Developing Sap Nitrate Tests for Wheat and Barley, Maricopa, 1998

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Abstract

The standard procedure for determining nitrogen (N) status in small grains is to sample lower stem tissue for nitrate (NO_3) ana-lysis. The tissues are then submitted to a laboratory for analysis. Sap nitrate (NO_3) can be analyzed in the field, immediately after collecting the sample, using a Cardy meter. Guidelines for sap analysis have not yet been determined. The objectives of this study were to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N, and (ii) develop sap NO_3 test guidelines for N management in durum and feed barley. In November 1997 one variety of durum (Kronos) and one variety of feed barley (Gustoe) were planted at the Maricopa Agricultural Center. Three N rates (80, 200, and 400 lbs N/acre) were applied in four split applications. Each treatment was replicated five times in a randomized complete block design. Samples were collected from lower stems at the 3-4 leaf, 2 node, flag leaf visible, and heading growth stages. Grain yields ranged from 5185 lbs/A to 7156 lbs/A for Kronos and 6314 lbs/A to 7517 lbs/A for Gustoe. Maximum yields were achieved at 200 lbs N/A for both varieties. Correlation coefficients between stem NO_3-N and sap NO_3-N were 0.79 for Kronos and 0.84 for Gustoe. Sap NO_3-N analysis can be used to determine N status during the season for both Kronos and Gustoe.

Introduction

Tissue analysis is an accurate method for determining plant N status. In wheat and barley, NO_3 concentration in the lower stem is an indicator of plant N status. Therefore, the NO_3-N concentration in lower stem tissue can be used to formulate an N management strategy.

Conventional plant tissue analysis requires the grower to collect representative samples in the field, store the samples properly, and then send them to a commercial lab for analysis. The turnaround time for the entire process is typically 3 or more days. This can delay timely application of N fertilizer. Rapid tests, such as a sap NO_3 test using the Cardy meter, are being developed to enable growers to determine crop N status almost instantaneously. This information can save time, increase yield, and result in wise fertilizer use.

Current tissue test guidelines apply to NO_3 measured in dried lower stem tissue. New guidelines are needed to correlate results obtained from the Cardy meter with those found in dried tissue analysis. The objectives of this study were to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N , and (ii) develop sap NO_3 test guidelines for N management in durum and feed barley.

Materials and Methods

One variety of durum wheat, Kronos, and one variety of feed barley, Gustoe, were planted at the Maricopa Agricultural Center Field 109 on 21 Nov., 1997. The experiment was a randomized complete block design with three N rates (80, 200, 400 lbs N/A) and five 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, phosphate was broadcast at a rate of 50 lbs $P_2 0_5$/A as 0-45-0 and incorporated. All N fertilizer was applied as urea 46-0-0 by hand in four split applications (Table 1). Plots were 13 by 20 ft.

Kronos durum was planted at a seeding rate of 120 lbs/A and Gustoe barley was planted at a seeding rate of 100 lbs/A using a grain drill with a 6 inch spacing. 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., 4 Mar., and 18 Mar. at Feekes GS 3, 7, 10, and 10.4 (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 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 NO_3 using an ion-specific 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 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 27 May 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, hard vitreous amber count (for Kronos only), plant height and lodging percent 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 (Figures 1).

Results and Discussion

Grain yields were responsive to N applications up to 200 lbs N/A (Tables 2 and 3). Grain yield was maximized at 200 lbs N/A in both Kronos (7805 lbs/A) and Gustoe (7517 lbs/A). For both varieties higher amounts of N resulted in significant losses of yield. This reflects the > 50 % lodging observed at the highest N rate for Kronos. Grain protein was maximized at 400 lbs N/A for Kronos (12.5%) and Gustoe (10.2%). Grain yield and grain protein were significantly affected by N rate for Kronos. For Gustoe grain yield and plant height were significantly affected by N rate, but grain protein was not. For both varieties, grain protein was lower than expected. Grain protein content is affected by N rate and other factors such as water availability and temperature.

Sap NO_3-N and stem NO_3-N were highly correlated for both Kronos and Gustoe. Correlation coefficients (r^2) for sap NO_3-N versus stem NO_3-N were 0.79 for Kronos and 0.84 for Gustoe. Regression equations relating these two measurements are: $Y = -123.8 + 6.29*X$ for Kronos and $Y = -786.8 + 14.2*X$ for Gustoe, 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.

Sap NO_3-N was highly correlated with N rate for both Kronos and Gustoe throughout the season (Figure 2). This relationship support a conclusion that sap NO_3-N can be used as an indicator of plant N status. These preliminary results suggest that sap analysis can be substituted for conventional stem tissue analysis at the 3-4 leaf, 2 node, flag leaf visible, and heading growth stages. Subsequent studies will allow development of sap NO_3-N test guidelines for optimizing yield and grain protein.

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, for use with established tissue testing guidelines for small grains.

References

Large, E.C. 1954. Growth stages in cereals. Illustrations of the Feekes scale. *Plant Physiology*. 3, 128-129.

Acknowledgments

The assistance of Mark Rogers was greatly appreciated. Financial support for this project was received from the Arizona Grain Research and Promotion Council.

Table 1. Nitrogen fertilization schedule

		N Rates lbs N/A		
Date	Stage	80	200	400
20 Nov	pre-plant	0	80	160
21 Jan	5-leaf	40	40	80
18 Feb	jointing	20	40	80
11 Mar	boot	20	40	80

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	Anthesis Date	Physio-logical Maturit y Date	Hard Vitrous Amber Count
	lbs/A	lbs/A	lbs/bu	grams	%	inches	%				%
Kronos	80	5185	63.1	58.0	8.70	34.4	0	3-14	3-22	-	15.8
	200	7805	61.4	53.4	10.6	34.2	28	3-13	3-22	-	57.6
	400	7156	61.9	52.7	12.7	33.0	58	3-14	3-22	-	80.0
Gustoe	80	6314	54.4	43.3	8.70	27.8	0	3-16	-	4-26	-
	200	7517	53.9	42.7	9.08	32.8	7	3-17	-	4-27	-
	400	4807	52.5	39.1	10.3	33.0	44	3-20	-	4-30	-

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

Variety	Sourc e	d f	Plant height	Kernel weight	Test weight	Grain yield	Grain protein
Kronos	Rep	4	NS	NS	NS	NS	NS
	N	2	NS	*	NS	**	**
	Error	8					
Gustoe	Rep	4	NS	NS	NS	NS	NS
	N	2	**	NS	**	**	NS
	Error	8					

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

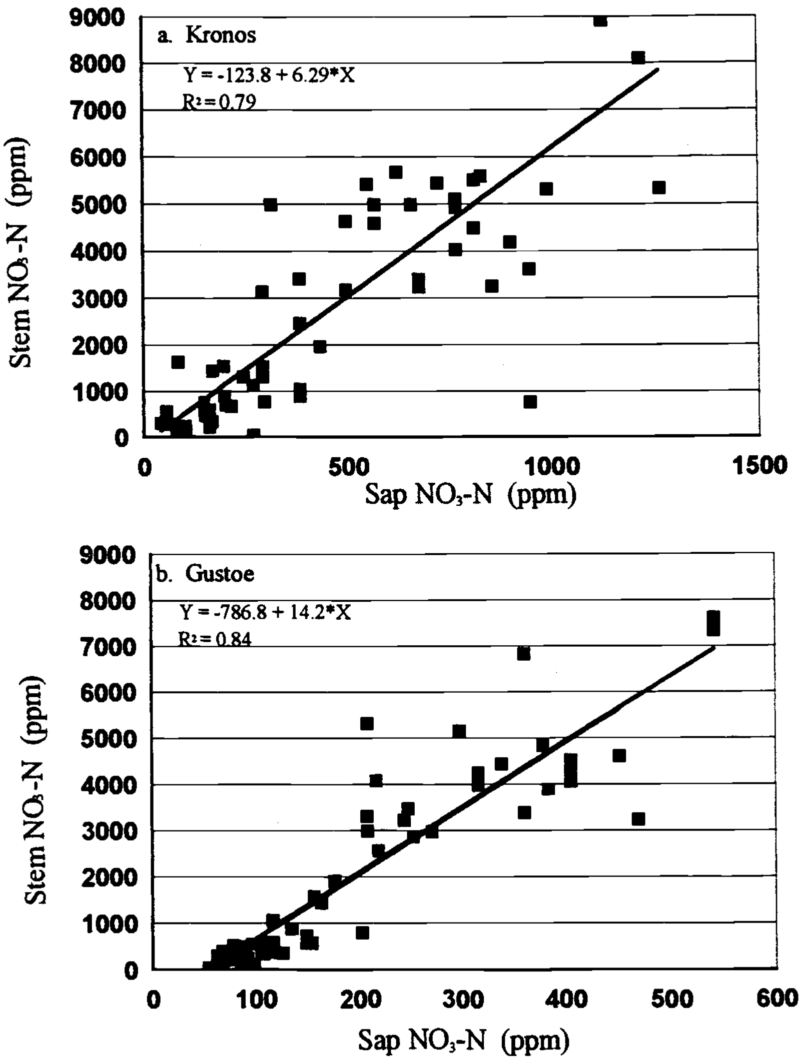

Figure 1. Linear regressions of sap vs. stem NO_3-N concentration in the lower stem, a. Kronos and b. Gustoe.

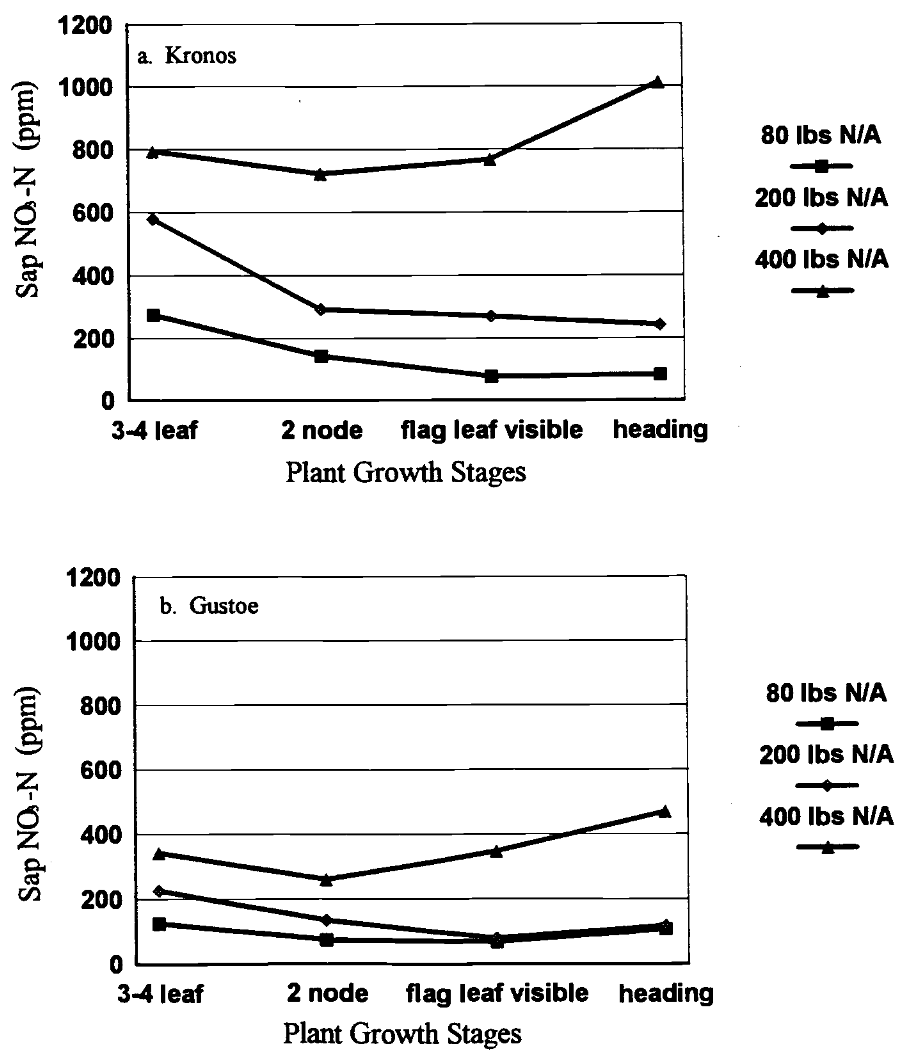

Figure 2. Sap NO_3-N throughout the growing season, a. Kronos and b. Gustoe.