Tissue Testing Guidelines for Nitrogen Management in Malting Barley, Maricopa, 1998

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Abstract

Malting barley is not a widely planted crop in the Southwest, due to grain protein contents that can sometimes exceed the industry standard of 11.4%. To achieve < 11.4% grain protein, careful nitrogen (N) management is needed. Tissue testing guidelines for N management for reduced grain protein and acceptable yields have not yet been determined for malting barley in the Southwest. The objectives of this study were to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N, and (ii) develop stem NO_3-N guidelines for N management in malting barley. In November 1997 two varieties of malting barley, Morex and Crystal, were planted at the Maricopa Agricultural Center. Five N rates (0, 60, 120, 180, and 240 lbs/acre) were applied in four split applications. Each treatment was replicated three times in a randomized complete block design. Samples were collected from lower stems at the 3-4 leaf, 2 node, and flag leaf visible growth stages. Grain yields ranged from 1765 lbs/A to 3439 lbs/A for Morex and 2104 lbs/A to 4274 lbs/A for Crystal. Grain protein ranged from 7.6-10.5% (Morex) and 7.0-10.7% (Crystal). Correlation coefficients between stem NO_3-N and sap NO_3-N were 0.80 for Morex and 0.84 for Crystal. For Morex and Crystal, grain protein was within the malting industry grain protein range of 10.5-11.4% at 240 lbs N/A, and yield was optimized at 180 lbs N/A. Sap NO_3 analysis can be a useful tool for determining N status of malting barley. Stem NO_3-N concentrations at 180 lbs N/A were generally within the optimum range for NO_3-N in small grains.

Introduction

A grain protein content of 10.5-11.4% for malting barley is a standard in the malting industry (Birch and Long, 1990). In the Southwest, irrigated malting barley can have a grain protein content greater than 11.4%. Although addition of N is essential for obtaining high yields, N also increases grain protein content. Tissue testing during the growing season can help growers make decisions concerning nutrient management. Tissue tests sent to a commercial lab for analysis may delay needed fertilization. Rapid tests, such as the sap NO_3 test using the Cardy meter, are being developed to enable growers to determine crop N status in the field. Such tests can enable more timely N applications and grain which will meet malting standards.

Tissue testing guidelines for N management for malting barley need to be developed. The objectives of this research were to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N , and (ii) develop stem NO_3-N test guidelines for N management in malting barley.

Materials and Methods

Two varieties of malting barley were planted at the Maricopa Agricultural Center Field 109 on 21 Nov., 1997. The experiment was a randomized complete block design with five N rates (0, 60, 120, 180, and 240 lbs N/A) and three replications. The soil at this site is of the Casa Grande series and the dominant surface texture is sandy loam. Sudangrass was grown the previous season to remove residual N. Soil samples collected before planting contained 11 ppm NH_4-N plus NO_3-N and 9 ppm HCO_3-available P. Before planting, P was broadcast at a rate of 50 lbs P_2O_5/A as 0-45-0 and incorporated. All fertilizer was applied as urea 46-0-0 by hand in four split applications (Table 1). Plots were 13 by 20 ft.

Morex and Crystal malting barley were planted using a grain drill with a 6 inch spacing at a seeding rate of 100 lbs/acre. Plots were border-flood irrigated. The irrigation dates were 22 Nov., 11 Dec., 22 Jan., 18 Feb., 11 Mar., and 2 Apr.

Lower stem tissue was sampled from each plot on 6 Jan., 11 Feb., and 4 Mar. at Feekes GS 3, 7, and 10 (Large, 1954) for stem and sap NO_3-N analysis. Approximately 30 to 50 stems were collected in each plot. The stem samples were kept refrigerated for 24 hours and then split. Half of each sample was used for the sap extraction and the other half was dried in an oven at 65° C for 48 hours. The dried samples were ground, extracted and analyzed for nitrate using an ion-selective electrode. The sap extraction was accomplished by cutting the halved stem into small pieces and then removing the sap with an arbor press. The sap was then collected and a small drop was placed on the sensing module of a calibrated Cardy meter.

Heading, anthesis, and physiological maturity dates were noted for each plot. Plots were harvested on 29 Apr. for Morex and 13 May for Crystal using a small plot combine. The harvest area was 5 ft x 14 ft. Grain yield was adjusted to a 12% moisture basis. Test weight, kernel weight, grain protein content, and plant height were determined at harvest (Table 2).

Data were analyzed using analysis of variance (Table 3). Linear regressions were used to determine correlation coefficients for sap versus stem NO_3-N (Figure 1).

Results and Discussion

Grain yields were responsive to N applications up to 180 lbs N/A (Table 2 and 3). Grain yield was maximized at 180 lbs N/A in both Morex (3470 lbs/A) and Crystal (4863 lbs/A). Grain protein was maximized at 240 lbs N/A in both Morex (10.5%) and Crystal (10.7%). For both varieties either lower or higher amounts of applied N resulted in loss of yield, while grain protein content increased with increasing applied N (Figure 2). This reflects the > 50% lodging at the 180 and 240 lbs N/acre N rates for both varieties. Grain yield and grain protein were significantly affected by N rate for Morex, and only grain yield was affected by N rate for Crystal. The grain protein never exceeded the 11.4% standard set by the malting industry.

Sap NO_3-N and stem NO_3-N were highly correlated for both Morex and Crystal. Correlation coefficients (r^2) for sap versus stem NO_3-N were 0.80 for Morex and 0.84 for Crystal. Regression equations relating these two measurements are: $Y = -527.8 + 13.75*X$ for Morex and $Y = -246.5 + 8.62*X$ for Crystal, where X is sap NO_3-N concentration and Y is stem NO_3-N. These results suggest that rapid measurements of sap NO_3-N using the Cardy meter can be converted for use with existing stem NO_3-N guidelines.

Stem NO_3-N was highly correlated with N rate for both Morex and Crystal throughout the season (Figure 3). Stem NO_3-N concentration at 180 lbs N/A were generally within the optimum range for NO_3-N concentration in small grains (Doerge et al., 1991). This relationship indicates that current small grain tissue testing guidelines should be applicable for malting barley as well.

Conclusions

1. Correlations between sap NO_3-N and stem NO_3-N are high.

2. Sap NO_3-N concentration can be converted to stem NO_3-N values using the regression equations above.

3. Current small grain tissue testing guidelines should be applicable for malting barley as well.

References

Birch, C.J. and K.E. Long. 1990. Effect of nitrogen on the growth, yield and grain protein content of barley (*Hordeum vulgare*). *Australian Journal of Experimental Agriculture*. 30, 237-242.

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Acknowledgments

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Table 1. Nitrogen fertilizer schedule.

		Nitrogen Rates				
Date	Stage	0	60	120	180	240
				lbs N/A		
20 Nov	pre-plant	0	24	48	72	96
21 Jan	5-leaf	0	12	24	36	48
18 Feb	jointing	0	12	24	36	48
11 Mar	boot	0	12	24	36	48

Table 2. Influence of Nitrogen Rates on Grain Yield and Other Characteristics

Variety	N rate	Grain Yield	Test Weight	1000 Kernel Weight	Grain Protein	Plant Height	Lodging	Heading Date	Physio-logical Maturity Date
	lbs/A	lbs/A	lbs/bu	grams	%	inches	%		
Morex	0	1706	49.3	33.8	7.62	29	7	3-9	4-15
	60	1634	49.2	33.8	8.53	39	17	3-9	4-8
	120	1479	47.2	34.2	9.23	46	30	3-9	4-8
	180	3470	47.7	35.4	10.0	49	79	3-9	4-13
	240	3112	46	33.2	10.5	48	76	3-9	4-13
Crystal	0	1967	52.3	42	7.0	28	0	3-21	4-24
	60	3576	53.2	42.6	7.35	36	20	3-16	4-21
	120	4610	53.5	42.2	9.66	40	60	3-16	4-22
	180	4863	53.1	40.8	10.0	45	5	3-16	4-23
	240	3997	51.3	40.2	10.7	45	80	3-18	4-23

Table 3. Analysis of variance summary for plant height, kernel weight, test weight, grain yield, and grain protein as affected by nitrogen rate.

Variety	Source	df	Plant height	Kernel weight	Test weight	Grain yield	Grain protein
Morex	Rep	2	NS	NS	NS	NS	NS
	N	4	**	NS	**	**	*
	Error	8					
Crystal	Rep	2	NS	NS	NS	NS	NS
	N	4	**	NS	*	**	NS
	Error	8					

*,**Significant at $P \leq 0.05$ and 0.01; NS, not significant.

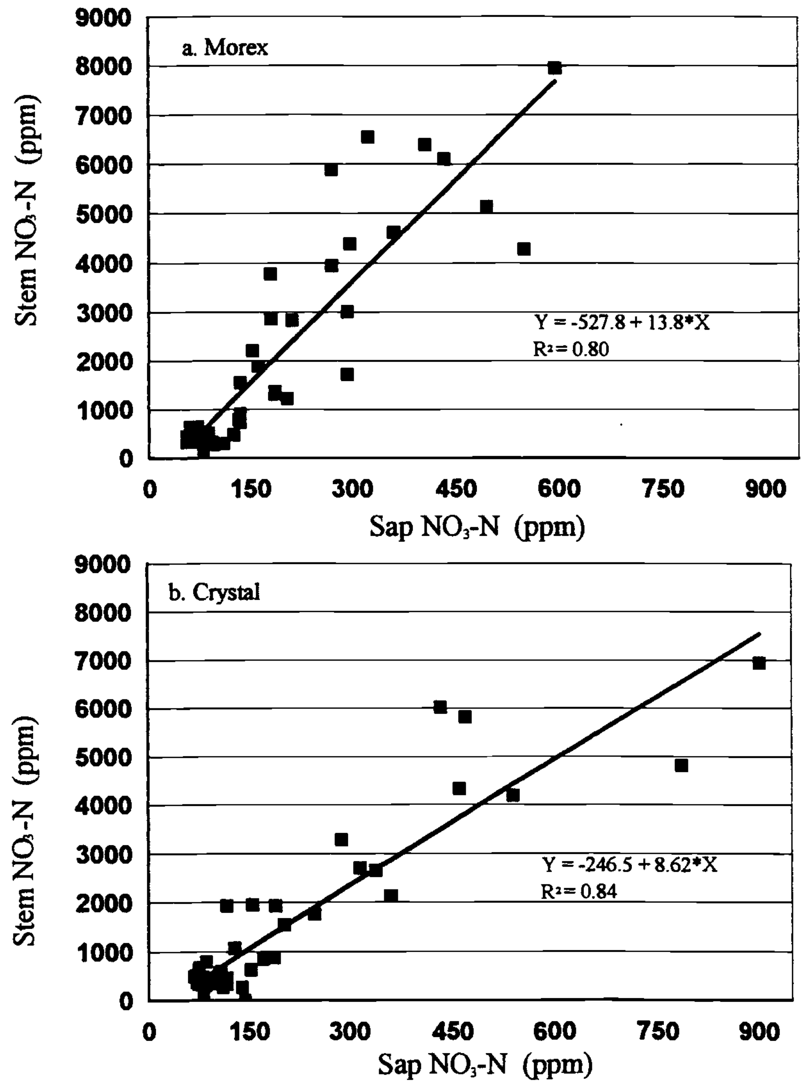

Figure 1. Linear regressions of sap vs. stem NO_3-N concentration in the lower stem, for a. Morex and b. Crystal.

Figure 2. Grain Yield and protein content vs. N rate, a. Morex and b. Crystal.

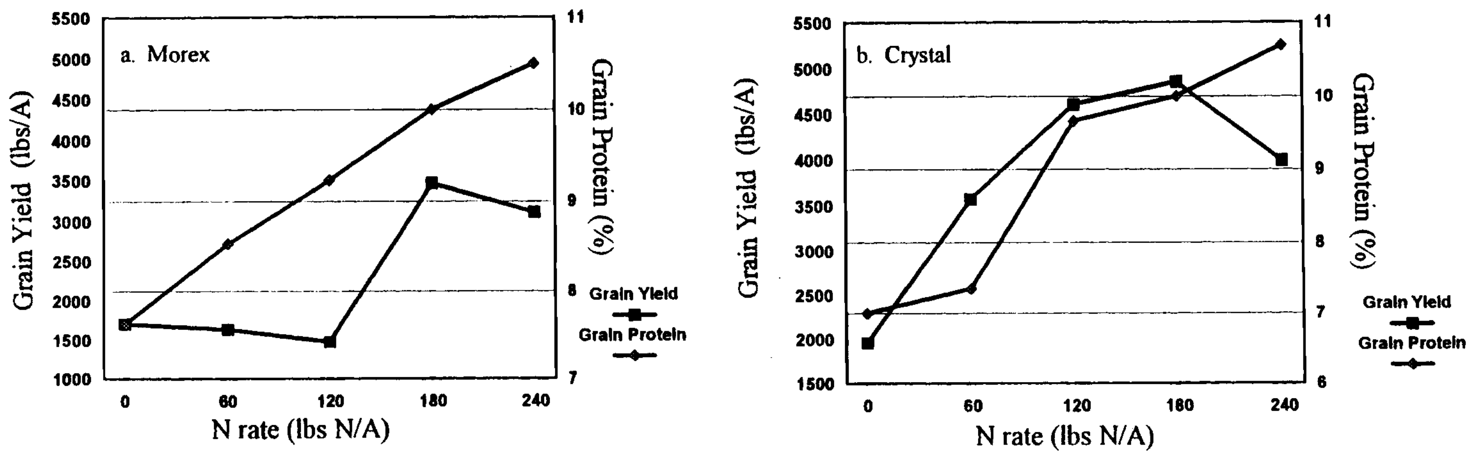

Figure 3. Sap NO_3-N concentration throughout the growing season, a. Morex and b. Crystal.