

Predicting the Nitrogen Requirements of Irrigate Durum Wheat in Graham County Using Soil and Stem Nitrate Analysis

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ABSTRACT

The high yielding spring wheats grown in Arizona usually require applications of fertilizer nitrogen (N) to achieve optimum grain yields and acceptable quality. The University of Arizona's currently recommended procedure (preplant soil plus periodic stem tissue analysis for NO₃-N to predict the N needs of wheat) is not widely used by Graham County growers for various reasons. A nitrogen fertility trial was conducted at the Safford Agricultural Center during the 1986-87 crop year to: 1) examine the relationships between basal stem nitrate-N levels, grain yields of durum wheat, and N fertilizer rates; and 2) to test the accuracy of the recommended procedure for predicting the N needs of durum wheat. Five rates of N from 0 to 419 lbs N/acre were applied in three split applications. One additional N treatment was made as indicated by the current University of Arizona procedure. Maximum grain yields of 5500 to 6200 lbs/acre and protein levels in excess of 14.5% were attained with the application of at least 186 lbs N/acre. An untimely early season irrigation induced a temporary N deficiency condition for all plots, which may have kept grain yields below the maximum yield possibility for this site. In spite of this, the amount of N predicted by the University of Arizona procedure (197 lbs N/acre) did attain an adjusted economic return which was not significantly different from the maximum numerical yield that was achieved for any of the other N treatments.

INTRODUCTION

Nitrogen (N) is the nutrient most often limiting small grain production in Graham County, as well as the remainder of Arizona. Deficiencies of N early in the season result in reduced plant biomass accumulation and consequently, reductions in final grain yield. Nitrogen deficiencies occurring during the reproductive period, i.e. after heading, tend to result in lower grain protein levels and higher incidence of non-vitreous starch inclusions in the wheat kernels, known as yellow berry.

The use of soil and plant tissue analysis for nitrate content have proven useful in estimating the N status of a particular wheat crop and can be effectively used to help predict the quantity of N fertilizer required to attain maximum yield and quality, but still avoid excessive N applications (Doerge and Ottman, 1986; Gardner and Jackson, 1976; Pennington et al., 1983).

However, soil and plant analysis are not widely used in Graham County due to the remoteness of commercial labs and grower uncertainty as to the accuracy and reliability of these tests. A nitrogen fertility field trial was conducted at the Safford Agricultural Center during the 1986-87 crop year to achieve the following objectives: 1) to determine the response of stem nitrate-N levels and grain yields of durum wheat to a wide range of N fertilizer

applications on a soil initially very low in nitrate-N; and 2) to test the accuracy of the soil and tissue testing procedure currently recommended by the University of Arizona for predicting the N needs of durum wheat grown on a clay loam soil when properly managed for "maximum yield" under Graham County conditions.

A third objective of the experiment, which will not be discussed in this report, is to establish plots with a wide range of residual soil nitrate-N levels for future work designed to evaluate the relative efficiency of residual and fertilizer N.

METHODS AND MATERIALS

A nitrogen fertility trial with "Aldura" durum spring wheat was conducted on a Pima clay loam (fine silty, mixed, thermic, Typic Torrifuvent) at the Safford Agricultural Center. The plot area had been previously cropped with unfertilized Sudan grass to reduce the level of available N in the rooting zone. Chemical properties of the surface soil were pH, 8.1; sodium bicarbonate extractable P, 8 ppm; electrical conductivity, 2.9 ds/m; ammonium acetate extractable sodium, 8.0 meq/100g; free CaCO₃, high; and computed exchangeable sodium percentage (ESP) 27.3%.

Prior to planting, composite soil samples from 0-1 and 1-2 foot depth increments were obtained and analyzed for nitrate and ammonium-N using 1N KCl extraction and steam distillation. Nitrate-N values were 1.3 and 1.4 ppm in the 0-1 and 1-2 foot samples, respectively. The NH₄-N contents of the corresponding samples were 1.7 and 2.8 ppm, respectively.

The rates, timing, and N sources of the six treatments used are listed in Table 1. Forty pounds of P₂O₅ per acre was banded at planting on all plots, either as triple super phosphate (0-45-0) for Treatment 1 or as ammonium phosphate-sulfate (16-20-0) for Treatments 2-6.

Table 1. Rates, timing and nitrogen sources applied to "Aldura" wheat grown on a Pima clay loam.

	Preplant	Banded	Joint	Heading	Total N
Treatment*	21-0-0	16-20-046-0-0.....		Applied
	-----lbs N/acre-----				
1	0	0	0	0	0
2	0	32	45	30	107
3	35	32	89	30	186
4	68	32	133	30	263
5	135	32	222	30	419
6	50	32	65	50	197

* 21-0-0, 16-20-0, and 46-0-0 refer to ammonium sulfate, ammonium phosphate-sulfate, and urea, respectively.

The N rates for treatments 1-5 were preassigned; however, the rate for treatment 6 were based on preplant soil, plus periodic stem, nitrate tests taken throughout the growing season. All mid-season applications of N were hand-broadcast onto dry soil no more than two hours before irrigation. Seed was drilled into flat borders at the rate of 200 lbs/acre on December 23, 1986 and irrigated up. Individual plots were 15.5 x 45 feet and all treatments were replicated four times in a randomized complete block design.

A total of about 29 inches of water containing approximately 14 lbs NO₃-N/acre was applied in five irrigations. Rainfall during the growth period was 3.4 inches. Irrigations were made on 23 December, 19 February (3-leaf stage), 3 April (joint), 17 April (boot) and 1 May (heading). No pesticides of any kind were applied. Weed control was accomplished by hand rouging.

Stem tissue samples were taken on 6 March (3-4 leaf stage), 3 April (joint), and 17 April (boot). The plant part sampled was the stem between ground level, and the seed for samples taken prior to jointing and the two inches of stem just above ground level for the remaining dates. Samples were dried at 60°C, ground to <30 mesh and analyzed for NO₃-N content, using a specific ion electrode.

Using a small-plot combine, grain yields were measured on 24 June from a 6 x 41 foot harvested area. A subsample of grain was dried, ground and analyzed for total ammonium plus organic-N, using Kjeldahl digestion and steam distillation. A subsample of grain from each plot was separated into vitreous and non-vitreous kernels for determination of percent yellow berry. Bushel weights were also determined on subsamples from all plots.

RESULTS AND DISCUSSION

The application of 186 lbs N/A resulted in maximum grain yield. Applications of N above this rate resulted in a non-significant trend toward increased grain yields, and increasing protein contents. However, this rate of N application had no effect on bushel weight or percent yellow berry (Table 2). No lodging was observed in any of the plots.

Table 2. Growth characteristics of "Aldura" wheat receiving various N treatments.

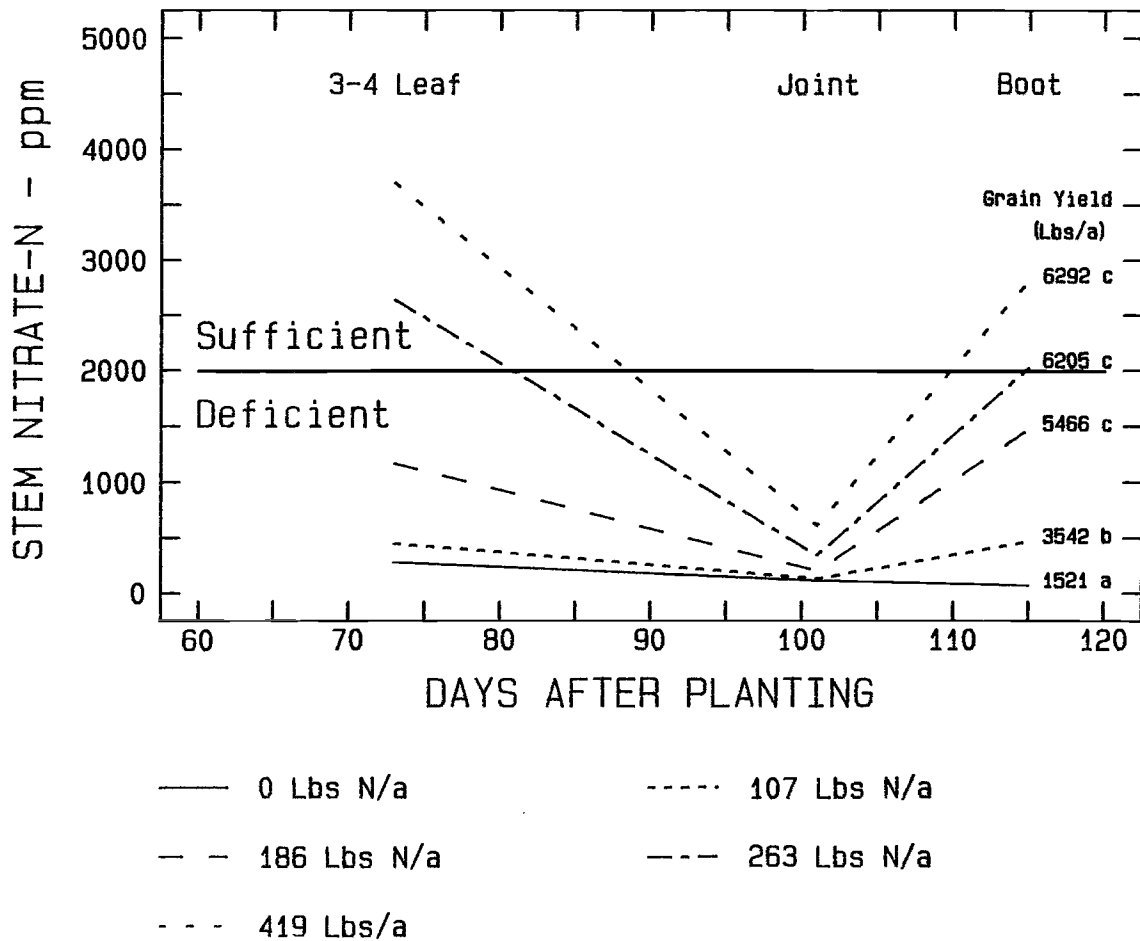
Treatment No.	Grain Yield*	Grain Protein	Yellow berry	Bushel Weight
	lbs/acre	%	%	lbs/bu
1	1521 a#	12.4 a	6 b	57.4 a
2	3541 b	13.8 b	1.2 a	57.8 ab
3	5466 c	14.9 c	0.5 a	59.1 bc
4	6205 c	15.2 c	0.2 a	59.2 bc
5	6292 c	16.1 d	0.2 a	59.8 c
6	5675 c	14.6 c	1.0 a	59.4 bc
LSD 0.05	753	0.7	2.6	1.3

* grain yields were adjusted to 10% moisture and represent clean grain weights.

means followed by the same letter within each column are not significantly different at the 5% level according to the SNK method.

Figure 1 shows the pattern of nitrate-N content in basal wheat stems throughout the growing season for treatments 1-5. Gardner and Jackson (1976) report values below 2000 ppm NO₃-N at the three diagnostic growth stages represent N-deficient conditions for irrigated spring wheat. This is consistent with observations of pale, yellowish-green colored plant foliage in all treatments at the joint growth stage. It was felt that this N-deficient condition was induced by an untimely early irrigation at the 3-leaf stage. The early irrigation probably resulted in leaching soluble NO₃-N below the root zone of the young plants. Subsequent applications of N at the joint stage did succeed in restoring adequate N nutrition in at least treatments four and five by the boot-stage sampling date (Figure 1). Based on this information, it seems likely that the >6000 lbs/a grain yields obtained in this trial do not represent the maximum yield possibility for this site. These results do strongly underscore the importance and interdependence of water and nitrogen management.

Figure 1. Seasonal basal stem nitrate-N levels measured in "Aldura" wheat receiving various N application rates.



The ultimate evaluation of a fertility experiment such as this involves determination of the net economic return associated with each fertilizer treatment. Under the conditions of this experiment and using the commodity costs indicated, the highest adjusted economic return occurred when N was supplied at a rate of about 186 to 277 lbs/acre (Table 3). Application of rates below this range resulted in significant reductions in yield and quality. On the other hand, supplying N above this range did not significantly increase grain yields enough to offset the cost of additional fertilizer N.

Table 3. Estimated adjusted economic returns from "Aldura" wheat receiving various rates of N.

Treatment No.	N Rate lbs/a	Estimated N Cost# \$/lb	Adjusted Economic Return* \$/a
1	0	0	84 a+
2	107	44.25	162 b
3	186	70.13	258 cd
4	263	95.21	277 d
5	419	146.04	231 c
6	197	75.05	265 cd

LSD .05

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Assumes costs of N derived from ammonium phosphate-sulfate, ammonium sulfate, and urea to be 0.75, 0.40, and 0.27 per pound respectively.

* Assumes prices of 6.00, 5.75, and 5.50 per cwt. for grain with protein contents of above 14%, 13.0 - 13.9%, and below 13.0% respectively.

+ Means followed by the same letter are not significantly different at the 0.5 level according to the SNK method.

Because of the problem with scheduling of the second irrigation and the inability to apply N prior to the joint growth stage, it is not felt that the currently recommended soil and tissue testing procedure used to schedule N applications for Treatment 6 was adequately tested for accuracy in this trial.

Nonetheless, the adjusted economic return associated with this treatment was not significantly different from the maximum numerical economic yield that was achieved in Treatment four. This strongly suggests that this method for predicting optimum levels of N fertilizer for durum wheat production in Graham County does hold promise. Further evaluation under optimum growing conditions is needed to verify this finding.

REFERENCES

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