Late Season Tissue Tests for Critical Grain Protein Content in Durum, Maricopa, 1998

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Abstract

Proper nutrient management is necessary for successful production of durum wheat in the desert. If grain protein content is less than 13%, significant economic losses to growers can result. Late season nitrogen (N) fertilization can resolve this problem, but tissue test guidelines have not yet been established. The objectives of this study were to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N, (ii) determine the minimum NO_3-N concentration in lower stem tissue at heading associated with the critical grain protein content, and (iii) determine whether flag leaf, head, or whole plant total N at heading can be used as indicators of N status. In November 1997 two varieties of durum wheat, Mohawk and Kronos, were planted at the Maricopa Agricultural Center. Five N rates (0, 100, 200, 300, and 400 lbs/A) were applied in four split applications. Each treatment was replicated three times in a randomized complete block design. Samples were collected from the lower stem, flag leaf, head, and whole plant from each plot at heading and analyzed for total N. Grain yields ranged from 1663 to 6916 lbs/A for Mohawk and 1529 to 7060 lbs/A for Kronos. Maximum yields were achieved at 200 lbs N/A for both varieties. Grain protein content averaged 8.6% to 13.4% (Mohawk) and 9.1% to 13.8% (Kronos). Correlation coefficients between stem NO_3-N and sap NO_3-N were 0.96 for Mohawk and 0.97 for Kronos. Lower stem sap critical NO_3-N concentration in Kronos is 1100 ppm NO_3-N and 1700 ppm NO_3-N for Mohawk at heading for a grain protein content of 13%. Lower dried stem tissue critical NO_3-N concentration in Kronos is 5500 ppm NO_3-N and 7500 ppm NO_3-N for Mohawk for a grain protein content of 13%. Nitrogen concentration in flag leaves, heads, and whole plants were highly correlated with N rate. Therefore, N concentration in these tissues could potentially be used as indicators of late-season N status.

Introduction

A grain protein content of 13% for durum is a standard in quality throughout the grain industry. In the Southwest, irrigated durum has a tendency to have a grain protein content less than the critical value. Research has proven that late season N fertilization can boost the grain protein content above 13% particularly with certain varieties (Ottman et al., 1996). However, growers are hesitant to use late season N applications because of cost. Tissue tests can aid growers in making decisions concerning nutrient management. Traditionally, stem tissue tests are performed in commercial labs and recommendations are made to the grower. This process can delay N applications. Rapid NO_3 tests, such as sap NO_3 analysis, are being developed to enable growers to determine N status of crops in the field. This information can save time, money, and increase yields due to timely N application.

Plant tissues other than stems have been used in small grains as indicators of N status. Whole plant N concentration at GS 5 was the best predictor of grain yield in a study conducted in Alabama (Reeves et al., 1993). Another study found that the protein concentration in the head could be used as an indicator of the final grain protein (Noaman et al.,

1988). These studies indicate that late season tissue test guidelines could be developed for whole plant, flag leaf and head tissue N. These other tissues could be analyzed for N status determination or compared to either stem or sap analysis.

The objectives of this study are to: (i) correlate NO_3-N in dried stem tissue with sap NO_3-N, (ii) determine the minimum NO_3-N concentration in lower stem tissue at heading associated with the critical grain protein content, and (iii) determine whether flag leaf, head, or whole plant total N at heading can be used as indicators of the N status of the plant.

Materials and Methods

Two varieties of durum wheat 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, 100, 200, 300, and 400 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 available N. Soil samples collected before planting contained 11 ppm NH_4-N plus NO_3-N and 9 ppm available P. Before planting, P was broadcast at a rate of 50 lbs P_2O_5/A as 0-45-0 and incorporated. All N fertilizer was hand-applied as urea 46-0-0 in four split applications (Table 1).

Mohawk and Kronos durum were planted using a grain drill with a 6 inch spacing at a seeding rate of 120 lbs/A. The plots were border-flood irrigated. 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 25 Mar. at the heading stage for stem and sap NO_3-N analysis. Flag leaves, heads, and whole plants were also sampled from each plot on the same day. The stem samples were refrigerated for 24 hours. 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 then ground, extracted and analyzed for NO_3 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 placed on the sensing module of a calibrated Cardy meter. The flag leaf, head, and whole plant samples were dried at 65° C for one week, ground, and analyzed for total N using the Kjeldhal method.

Heading, anthesis, and physiological maturity dates were noted for each plot. A 5 ft x 14 ft area in each plot was harvested on 27 May using a small plot combine. Grain yield was adjusted to a 12% moisture basis. Test weight, kernel weight, hard vitreous amber count, grain protein content and plant height were determined at harvest (Table 2). No lodging occurred in any of the treatments. Kernel weight and hard vitreous amber count were determined from a 10 g hand picked sample.

Data were analyzed for 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 yield and hard vitreous amber count for both varieties were highly responsive to N rate (Table 2). The grain yield was maximized at 200 lbs N/A in both the Mohawk (8020 lbs/A) and Kronos (7424 lbs/A). Grain protein, however, was maximized at 400 lbs N/A for both Mohawk (13.4%) and Kronos (13.8%). Hard vitreous amber count should be > 90% to meet industry standards (Ottman et al., 1997). A value of 90% was achieved for Mohawk with 400 lbs N/A and for Kronos at 300 lbs N/A. Therefore, in this study, 300-400 lbs N/A were sufficient to maximize yield and grain quality in Mohawk and Kronos without N applications at flowering.

Correlation coefficients (r^2) for sap versus stem NO_3-N were high for Mohawk (0.96) and Kronos (0.97) at heading (Figure 1). These high correlation coefficients indicate that sap NO_3-N can be used to determine the nitrogen status of the plant at heading for both varieties.

The critical NO_3-N concentration in the sap associated with >13% grain protein is 1700 ppm at heading for Kronos and 1100 ppm at heading for Kronos (Figure 2). The corresponding critical NO_3-N concentration for the stem tissue is 8000 ppm for Mohawk and 6000 ppm for Kronos (Figure 3). If tissue NO_3-N is above the critical concentration, no further N application is needed before harvest. If NO_3-N falls below the critical concentration, grain protein below 13% will likely result unless additional N is added. Grain protein content is affected by N rate, and other factors such as water availability and temperature.

The total N contents of the flag leaves, heads, and whole plants were related to N rate (Table 3). Flag leaf N and whole plant N may be useful indicators of plant N status at heading (Figures 4 and 5). Head total N was significantly affected by N rate for Kronos but not for Mohawk (Figure 6). These parameters are correlated with grain protein content and yield, therefore they could be used as indicators of the nitrogen status for N management.

Conclusions

Three conclusions can be made from these preliminary results:

1. Correlations between sap NO_3-N and stem NO_3-N at the heading stage were good ($r^2 > 0.96$) for both Mohawk and Kronos.

2. Critical concentrations for > 13% grain protein are 1700 ppm NO_3-N in sap and 8000 ppm NO_3-N in stem tissue for Mohawk and 1200 ppm NO_3-N in sap and 6000 ppm NO_3-N in stem tissue in Kronos.

3. Whole plant, flag leaf, and head samples may be useful as indicators of durum N status at heading.

References

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Acknowledgments

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Table 1. Nitrogen fertilizer schedule.

Date	Stage	Nitrogen Rates				
		0	100	200	300	400
		lbs/acre				
20 Nov	pre-plant	0	40	80	120	160
21 Jan	5-leaf	0	20	40	60	80
18 Feb	jointing	0	20	40	60	80
11 Mar	heading	0	20	40	60	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	HVA C
	lbs/A	lbs/A	lbs/bu	grams	%	inches	%			%
Mohawk	0	1663	63.8	52.0	8.62	30	0	3-14	3-21	36.9
	100	6835	63.6	54.0	9.6	32	0	3-14	3-23	52.6
	200	8020	63.4	52.6	10.8	36	7	3-17	3-24	80.5
	300	6868	62.4	52.3	12.8	37	63	3-19	3-26	86.8
	400	6916	62.0	52.6	13.4	34	63	3-19	3-26	93.0
Kronos	0	1529	63.6	52.9	9.1	27	0	3-15	3-22	15.0
	100	4596	63.2	57.8	8.9	36	0	3-14	3-22	12.8
	200	7424	63.0	53.7	11.0	34	15	3-16	3-24	46.7
	300	7157	61.6	50.9	13.3	34	50	3-17	3-25	92.2
	400	7060	61.8	52.0	13.8	35	48	3-18	3-26	88.9

Table 3. Analysis of variance summary for plant height, kernel weight, test weight, grain yield, grain protein, whole plant total nitrogen, head total nitrogen, flag leaf total nitrogen, and hard vitreous amber count as affected by nitrogen rate.

Variety	Source	df	Plant ht.	Kernel wt.	Test wt.	Yield	Protein	Total N			HVAC
								w.p.	head	f.l.	
Mohawk	Rep	2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	N	4	NS	NS	*	**	**	**	NS	**	**
	Error	8									
Kronos	Rep	2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	N	4	**	NS	*	**	NS	**	**	**	**
	Error	8									

*,**Significant at P ≤ 0.05, and 0.01 respectively; NS, not significant.

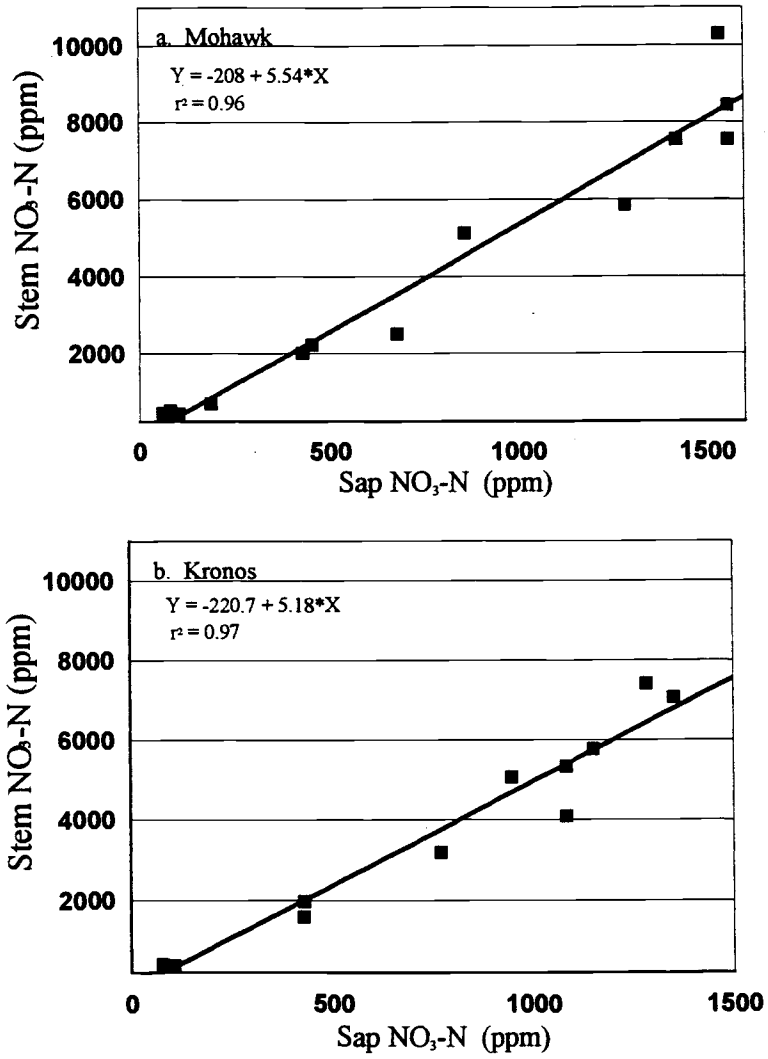

Figure 1. Linear regression of sap vs. stem NO_3-N concentration in the lower stem, a. Mohawk and b. Kronos.

Figure 2. Sap nitrate-N vs. grain protein for Mohawk and Kronos.

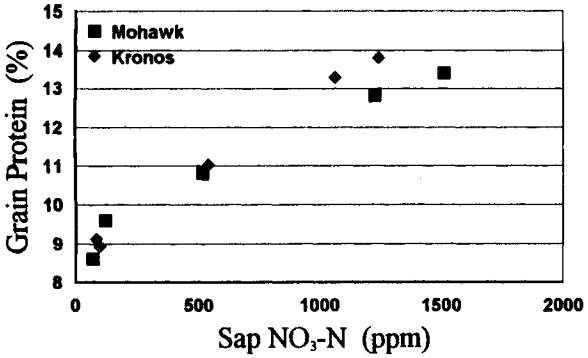

Figure 3. Stem nitrate-N vs. grain protein for Mohawk and Kronos.

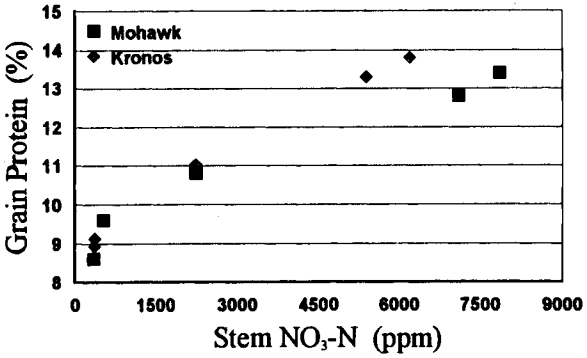

Figure 4. Flag leaf total N vs. grain protein for Mohawk and Kronos.

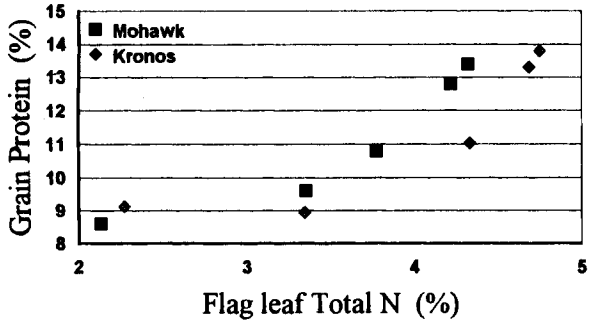

Figure 5. Whole plant total N vs. grain protein for Mohawk and Kronos.

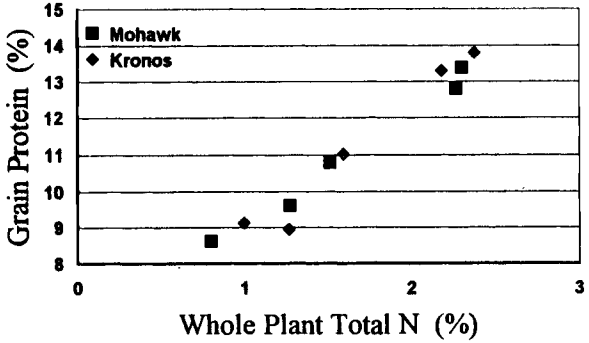

Figure 6. Head total N vs. grain protein for Mohawk and Kronos.