CALIBRATION OF THE NITRATE SOIL TEST FOR MALTING BARLEY IN WESTERN NORTH DAKOTA

R. Jay Goos and Brian Johnson
North Dakota State University, Fargo, ND 58105
rj.goos@ndsu.edu, 701-231-8581
Eric Eriksmoen, Hettinger Research Extension Center
James Nelson, Glen Martin, and Pat Carr, Dickinson Research Extension Center
Neil Riveland and Gordon Bradbury, Williston Research Extension Center

ABSTRACT

Malting barley production is moving westward into semi-arid regions, such as western North Dakota. The objective of this study was to determine if the "nitrogen factor" traditionally used for malting barley in eastern ND, 1.5 lb (soil nitrate + fertilizer)-N per bushel, was valid for western ND. Six experiments were conducted. At each site, twenty unique combinations of residual nitrate-N and fertilizer N were combined with two varieties, a 6-row variety (Drummond) and a 2-row variety (Conlon), for a total of 120 calibration points for each variety. Analyses were performed using a more restrictive quality scenario (≤13% protein, ≥90% plump) and a less restrictive quality scenario (≤13.5% protein, ≥80% plump). The 6-row variety seldom met the more restrictive quality standard, no matter how starved for nitrogen the crop was. The less restrictive quality standard could be reached about 60% of the time, but only with unacceptable yield loss due to N deficiency. Prospects for 2-row barley are more promising in western ND, where the quality criteria were achieved a majority of the time without yield loss, when the N factor was between 1.0 and 1.2 lb (soil nitrate + fertilizer)-N per bushel. A nitrogen factor of 1.2 lb (soil nitrate + fertilizer)-N per bushel prevented N deficiency in both 6-row and 2-row barley, but malting quality was generally only met with the 2-row variety.

The past two decades have not been kind to barley producers in North Dakota. Until recently, prices were low, and a series of wet years led to devastating yield and quality losses due to disease. As a result, barley acreage in North Dakota declined from about 3.5 million acres in 1985 and 1986, to about half of that value in 2005-2007. One response has been to attempt to move malting barley production westward, into a drier climate, in order to minimize yield and quality losses due to disease. However, moving barley production westward introduces a new array of challenges. To make malting grade, barley grain needs to be plump and low in protein. Both of these conditions are difficult to achieve with the water and heat stress that commonly occurs in western ND. Since nitrogen supply also influences grain protein and plumpness, improper control of the nitrogen supply of the crop is likely to be less forgiving for the production of malting barley in western ND than in the cooler and moister climate of eastern ND.

Nitrogen fertilizer recommendations for non-legumes in ND are calculated by the following generalized equation:

Nitrogen fertilizer recommendation = [A x B] - C - D, where:

A=the yield goal, B=the "N factor" for the crop, C=the nitrate-nitrogen in the soil, usually to a depth of 2', and D=various adjustments for legumes or manure

Traditionally, the N factor for malting barley was 1.5 lbs (soil nitrate + fertilizer)-N per bushel. It is likely that this number will need adjustment for western ND. McKenzie and Jackson (2005) has suggested a N factor of 1.2 lb N/bu for dryland areas of Montana and Alberta. Studies were begun in 2002 in order to determine if the traditional N factor of 1.5 lb N/bu should be changed for western ND.

MATERIALS AND METHODS

Studies were done near Hettinger, Dickinson, and Williston, ND over the years 2002-2004. Each study took two years to complete. In the first year, oats were grown in large blocks, and fertilized with 0, 50, 100, and 150 lb N/A as calcium nitrate. There were four replicates in a randomized complete block design. After the oats were harvested, in October of the first year, soil samples were taken. Eight cores per plot were taken to a depth of 2 feet. The samples were mixed, subsampled, air-dried, crushed (< 2 mm), and analyzed for nitrate content. The second year of the study, the main plots were split by N rate (0, 20, 40, 60, 80 lb N/A as calcium nitrate), and again by variety. The varieties were a 6-row variety (Drummond) and a 2-row variety (Conlon). Grain yields were determined, as well as grain quality parameters, such as protein content and plump kernel percentage.

Only a summary of the data obtained can be presented in this short paper. The data were averaged across replicate before calibration analysis. The (soil nitrate + fertilizer)-N was divided by the yield, to give an observed N factor. There were 20 observed N factors per variety x 6 sites, for 120 calibration points per variety. The observed N factors were classified into five ranges: < 1.0, 1.0-1.2, 1.21-1.5, 1.51-2.0, and > 2.0 lb (soil nitrate + fertilizer)-N per bushel. The data were judged against quality criteria, and for yield loss. Two scenarios of quality criteria were assumed. A "more restrictive" set of quality criteria were for ≤13% protein and ≥90% plump kernel percentage. A "less restrictive" set of quality criteria were for ≤13.5% protein and ≥80% plump kernel percentage. Also, yield loss was estimated, compared versus the average of treatments for each site receiving 1.51-2.0 lb N/bu.

RESULTS AND DISCUSSION

The range of the data used in the calibration study is shown in Table 1. Grain yields ranged from 30-90 bu/A, soil nitrate-N to a depth of 2' ranged from 17-206 lb/A, observed N factors ranged from 0.34-7.19 lb (soil nitrate + fertilizer)-N per bu, grain protein levels ranged from 11.1-16.3%, and plump kernel percentage ranged from 9.8-99.1%. Even though the number of sites involved was limited, a considerable range in the parameters of interest was obtained.

Table 1. Range of observations in the calibration study.

Site	Yield	Soil nitrate-N	Observed N factor	Protein	Plump kernels
	----------------------- Range in data				-----------------------
	bu/A	lb/A	lb N/bu	%	%
6-row barley, Drummond					
Hettinger 2003	36.7-42.4	94-206	2.32-7.19	14.0-15.7	9.8-21.1
Dickinson 2003	60.9-84.3	21-128	0.34-2.88	13.2-16.3	53.2-76.9
Williston 2003	58.0-79.0	27-129	0.46-3.44	12.5-16.1	53.3-84.1
Hettinger 2004	31.5-42.1	32-60	0.89-3.75	12.6-14.7	86.3-93.9
Dickinson 2004	40.2-50.1	27-104	0.67-4.39	13.4-16.0	45.1-64.0
Williston 2004	32.1-43.2	17-108	0.48-4.79	12.8-15.2	81.7-89.6
2-row barley, Conlon					
Hettinger 2003	52.1-56.3	94-206	1.75-5.26	13.7-14.9	73.8-84.5
Dickinson 2003	57.1-82.0	21-128	0.37-3.03	12.2-15.1	93.0-97.0
Williston 2003	59.3-90.0	27-129	0.46-2.49	11.1-14.6	81.8-97.1
Hettinger 2004	32.7-41.6	32-60	0.87-3.72	11.7-13.6	97.6-99.1
Dickinson 2004	38.4-46.8	27-104	0.70-4.38	12.5-15.1	90.3-94.0
Williston 2004	30.3-42.0	17-108	0.49-4.57	11.5-13.9	93.8-95.8

A summary of the relationship between the observed N factor and various yield and quality parameters for 6-row Drummond barley is shown in Table 2. With the more restrictive quality criteria, it was difficult to achieve acceptable quality, even if the barley was significantly starved for nitrogen (< 1.0 lb N/bu). With the less restrictive quality criteria, it was possible to produce malting grade barley about 60% of the time, but only with < 1.0 lb N/bu, which was associated with significant yield loss (averaging 6.0 bu/A). In other words, production of malting-grade 6-row barley in western ND will prove to be difficult, even if substantial nitrogen starvation was tolerated. It is important to note that, malting-grade barley was almost never produced with the traditional N factor of 1.5 lb (soil nitrate + fertilizer)-N. A N factor of 1.2 lb N/bu was adequate to prevent N deficiency.

Table 2. Summary of the relationship between N factor and yield and quality of 6-row Drummond barley. Western ND, 2003-2004.

Observed N factor*	Number of obs.	Quality criteria: More restrictive 13% Protein	More restrictive 90% Plump	Less restrictive 13.5% Protein	Less restrictive 80% Plump	Avg. yield loss+
lb N/bu	#	% of observations meeting quality criteria				bu/A
< 1.0	15	27	13	67	60	6.0
1.0-1.2	7	14	14	14	14	2.0
1.21-1.5	15	7	13	40	33	0.2
1.51-2.0	20	0	15	10	40	--
> 2.0	63	0	10	0	27	1.0

+ Average yield loss, relative to barley receiving 1.51-2.0 lb N/bu at the same site
* lb/A of soil nitrate-N to 2 feet plus pre-plant fertilizer N, divided by yield

The prospects for producing malting-grade 2-row barley in western ND are more hopeful. Table 3 shows the relationship between the range of N factors observed and the various yield and quality parameters. For both quality criteria, malting grade barley was produced the majority of the time, as long as N factor was 1.5 or less. Yield losses were largely avoided by providing more than 1.0 lb (soil nitrate + fertilizer)-N per bushel. A N factor of 1.2 would seem to be a reasonable value for both 2-row and 6-row barley in western ND, agreeing with work in Montana and Alberta.

Table 3. Summary of the relationship between N factor and yield and quality of 2-row Conlon barley. Western ND, 2003-2004.

Observed N factor*	Number of obs.	Quality criteria: More restrictive 13% Protein	More restrictive 90% Plump	Less restrictive 13.5% Protein	Less restrictive 80% Plump	Avg. yield loss+
lb N/bu	#	% of observations meeting quality criteria				bu/A
< 1.0	16	81	100	94	100	7.3
1.0-1.2	9	56	100	67	100	1
1.21-1.5	10	50	90	70	100	-1
1.51-2.0	25	20	80	36	100	--
> 2.0	60	2	67	23	82	0.4

+ Yield loss relative to barley receiving 1.5-2.0 lb N/bu
* lb/A of soil nitrate-N to 2 feet plus pre-plant fertilizer N, divided by yield

Paper cited: McKenzie, Ross, and Grant Jackson. 2005. Barley production in semiarid regions--Making the malting grade. Better Crops with Plant Food 89 (4):10-12. Available at: www.ipni.net/bettercrops