

# Late Season Tissue Tests for Critical Grain Protein Content in Durum, Maricopa, 1999

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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  $\text{NO}_3\text{-N}$  in dried stem tissue with sap  $\text{NO}_3\text{-N}$ , (ii) determine the minimum  $\text{NO}_3\text{-N}$  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 1998 three varieties of durum wheat, Mohawk, Kronos, and Westbred 881, 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 1937 to 6174 lbs/A for Mohawk, 1706 to 6161 lbs/A for Kronos, and 864 to 5162 lbs/A for Westbred 881. Grain protein content averaged 5.7% to 14.0% for Mohawk, 7.3% to 13.7% for Kronos, and 7.9% to 14.5% for Westbred 881. Correlation coefficients between stem  $\text{NO}_3\text{-N}$  and sap  $\text{NO}_3\text{-N}$  were 0.88 for Mohawk, 0.94 for Kronos, and 0.98 for Westbred 881. The critical  $\text{NO}_3\text{-N}$  concentration in the sap associated with >13% grain protein was 550-770 ppm at heading for three varieties. Lower dried stem tissue critical  $\text{NO}_3\text{-N}$  concentration for Kronos was 4500 ppm  $\text{NO}_3\text{-N}$ , 4700 ppm  $\text{NO}_3\text{-N}$  for Mohawk, and 3600 ppm  $\text{NO}_3\text{-N}$  for Westbred 881 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  $\text{NO}_3$  tests, such as sap  $\text{NO}_3$  analysis, are being developed to enable growers to determine N status of crops in the field. This information can save time, money, and increase yield and quality 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). Protein concentra-tion

in heads has been used as an indicator of 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  $\text{NO}_3\text{-N}$  in dried stem tissue with sap  $\text{NO}_3\text{-N}$ , (ii) determine the minimum  $\text{NO}_3\text{-N}$  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 on 19 Nov, 1998. 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  $\text{NH}_4\text{-N}$  plus  $\text{NO}_3\text{-N}$  and 9 ppm available P. Before planting, P was broadcast at a rate of 50 lbs  $\text{P}_2\text{O}_5\text{/A}$  as 0-45-0 and incorporated. All N fertilizer was hand-applied as urea (46-0-0) in four split applications.

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 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 for stem and sap  $\text{NO}_3\text{-N}$  analysis on 24 Mar. at the heading stage. 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  $65^\circ\text{C}$  for 48 hours. The dried samples were ground, extracted and analyzed for  $\text{NO}_3$  using an ion-selective 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  $\text{NO}_3$  meter. The flag leaf, head, and whole plant samples were dried at  $65^\circ\text{C}$  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. Kernel weight and hard vitreous amber count were determined from a 10 g hand picked sample.

Data were analyzed for analysis of variance. Linear regressions were used to determine correlation coefficients for sap versus stem  $\text{NO}_3\text{-N}$ .

## Results and Discussion

Grain yield, protein, plant height, and hard vitreous amber count for all varieties were highly responsive to N rate (Table 2). The grain yield was maximized at 300 lbs N/A in both the Kronos (6161 lbs/A) and Westbred 881 (5162 lbs/A) and at 200 lbs N/A for Mohawk (6174 lbs/A). Grain protein, however, was maximized at 400 lbs N/A for Mohawk (14.0%), Kronos (13.7%), and Westbred 881 (14.5%). Grain yield decreased at the highest N rate due to lodging, whereas for grain protein the more N added the greater the protein. Hard vitreous amber count should be  $> 90\%$  to meet industry standards (Ottman et al., 1997). Values of 90% were achieved for Mohawk and Westbred 881 with 200 lbs N/A and Kronos at 300 lbs N/A. Therefore, in this study, 300-400 lbs N/A were sufficient to maximize yield and grain quality in all varieties without N applications at flowering.

Correlation coefficients ( $r^2$ ) for sap versus stem  $\text{NO}_3\text{-N}$  were high for Mohawk (0.88), Kronos (0.94), and Westbred 881 (0.98) at heading (Figure 1). These high correlation coefficients indicate that sap  $\text{NO}_3\text{-N}$  can be used to determine the

nitrogen status of the plant at heading for both varieties.

The critical NO<sub>3</sub>-N concentration in the sap associated with >13% grain protein was 550-770 ppm at heading for three varieties (Figure 2). The corresponding critical NO<sub>3</sub>-N concentration for the stem tissue was 4500 ppm for Mohawk, 4700 ppm for Kronos, and 3600 ppm for Westbred 881 (Figure 3). If tissue NO<sub>3</sub>-N is above the critical concentration, no further N application should be needed before harvest. If NO<sub>3</sub>-N falls below the critical concentration, grain protein < 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, whole plant N, and head N may be useful indicators of plant N status at heading (Figures 4,5, and 6). These parameters were 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<sub>3</sub>-N and stem NO<sub>3</sub>-N at the heading stage were good ( $r^2 > 0.88$ ) for all varieties.
2. Critical concentrations for > 13% grain protein were 650 ppm NO<sub>3</sub>-N in sap and 4500 ppm NO<sub>3</sub>-N in stem tissue for Mohawk, 770 ppm NO<sub>3</sub>-N in sap and 4700 ppm NO<sub>3</sub>-N in stem tissue in Kronos, and 550 ppm NO<sub>3</sub>-N in sap and 3600 ppm NO<sub>3</sub>-N in stem tissue for Westbred 881.
3. Whole plant, flag leaf, and head samples may be useful as indicators of durum N status at heading.

## References

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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
12 Jan	5-leaf	0	20	40	60	80
14 Feb	jointing	0	20	40	60	80
3 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	Hard Vitreous Amber Count
	lbs/A	lbs/A	lbs/bu	grams	%	inches	%
Mohawk	0	1937	61.9	51.1	5.7	29	8.5
	100	5355	64.4	55.1	8.2	36	54.9
	200	6174	64	51.1	10.8	36	94.5
	300	5865	61.6	47.4	12.8	36	98.6
	400	4640	61.5	47.9	14.0	36	98.6
Kronos	0	1706	62	49.4	7.3	27	6.9
	100	4153	63.1	57.4	7.2	34	3.0
	200	5522	63.3	49.4	9.7	34	48.5
	300	6161	62.1	43.9	12.8	34	96.4
	400	3598	60.6	42.6	13.7	35	97.6
Westbred 881	0	864	61.1	46.7	7.9	29	12.5
	100	3612	62.7	56.1	8.3	36	24.3
	200	5078	62.9	51.8	11.3	37	93.8
	300	5162	60.7	46	13.8	37	100.0
	400	4510	59.8	44.8	14.5	37	99.3

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
								Plant	Head	Flag leaf	
Mohawk	Rep	2	NS	NS	NS	NS	NS	*	NS	NS	NS
	N	4	**	**	**	**	**	**	**	**	**
	Error	8									
Kronos	Rep	2	NS	NS	NS	NS	*	NS	NS	NS	NS
	N	4	**	**	*	**	**	**	**	**	**
	Error	8									
Westbred 881	Rep	2	>*	NS	NS	NS	**	NS	NS	NS	NS
	N	4	**	NS	**	**	**	**	**	**	**
	Error	8									

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

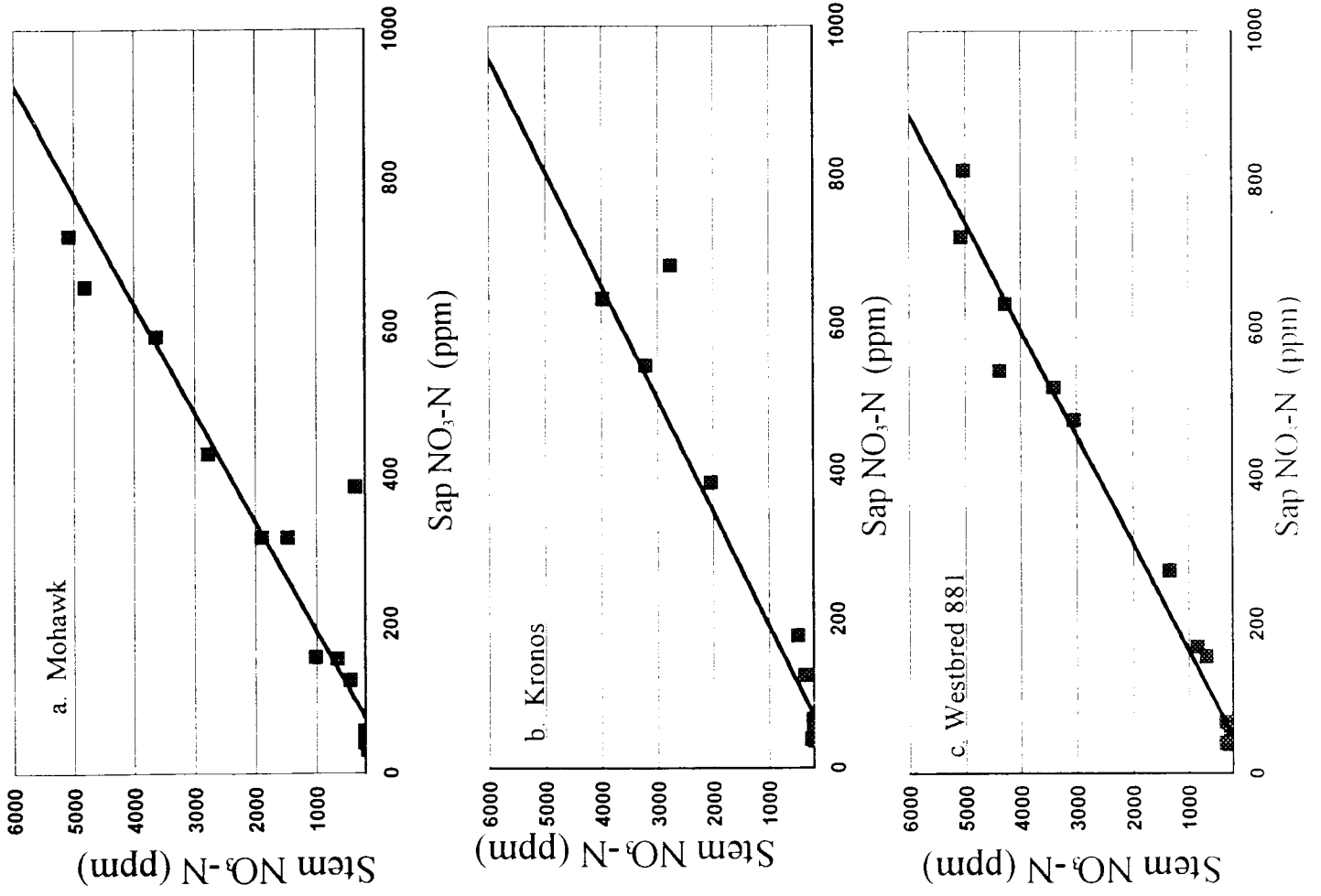


Figure 1. Linear regression of sap vs stem  $\text{NO}_3\text{-N}$  concentration in the lower stem, a Mohawk, b Kronos and c Westbred 881.

Figure 2. Sap nitrate-N vs. grain protein for Mohawk, Kronos, and Westbred 881.

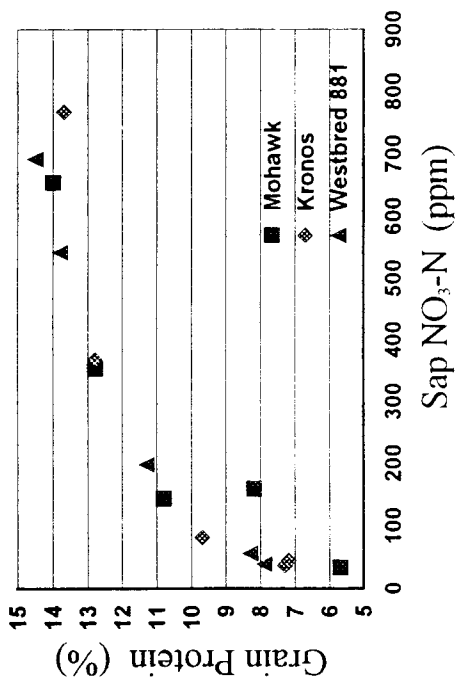


Figure 3. Stem nitrate-N vs. grain protein for Mohawk, Kronos, and Westbred 881.

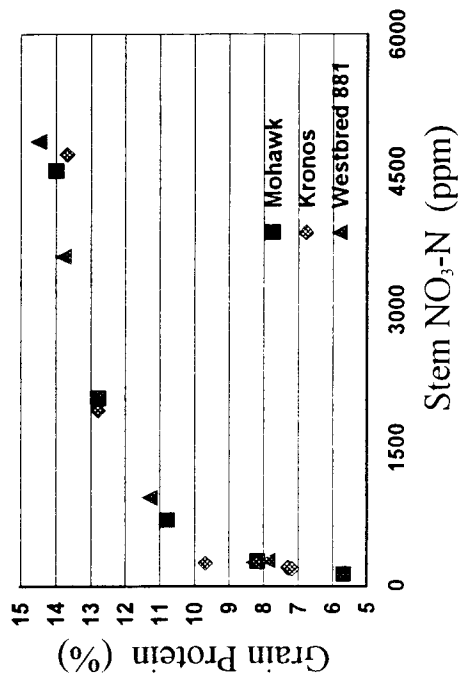


Figure 4. Flag leaf total N vs. grain protein for Mohawk, Kronos, and Westbred 881.

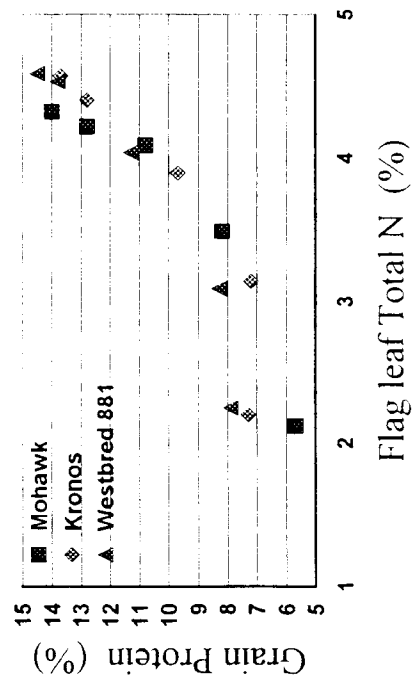


Figure 5. Whole plant total N vs. grain protein for Mohawk, Kronos, and Westbred 881.

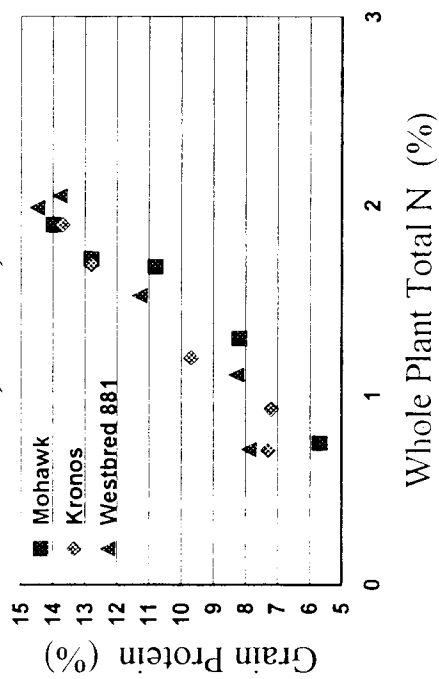


Figure 6. Head total N vs. grain protein for Mohawk, Kronos, and Westbred 881.

