing of the midrib). The value is the number of deficiency leaves observed in 10 plants.
- Stalk N is the end of season stalk nitrate test as an index of N sufficiency/excess.

Results
Results for each site are reported in Tables 4-8.

Table 4. St. Adolphe corn response to different N treatments.

Treatment (lb N/acre)	NDVI	Visual def.	Moisture (%)	Yield (bu/ac)	Test wt (lb/bu)
1=0N	0.69	9 a	26.8	202	52
2=40N	0.70	7 ab	26.6	201	52
3=80N	0.70	4 bc	26.7	211	51
4=120N	0.68	3 c	27.0	202	51
5=160N	0.69	3 c	26.8	203	52
6=200N	0.71	1 c	26.6	206	51
7=40N+40N	0.70	5 bc	25.8	204	50
8= 40N+80N	0.70	5 bc	26.1	204	51
Mean	0.7	5	26.5	204.1	51.1
Pr>F	0.9917	<.0001	0.0763	0.9321	0.6441
CV (%)	6	60	2	5	2

Values in columns followed by different letters are significantly different at the 5% probability level (according to Tukey-Kramer).

Table 5. Carberry corn N response to different N treatments.

Treatment (lb N/acre)	SPAD	SPAD Index	NDVI	Visual def.	Yield (bu/ac)	Green snap
1=0N	49.3	87%	0.38	5 a	120	1.0
2=40N	56.3	100%	0.44	1 b	115	1.5
3=80N	53.8	95%	0.41	1 b	111	1.5
4=120N	52.5	93%	0.48	0 b	123	1.8
5=160N	52.8	94%	0.44	0 b	119	2.3
6=200N	53.0	94%	0.39	0 b	123	2.3
7=40N+40N	49.0	87%	0.35	0 b	123	2.3
8= 40N+80N	56.3	100%	0.42	1 b	122	2.0
Mean	52.8		0.41		119	1.8
Pr>F	0.6484		0.1535	<.0001	0.7197	0.4312
CV (%)	14		22	89	3	115

Values in columns followed by different letters are significantly different at the 5% probability level (according to Tukey-Kramer).

- Volunteer wheat was not controlled until mid June and competed for N and early season corn growth.
- Severe wind caused green snap of plants. Values in table are the number of 10 plants that snapped.
- Deer damaged several of the plots adding variability to yield results.

Table 6. Arborg corn N response to different N treatments.

Treatment (lb N/acre)	SPAD	SPAD Index	NDVI	Visual def.	Moisture (%)	Yield (bu/ac)	Weed growth (lb/ac)	N in weeds (lb/ac)
1=0N	47.0 b	87	0.78	10 a	26.5	154 c	858	23
2=40N	50.0 ab	93	0.79	8 a	26.1	169 bc	444	13
3=80N	50.5 ab	94	0.78	5 b	25.5	186 ab	605	25
4=120N	54.3 a	100	0.80	3 bc	25.1	194 a	327	17
5=160N	54.1 a	100	0.81	2 bc	25.2	191 a	480	14
6=200N	53.2 a	98	0.79	1 c	25.7	193 a	599	19
7=40N+40N	50.0 ab	93	0.80	4 b	26.2	187 ab	616	19
8= 40N+80N	49.7 ab	93	0.80	3 b	25.7	194 a	911	37
Mean	51			4	25.8	183.4		
Pr>F	0.0014		0.4293	<.0001	0.1661	<.0001		
CV (%)	7		3	70	3	9		

Values in columns followed by different letters are significantly different at the 5% probability level (according to Tukey-Kramer).

- The broadcast N application was not applied until early July. A second flush of weeds was not controlled and biomass and N uptake was measured and reported in Table 6.

Table 7. Morden corn N response to different N treatments.

Treatment (lb N/ac)	SPAD	SPAD Index	NDVI	Visual def.	Moisture (%)	Yield (bu/ac)	Test wt (lb/bu)	Stalk N pm NO_3
1=0N	41.9 c	88	0.64	9 a	23	178	49	46
2=40N	46.7 ab	98	0.65	7 ab	24	194	52	502
3=80N	45.1 bc	94	0.69	6 bc	24	196	52	4102
4=120N	47.3 ab	98	0.70	4 cd	23	199	51	2234
5=160N	48.5 a	100	0.66	3 de	24	199	51	4234
6=200N	47.6 ab	100	0.69	1 e	23	197	50	3885
7=40N+80N	45.9 ab	96	0.67	5 bcd	24	186	51	2173
8= 40N+120N	46.7 ab	98	0.70	4 cd	23	184	51	3931
Mean	46		0.7	5	23	191	51	2638
Pr>F	<.0001		0.1500	<.0001	0.2183	0.1856	0.7873	
CV (%)	6		5	54	4	7	5	

Values in columns followed by different letters are significantly different at the 5% probability level (according to Tukey-Kramer).

Table 8. Melita corn N response to different treatments.

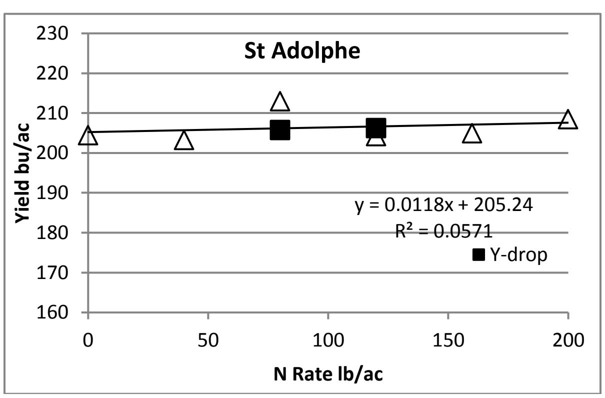
Treatment (lb N/acre)	*SPAD*	*SPAD Index*	*NDVI*	*Moisture (%)*	*Yield (bu/acre)*	*Test wt (lb/bu)*
1=0N	*41.4 bc*	*89*	*0.46*	*27.2 a*	*187 b*	*52*
2=40N	*42.4 abc*	*91*	*0.50*	*24.6 ab*	*210 ab*	*54*
3=80N	*42.6 abc*	*93*	*0.51*	*24.7 ab*	*214 ab*	*53*
4=120N	*45.6 a*	*100*	*0.52*	*23.7 b*	*223 ab*	*54*
5=160N	*42.8 abc*	*93*	*0.49*	*24.4 b*	*232 ab*	*53*
6=200N	*44.2 ab*	*96*	*0.53*	*24.5 ab*	*244 a*	*54*
7=40N+40N	*40.1 c*	*87*	*0.51*	*23.4 b*	*230 ab*	*54*
8= 40N+80N	*41.8 bc*	*91*	*0.56*	*23.8 b*	*228 ab*	*54*
Mean	*42.6*		*0.51*	*24.5*	*221*	*53*
Pr>F	*0.0039*		*0.6096*	*0.0064*	*0.015*	*0.2933*
CV (%)	*6*		*13*	*6*	*11*	*2*

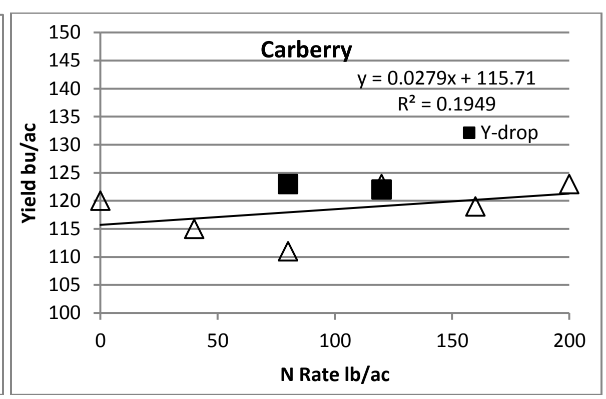
Values in columns followed by different letters are significantly different at the 5% probability level (according to Tukey-Kramer).

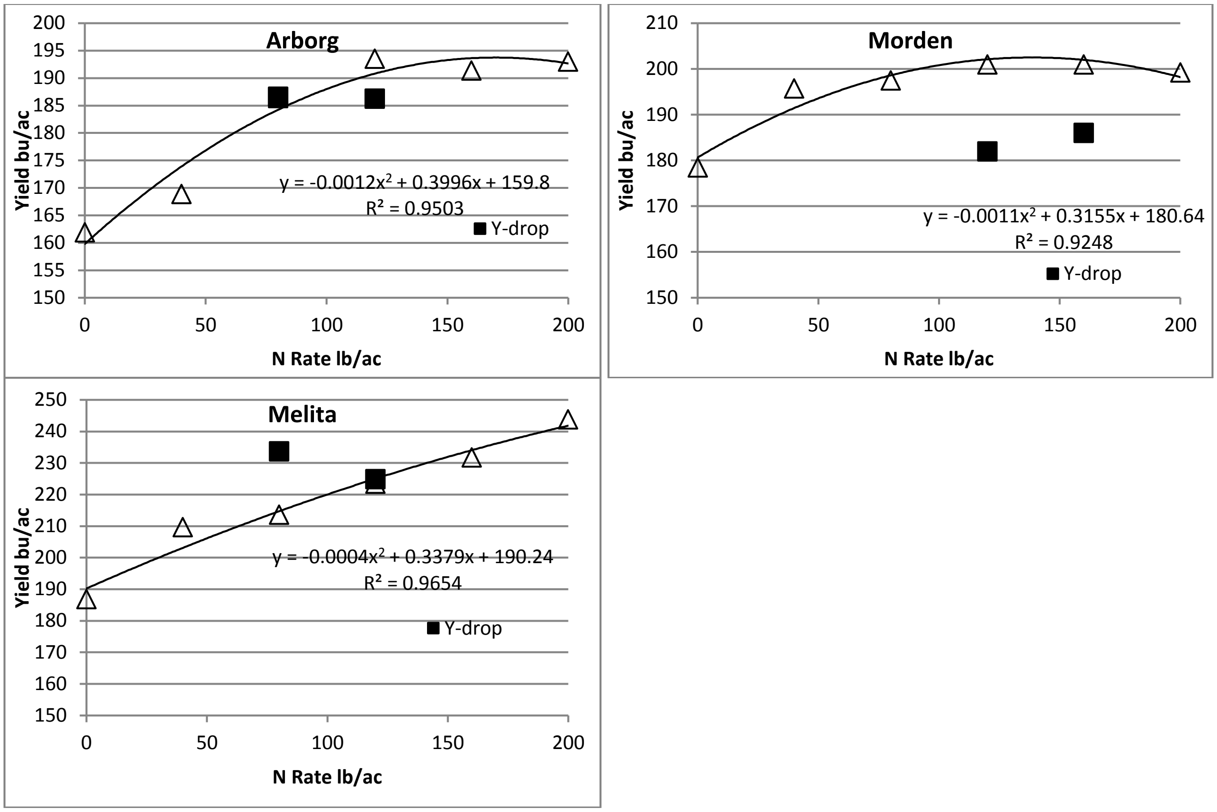
Corn did not respond to applied N at St Adolphe or Carberry sites, but responded significantly at Arborg and Melita and tended to increase at Morden (Figures 1-5).

The post plant applications to simulate the Y-drop applicator did not produce different yield than post plant surface applications of Super U. The exception was at Morden where the UAN application inadvertently splashed onto bottom leaves causing leaf burn and slightly lower yields (but non-significant). The application technique was modified to prevent such splash at other locations.

Few of the N decision methods or guides (Table 9) matched well with the actual N rate producing the most economic yield (Table 10). Even though visual N deficiency symptoms matched well with N rate at St Adolphe, Carberry, Arborg and Morden, they were not a particularly good guide for nitrogen sufficiency. Even where there was no yield response to N at St Adolphe, 9 of 10 plants had leaves with N deficiency symptoms (Table 4).







Figures 1-5. Nitrogen response of corn at St Adolphe, Carberry, Arborg, Morden and Melita.

Table 9. Decision criteria for N rate recommendations for corn.

Source	
MERN	*Determined using $5/bu corn and $0.50/lb N and by fitting a quadratic function to yield response (where applicable).*
Manitoba Agriculture	*Using N recommendations from soil fertility Guide for 130 bu/ac corn and soil test N.*[1]
NDSU	*Using N calculator based on soil texture, historic yields less than 160 bu/ac, soil test N and OM, $5/bu corn and $0.50 /lb N.*[2]
AgVise	*Using yield goal of 150 bu/ac for Morden and 125 bu/ac for other locations and soil test N.*
SPAD	*Sufficiency is the N rate when SPAD index is >95%.*
NDVI	*Using NUE web-based N rate calculator for Minnesota corn.*[3]
PSNT	*Measured on plots with base rate of 40 and using AgVise criteria for supplementation and yield goal of 150 bu/ac for Morden and 125 bu/ac for others. See Table 1 for PSNT amounts.*
Stalk nitrate	*Low (<250 ppm) = N was deficient, Marginal (250-700 ppm) = possible that N shortage limited yield, Optimal (700-2,000 ppm) = yield not limited by N shortage, Excessive (>2,000 ppm) = N rates was high or some other factor reduced yield.*

Table 10. Observed N response and predicted N needs.

Site	*St Adolphe*	*Carberry*	*Arborg (lb N/acre)*	*Morden*	*Melita*
MERN	***0***	***0***	***125***	***98***	***200+***
Mb Ag	*95*	*130*	*0*	*170*	*120*
NDSU	*0*	*95*	*0*	*112*	*93*
AgVise	*79*	*95*	*44*	*144*	*93*
SPAD	*-*	*40*	*120*	*40*	*120*
NDVI	*0*	*120*	*0*	*0*	*0*
PSNT	*10*	*75*	*10*	*128*	*55*
Stalk N	*80*	*-*	*-*	*80*	*-*

The lack of agreement between N guidelines and actual response may be caused by:

- Higher yields that we have previously experienced.
- Higher mineralization of N from organic matter.

Soil mineralization of organic matter obviously contributed greatly to the high check yields. A very crude calculation of N mineralization is shown in Table 11. The estimate is based on using a 1.12 lb whole plant N uptake/bu[4] less soil nitrate, less starter fertilizer N. The estimated mineralization values of 56 – 160 lb N/ac are much greater than normally anticipated. Unfortunately, measurements were not taken to allow consideration of nitrate-N from deeper depths or residual N at harvest.

Table 11. Crude estimate of nitrogen mineralization

Site	*St Adolphe*	*Carberry*	*Arborg lb N/acre*	*Morden*	*Melita*
Check Yield bu/ac	*202*	*120*	*154*	*178*	*187*
Est .N uptake[4]	*226*	*134*	*172*	*199*	*209*
Soil nitrate 0-2'	*71*	*55*	*106*	*35*	*57*
Starter fertilizer N	*4*	*6*	*10*	*4*	*4*
Mineralized N est.	*151*	*73*	*56*	*160*	*148*
Measured OM%	*7.7%*	*4.9%*	*8.6%*	*2.9%*	*4.0%*

Such high corn yields and large N mineralization rates challenge N recommendations developed with current preplant planning techniques. A next step would be to use combined models of soil N dynamics and crop growth adjusted with real-time weather information.

References

1) Manitoba Soil Fertility Guide. 1996. Manitoba Agriculture
2) Franzen. 2014. Soil Fertility Recommendations for Corn. NDSU SF722
3) http://www.nue.okstate.edu/SBNRC/mesonet.php
4) Bender et al. 2013. Better Crops. Vol.97 No. 1 p7-10.