ASSESSING THE ILLINOIS N TEST AS A DECISION MANAGEMENT TOOL FOR SUGARBEET

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Abstract

The Illinois nitrogen soil test (INST) was developed to detect sites where corn is nonresponsive to nitrogen (N) fertilization. Nitrogen management is critical for sugarbeet production because sucrose content can be compromised with excessive applications of N. The objective of this study was to assess the ability of the INST and other parameters (OM, total N, and NO_3^--N) to predict N responsiveness in sugarbeet. Yield and RWSA response to N was assessed at five sites each in 2002 and 2003. INST was measured on 0-30 cm preplant soil samples. Response to N fertilizer was calculated based on yield and recoverable white sucrose at each site and compared with the results of the INST. Two sites in 2002 and one site in 2003 were nonresponsive to N fertilization. The INST correctly identified two of the three sites as being nonresponsive with a critical threshold range of 230-270 mg kg^{-1}. Other soil test characteristics were also evaluated as predictors of N responsiveness. Soil organic matter (OM) identified all three sites as being nonresponsive with a critical threshold range of 3.12-3.25%. Total N identified two of three sites at a value greater than 0.2%. NO_3^--N predicted two of three sites with a critical range of 6.13-7.66 mg kg^{-1}. Routine OM and/or NO_3^--N soil tests may be as important as the INST at predicting fields where sugarbeet will not respond to N.

Introduction

Detecting sugarbeet (*Beta vulgaris* L.) fields that are nonresponsive to nitrogen (N) fertilization is very important to the sugar industry. Lack of N can result in decreased yield; however, excess N decreases sucrose content and juice quality (Draycott, 1993). In Michigan, sugarbeet grower payment is based on yield and sucrose content. Recoverable white sucrose per acre (RWSA) is the actual amount of raw sugar produced for the consumer. RWSA is a useful parameter in the sugarbeet industry because it encompasses sucrose content and yield.

The Illinois nitrogen soil test (INST) was developed to predict fields where corn will not respond to additions of N fertilizer. The INST estimates potentially mineralizable soil N by a diffusion method that recovers amino sugar-N (Anonymous, 2002). Amino sugar-N is a fraction of soil organic N that Khan et al. (2001) have linked with responsiveness to N fertilization. Mulvaney et al. (2001) determined that a test value greater than 250 mg kg^{-1} suggests that corn will be nonresponsive to N fertilization. The INST has not been widely investigated on other crops.

Current nutrient recommendations for sugarbeet in Michigan are based yield goal and previous crop (Warncke et al., 2004). N recommendations in kg N ha^{-1} equal two times the sugarbeet yield goal (Mg ha^{-1}); plus 34 kg N ha^{-1} if the previous crop was corn. On average, many sugarbeet fields are over fertilized with N with respect to these recommendations. The INST and/or other routine soil testing parameters may determine the responsiveness of sugarbeet to N.

Field specific N recommendations based on soil testing can assist growers in N management decisions.

Methods and Materials

Five sites each in 2002 and 2003 were selected in the Saginaw Valley and Thumb sugarbeet production regions in Michigan. Preplant soil samples were collected to a depth of 15 cm in each replication and analyzed for organic matter (OM), pH, total N and total C, Olsen-P or Bray-P, exchangeable K, Ca, and Mg. Soil characterization information is provided in Table 1. Soil samples were collected to a depth of 30 cm to determine NO_3^--N and INST values; additionally, preplant profile NO_3^--N was measured on samples collected to 90 cm. INST values were determined using the method outlined in University of Illinois Department of Natural Resources and Environmental Sciences Technical Note 02-01 (rev. e) (Anonymous, 2002).

Sugarbeet variety Hilleshog E-17[†] was planted at a rate of 129,100 seeds ha^{-1} in 0.76 m rows in April. Plots were 4.6 m wide and 15.2 m long. Nitrogen treatments were applied in a randomized complete block with four replications. Nitrogen rates ranged from 0 to 238 kg ha^{-1} in 34 kg ha^{-1} increments in 2002 and 0 to 225 kg ha^{-1} in 45 kg ha^{-1} increments in 2003. All plots, except the control, received 34 or 45 kg N ha^{-1} as urea at planting. The remaining N, to obtain targeted rates, was sidedressed when the sugarbeet plants had two to four true leaves.

Sugarbeets were machine harvested from 9.1 m in each of the center two rows in late-October through early-November each year. Harvested roots were analyzed for sucrose content and clear juice purity (CJP). RWSA was then calculated using a formula that included yield, sucrose content, and CJP.

Optimum N rates for yield and RWSA at each location were calculated using linear and quadratic plateau models in SAS (SAS Institute, 1999). Response of yield to N fertilization was calculated as:

((Optimum Yield – Check Plot Yield) / Check Plot Yield) x 100.

Response of RWSA was calculated similarly. Optimum N rates for yield and RWSA are provided in Table 1.

The Cate-Nelson approach (Cate and Nelson, 1971) was used to determine the critical threshold range for a soil parameter to predict N responsiveness. Correlations between soil test values and optimum N rate or percent N response were calculated using SAS (SAS Institute, 1999) (Table 2).

Results

The data in Figure 1 show the relationship of the INST with response of sugarbeet yield and RWSA to N fertilizer. The critical threshold range is 230 to 270 mg kg^{-1} for both yield and RWSA. Neither RWSA nor yield response are correlated with the INST ($P > 0.05$) (Table 2).

[†] Produced by Syngenta Seeds, Longmont, CO.

The INST is significantly ($P < 0.05$) correlated with the RWSA optimizing nitrogen rate (RONR); however, the INST is not correlated ($P > 0.05$) with the yield optimizing N rate (YONR).

The critical threshold for total N versus response of yield and RWSA to N fertilizer is 0.20% (Figure 2). However, the critical threshold was calculated as lying between two points, both having 0.20% N. Yield response is correlated with total N, but total N is not correlated to RWSA response, YONR, or RONR ($P > 0.05$) (Table 2).

Figure 3 shows the critical threshold range 6.13 to 7.66 mg kg^{-1} for response of yield and RWSA to N fertilizer for NO_3^--N for a sample collected to a depth of 30 cm. A correlation exists between NO_3^--N and both yield and RWSA response ($P < 0.05$). Table 2 shows NO_3^--N is correlated with YONR ($P < 0.05$), but not RONR ($P > 0.05$).

Response of sugarbeet yield and RWSA to N fertilization and OM correlated ($P < 0.05$) (Table 2). The critical threshold range as shown in Figure 4 is 3.12 to 3.25%. Organic matter is also correlated with YONR and RONR ($P < 0.05$).

Summary

Previous research has linked the INST with response of corn to N fertilization; although a similar critical threshold range was found in sugarbeet, the relationship between INST and N fertilizer response is not strong enough to be used for predicting nonresponsive sugarbeet production sites. The INST only predicted two out of three nonresponsive sites and was not correlated to sugarbeet response to N fertilizer based on yield and RWSA ($P = 0.05$).

Total N was only correlated to yield response. Two sites that were responsive and one nonresponsive site were at the critical threshold of 0.20% N. The Cate-Nelson procedure did not provide a good separation of responsive and nonresponsive sites with total N.

NO_3^--N (0-30 cm) is correlated to responsiveness of N fertilizer to yield and RWSA, and the YNOR. Unlike amino sugar-N, determined by the INST, NO_3^--N is not a stable soil parameter, but it can be important in determining N fertilizer recommendations during the growing season.

Profile NO_3^--N is correlated to yield response ($P < 0.05$), but the correlation is stronger for NO_3^--N in the 0–30 cm depth compared to the 0–90 cm depth. Soil sampling to a greater depth did not strengthen NO_3^--N as a predictor for N responsiveness to fertilization.

Organic matter is a soil parameter that may be able to predict nonresponsive sites to N fertilization because it has the greatest correlation to yield and RWSA response to N fertilizer. However, the narrow threshold range (3.12–3.25%) raises concern for using OM as a predictor for nonresponsive sites.

For all soil parameters considered, the R^2 generated for the threshold range for responsiveness, calculated by the Cate-Nelson approach, were similar for both RWSA and yield. RWSA is important because it is a calculation that contains both yield and sugar content parameters which are used to calculate grower payment.

Correlation of YONR and RONR to soil parameters may become an important tool for developing field specific N recommendations to assist growers in N management decisions. However, more research and data exploration are necessary to strengthen the relationship between soil parameters and YONR and RONR.

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Table 1. Soil characterization information.

Location	Soil	P[†]	K	Ca	Mg	pH	OM	YONR[‡]	RONR[§]	Response to N fertilizer Yield	Response to N fertilizer RWSA
		ppm					%	kg ha^{-1}		%	
2002 - 1	Misteguay silty clay loam	9	264	4004	719	8.1	2.7	116	110	63	61
2002 - 2	Misteguay silty clay loam	21	335	3618	880	8.0	2.1	139	82	37	34
2002 - 3	Parkhill loam	29	215	3647	236	7.9	4.2	0	0	0	0
2002 - 6	Sloan silty clay loam	26	155	1558	371	7.9	2.5	0	0	0	0
2002 - 5	Sloan silty clay loam	26	147	2624	564	7.8	4.1	105	99	39	33
2003 - 1	Misteguay silty clay loam	48	243	4129	839	8.2	3.1	106	100	46	48
2003 - 2	Misteguay silty clay loam	66	238	3968	861	8.1	3.1	125	188	48	59
2003 - 3	Parkhill loam	60	206	1793	290	6.5	3.3	0	0	0	0
2003 - 4	Parkhill loam	172	330	1983	255	7.0	3.0	144	136	31	41
2003 - 5	Tappan loam	77	205	2334	375	7.9	2.8	105	142	36	41

† P values were determined by Olsen, except for locations 2003-3 and 2003-4 where the Bray-P test results are reported because pH < 7.2
‡ YONR = Yield optimizing N rate; as determined by linear or quadratic plateau models.
§ RONR = RWSA optimizing N rate; as determined by linear or quadratic plateau models.

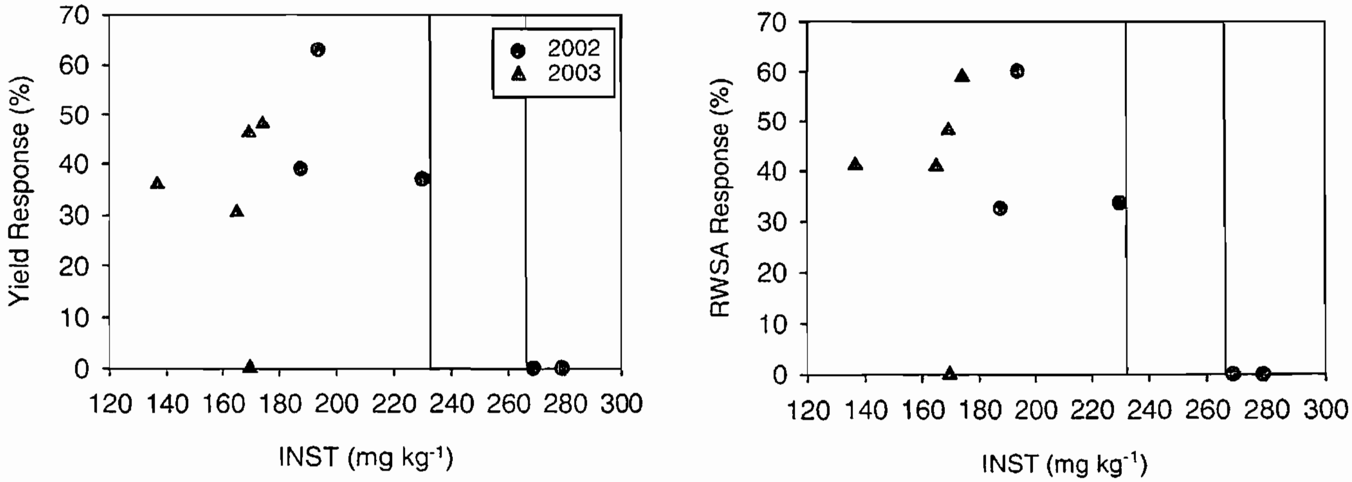

Figure 1. Relationship of INST with response of sugarbeet yield and RWSA to N fertilizer.

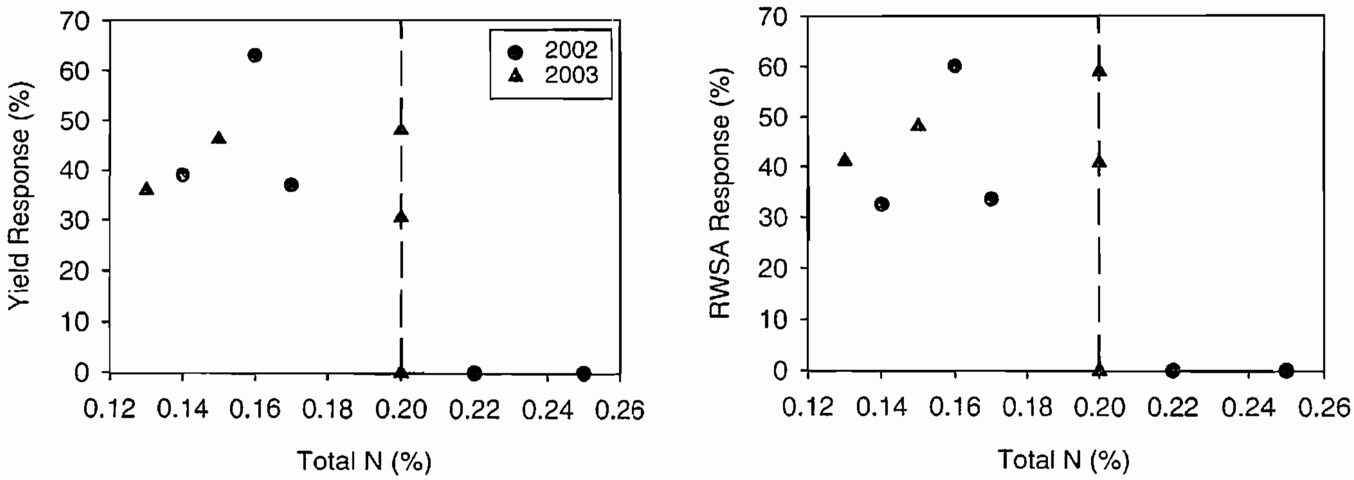

Figure 2. Relationship of total N with response of sugarbeet yield and RWSA to N fertilizer.

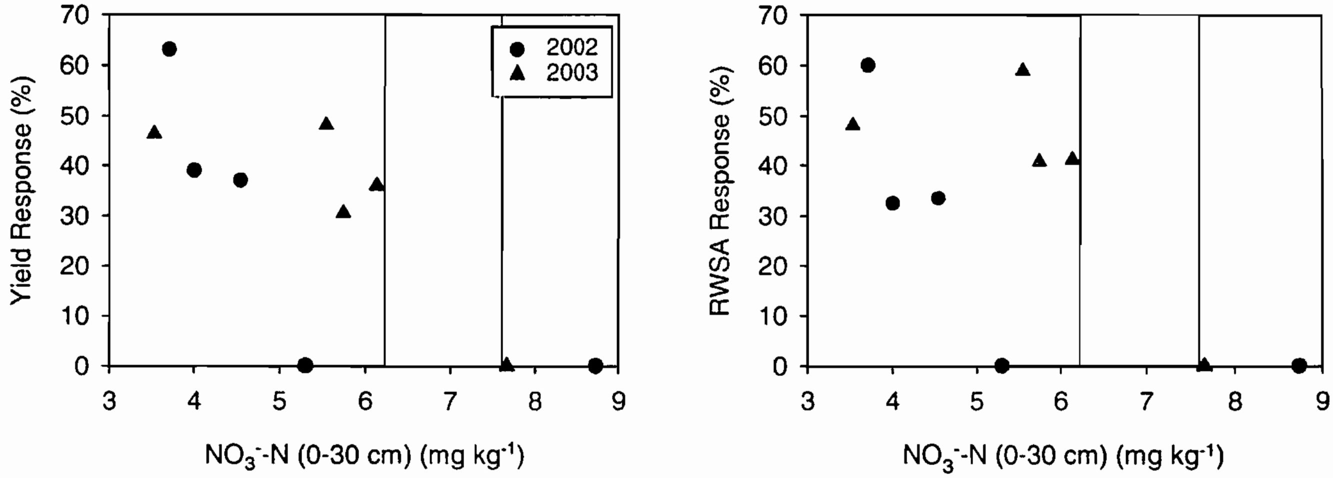

Figure 3. Relationship of NO_3^--N (0-30 cm) with response of sugarbeet yield and RWSA to N fertilizer.

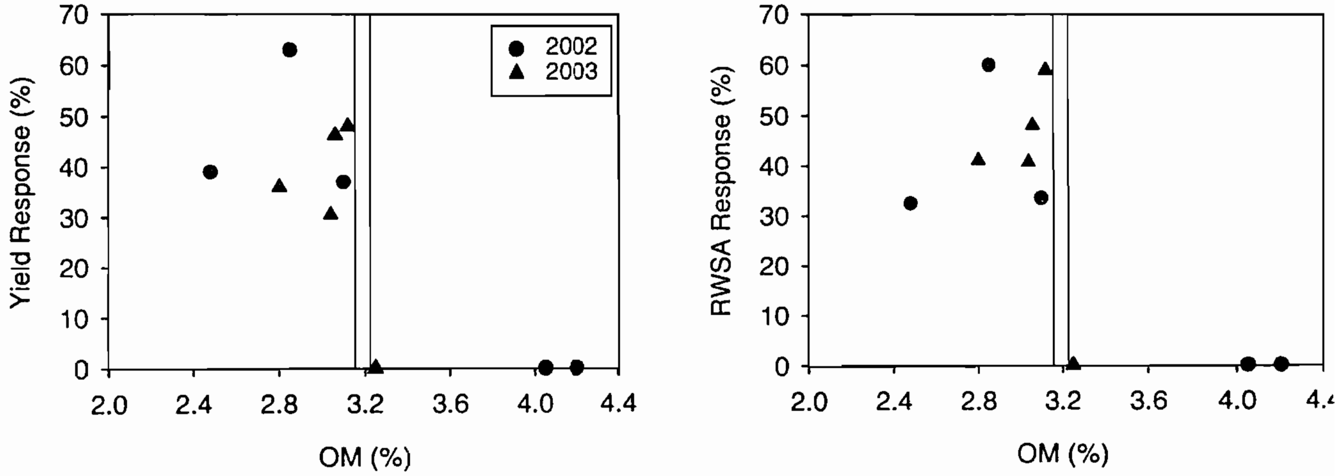

Figure 4. Relationship of OM with response of sugarbeet yield and RWSA to N fertilizer.

Table 2. Correlation coefficient of soil parameters with optimum N rates and response to N fertilizer.

Soil Parameters	Optimum N				% Response			
	Yield		RWSA		Yield		RWSA	
	r	P value	r	P value	r	P value	r	P value
INST	-0.55	0.098	-0.68	0.031	-0.53	0.118	-0.60	0.066
Total N	-0.62	0.057	-0.54	0.106	-0.70	0.025	-0.61	0.060
NO_3^--N (0-30 cm)	-0.65	0.041	-0.65	0.163	-0.77	0.010	-0.67	0.034
NO_3^--N (0-90 cm)	-0.55	0.097	-0.24	0.508	-0.65	0.043	-0.55	0.103
OM	-0.75	0.012	-0.69	0.026	-0.76	0.012	-0.71	0.022

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