Developing Sap Nitrate Tests for Durum Wheat and Barley, Maricopa, 1999

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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) analysis. 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 1998 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 4330 lbs/A to 6794 lbs/A for Kronos and 3220 lbs/A to 4533 lbs/A for Gustoe. Correlation coefficients between stem NO_3-N and sap NO_3-N were 0.76 for Kronos and 0.60 for Gustoe. Sap NO_3-N analysis can be used to determine N status during the season for Kronos. Results for the barley suggest at low concentrations of NO_3 in the lower stem, the Cardy meter may underestimate NO_3 concentrations. This may be due to changes in moisture content in the stem as the season progresses.

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 on 19 Nov., 1998. 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_2O_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 20 Nov., 12 Jan., 14 Feb., 26 Mar., and 21 Apr. About 20 inches of water were applied and 1.47 inches of rain.

Lower stem tissue was sampled from each plot on 5 Jan., 3 Feb., 24 Feb., and 16 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 stems into small pieces and then expressing the sap with an arbor press. The sap was then collected and placed on the sensing module of a calibrated Cardy NO_3 meter.

Gustoe was harvested on 12 May and Kronos was harvest on 19 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.

Data were analyzed using analysis of variance. Linear regressions were used to determine correlation coefficients for sap versus stem NO_3-N.

Results and Discussion

Grain yields were responsive to N applications up to 200 lbs N/A for Gustoe and 400 lbs N/A for Kronos (Tables 2 and 3). Grain yield was maximized at 200 lbs N/A in Gustoe (4533 lbs/A)and 400 lbs N/A in Kronos (6794 lbs/A) . Less than 10 % lodging occurred for either variety at any N rate. Grain protein was maximized at 400 lbs N/A for Kronos (13.5%) and Gustoe (10.3%). 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 at 200 lbs N/A. 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 correlated for both Kronos and Gustoe (Fig. 1). Correlation coefficients (r^2) for sap NO_3-N versus stem NO_3-N were 0.76 for Kronos and 0.60 for Gustoe. Regression equations relating these two measurements were: $Y = 52.9 + 5.22*X$ for Kronos and $Y = -34.3 + 7.54*X$ 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 for durum. Results for the barley suggest at low concentrations of NO_3 in the lower stem, the Cardy meter may underestimate NO_3 concentrations. This may be the result of lower moisture contents in the stem as the season progresses. As the moisture content changes, the correlation between stem and sap NO_3 also changes, thus making late season measurements with the Cardy meter less accurate for the barley.

Sap NO_3-N was correlated with N rate for both Kronos and Gustoe throughout the season (Fig. 2). This relationship supports 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.

Conclusions

1. Correlations between sap NO_3-N and stem NO_3-N are good for Kronos. Correlations between sap NO_3-N and stem NO_3-N are adequate at higher NO_3-N concentrations, but not at lower concentrations.

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

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Table 1. Nitrogen fertilization schedule

		N Rates lbs N/A		
Date	Stage	80	200	400
20 Nov	pre-plant	0	80	160
12 Jan	5-leaf	40	40	80
14 Feb	jointing	20	40	80
3 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	Hard Vitreous Amber Count
	lbs/A	lbs/A	lbs/bu	grams	%	inches	%	%
Kronos	80	4330	62.4	54.9	7.4	34.6	0	3.7
	200	6482	63.6	51.7	9.7	34.6	7	39.1
	400	6794	61.4	45.2	13.5	32.4	8	98.7
Gustoe	80	3220	52.7	43.6	7.65	30.4	1	-
	200	4533	52.1	39.9	8.38	27.8	0	-
	400	3721	50.3	36.1	10.3	28.0	0	-

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	HVAC
Kronos	Rep	4	NS	NS	NS	NS	NS	NS
	N	2	NS	**	**	**	**	**
	Error	8						
Gustoe	Rep	4	NS	NS	NS	NS	NS	-
	N	2	NS	**	*	**	NS	-
	Error	8						

*,**Significant at P≤ 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.

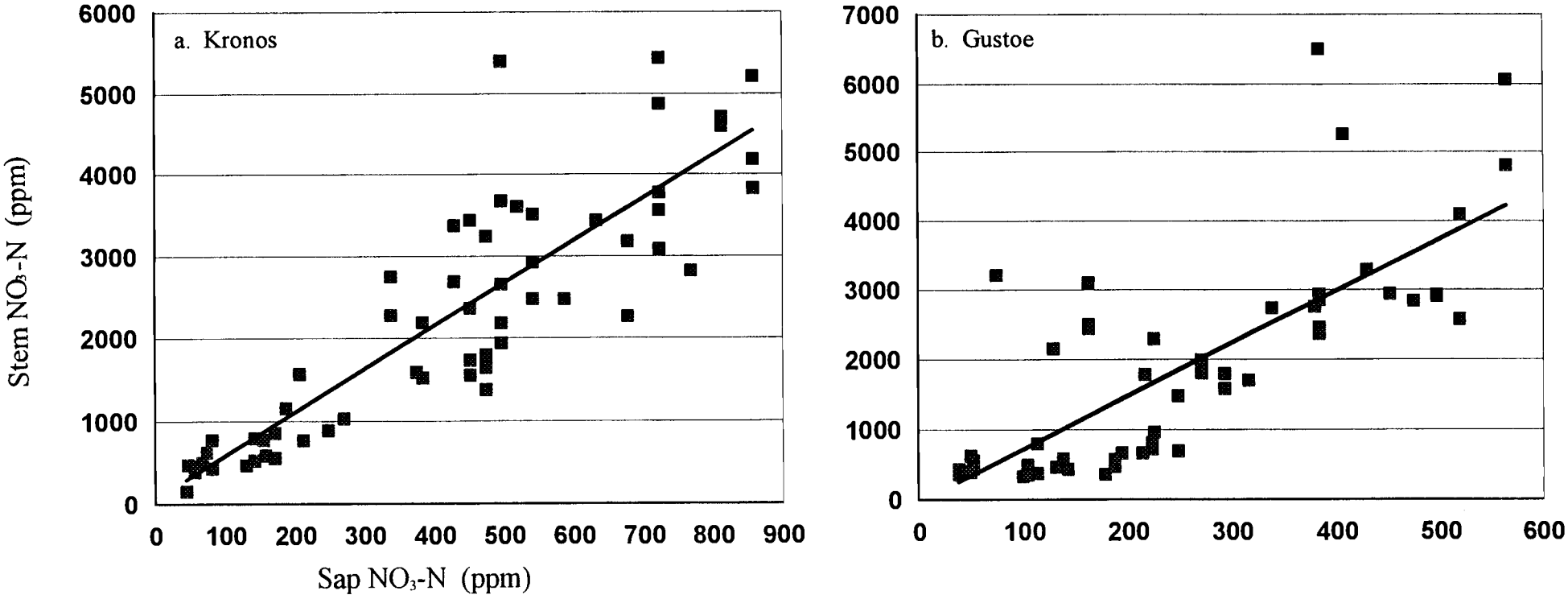

Figure 2. Sap NO3-N throughout the growing season, a. Kronos and b. Gustoe.