Improved Late Season Nitrogen Fertilizer Management With Irrigated Durum Wheat Using Stem Nitrate Analyses

T.A. Doerge and M.J. Ottman

Abstract

A field experiment was conducted on a Trix clay loam at the Maricopa Agricultural Center to 1) determine the optimum rates of late season N needed to achieve optimum yield and quality of irrigated durum wheat in conjunction with varying rates of early season N, and 2) to evaluate the usefulness of stem NO_3-N analysis in predicting the late season N rates which optimize grain production but minimize the potential for nitrate pollution of groundwater. The application of 75, 150 and 300 lbs. N/a during vegetative growth resulted in wheat with highly deficient, slightly deficient and excessive N status at the boot stage as indicated by stem NO_3-N analysis. The application of 60 lbs. N/a at heading to highly N-deficient and slightly N-deficient wheat resulted in grain protein levels of 12.7 and 14.3 % respectively but had little effect on grain yield. Applications from 0 to 60 lbs. N/acre at heading to wheat which had previously received excessive N did not affect grain yield but did increase grain protein levels from 15.2 to 17.4%. The use of stem NO_3-N analysis appears to be a useful tool in predicting the minimum N rate to be applied during the early reproductive period to insure acceptable levels of grain protein at harvest in cases where N status during the vegetative period was not highly deficient.

Introduction

The adequacy of nitrogen (N) supplies during the vegetative growth of durum wheat has the greatest effect on biomass accumulation and grain yield while the crop's N status during the grain filling period has the most influence on grain protein content.

Applications of N between heading and the soft dough stage have been shown to increase grain protein levels at harvest although there is little information currently available to help predict the minimum quantity of late season N needed to achieve optimum yield and quality of durum wheat. It is expected that the N status of the crop as it enters the grain-filling period is the best indicator of late season N fertilizer needs. These applications of N should boost protein content to acceptable levels without resulting in excessive and potentially polluting levels of residual nitrate-nitrogen (NO_3-N) remaining in the soil following harvest.

The use of stem NO_3-N analysis between the boot stage and early heading has shown potential to be a useful tool in assessing the N status of the crop immediately prior to the grain-filling period (Doerge et al., 1989 and Doerge and Ottman, 1990). A field experiment was conducted at the Maricopa Agricultural Center in 1990-91 to 1) evaluate the effects of early season N rates on durum wheat stem NO_3-N content just prior to heading, and 2) to determine the optimum rates of late season N needed to achieve optimum yield and quality of durum wheat in conjunction with varying rates of early season N.

Materials and Methods

This experiment was conducted on a Trix clay loam [fine loamy, mixed (calcareous), hyperthermic Typic Torrifluvent]. The chemical characteristics of this site were; NO_3-N, 3.0 ppm; pH, 7.5; electrical conductivity, 2.5 dS/m. On 27 November, 1990, 'Aldura' wheat was drilled into flat basins at the rate of about 150 lbs./a and irrigated. A uniform application of 100 lbs. P_2O_5/a as triple superphosphate (0-45-0) was broadcast and disked into the top 4 to 6 inches of soil prior to planting. The timing and rates of three early-season N treatments are listed in Table 1. These rates were based on previous experience at this site and were designed to provide deficient, sufficient and excessive N to the crop throughout the vegetative growth period. These N rates were applied to four 9 x 33 foot plots within each of four replications. Preplant N was supplied as ammonium sulfate while all midseason N applications were derived from urea. All N applications were hand broadcast onto dry soil immediately prior to seeding and/or irrigation events.

Table 1. Rates and timing of deficient, sufficient and excessive early season N treatments applied to 'Aldura' durum wheat grown on a Trix cl.

Treatment	Nitrogen Applied			
	Preplant	5-6 Leaf	Boot	Total
	---------- lbs./a ----------			
Deficient N	20	30	25	75
Sufficient N	65	50	35	150
Excessive N	100	125	75	300

At heading four additional N rates were applied in a completely randomized factorial design to the four plots within each replication which had initially received 75, 150 or 300 lbs. N/a during vegetative growth. These late season N rates were 0, 15, 30 and 60 lbs. N/a supplied from urea.

Basal stem tissue samples were collected on 17 January at the 3 to 4-leaf stage, and then again at the jointing (21 February) and boot (26 March) growth stages according to the method described by Knowles et al. (1989a). Tissue samples were dried, ground to pass a 30 mesh sieve and analyzed for NO_3-N content (Knowles et al., 1989a).

A total of 25 inches of water containing about 13 lbs. NO_3-N/a was applied in 4 irrigations. Rainfall during the growth period was 4.2 inches.

Grain yields were estimated by harvesting a 100 sq. ft. area in each plot using a plot combine with a 5.0 ft. swath on 30 May. A subsample of grain was dried, ground and analyzed for total-N using an automated CNS analyzer. Protein was estimated by multiplying the total N concentration by a conversion factor of 5.7. A random subsample of 100 seeds from grain harvested within each plot was separated into vitreous and nonvitreous kernels to estimate the incidence of yellowberry. A random subsample containing 500 seeds was taken to estimate seed weight.

Results and Discussion

The application of 75, 150 and 300 lbs. N/a during vegetative growth resulted in plots with highly deficient, slightly deficient, and excessive N status at the boot stage as indicated by stem NO_3-N analysis (Figure 1).

Figure 2 depicts the effect of N applied at heading on grain yields. No significant increases in grain yield were measured in response to N applied at heading. The application of excessive amounts of N during vegetative growth significantly decreased grain yield regardless of the N rate applied at heading. There was no interaction of early and late season N on grain yield.

The interactive effects of early-season N and N applied at heading on grain protein content and incidence of yellowberry are shown in Figures 3 and 4. For both factors there was a significant early season N rate x heading N rate interaction. In wheat receiving deficient or near-adequate levels of early season N, applications of N at heading consistently increased grain protein content. Grain from plots receiving excess N fertilizer during vegetative growth also showed a significant increase in protein content in response to N applied at heading. However, the protein level in grain from plots receiving excessive early season N and no N applied at heading still exceeded the 14% cutoff which is generally considered adequate for durum wheat. These results strongly indicate that the need for late season N to boost protein content depends on the N status of the crop at the end of the vegetative growth period. Indiscriminate applications of N late in the season to fields previously supplied with unnecessarily high levels of N will probably result in little improvement in grain quality, lower economic returns and a greater potential for creating conditions which might contribute to the nitrate contamination of groundwater.

The expected inverse relationship between N application rates and the incidence of yellowberry was observed (Figure 4). Under the conditions of this trial, acceptable grain protein levels (i.e. 14% or above) were achieved when yellowberry did not exceed 1-2%. The application of excessive early season N was found to significantly decrease 500 seed weight from 22.0 and 21.9 grams in the slightly- and highly-deficient early N treatments to 18.9 grams.

Conclusions

The application of 75, 150 and 300 lbs. N/a to 'Aldura' durum wheat in three split applications during the vegetative growth period resulted in highly deficient, slightly deficient and excessive N status for these treatments respectively. The use of stem NO_3-N analysis at the boot stage accurately assessed the N status of wheat receiving these three N levels according to the proposed guidelines of Knowles et al. (1989b). Applications of 60 lbs. N/a at heading to highly N-deficient and slightly N-deficient wheat resulted in grain protein levels of 12.7 and 14.3% respectively but had little effect on increasing grain yields. Applications of N at heading to wheat previously supplied with excessive N did result in some further improvement of grain quality. In this experiment the incidence of yellowberry had to be nearly eliminated to achieve acceptable grain protein levels. The use of stem NO_3-N analysis appears to be a useful tool in predicting the minimum rate of N to be applied during the early reproductive period which will result in acceptable levels of grain protein at harvest.

References

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Figure 1. Stem nitrate levels in 'Aldura' wheat measured during vegetative growth in response to deficient, sufficient and excessive early-season N supplies.

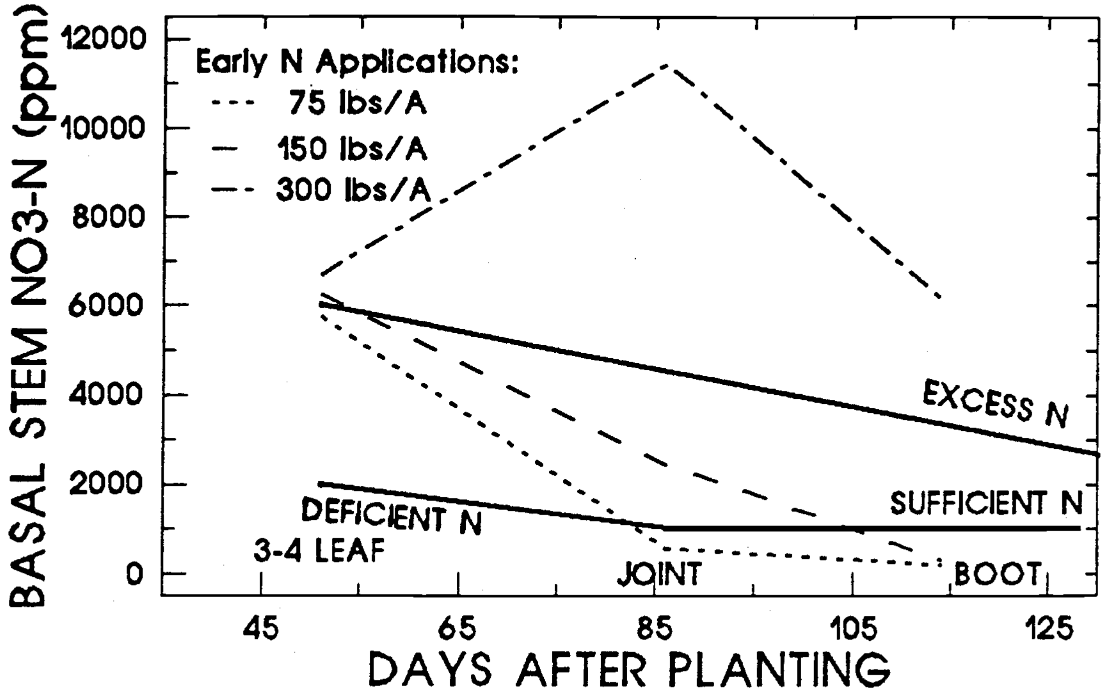

Figure 2. Grain yields of 'Aldura' wheat receiving three rates of early-season N and four rates of N applied at heading. The $LSD_{0.05}$ value for comparing individual mean yields is 512 lbs. grain/a. The reported yields have been adjusted to 10% moisture content and represent clean grain weights.

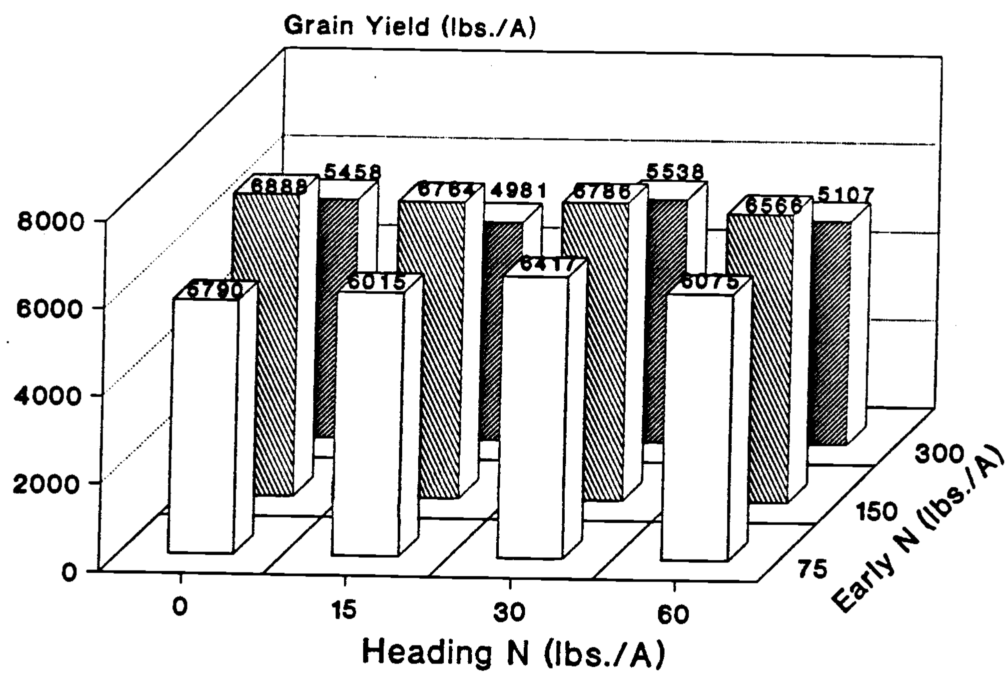

Figure 3. Grain protein content in 'Aldura' wheat receiving three rates of early-season N and four rates of N applied at heading. The $LSD_{0.05}$ for comparing individual mean protein values is 0.81%.

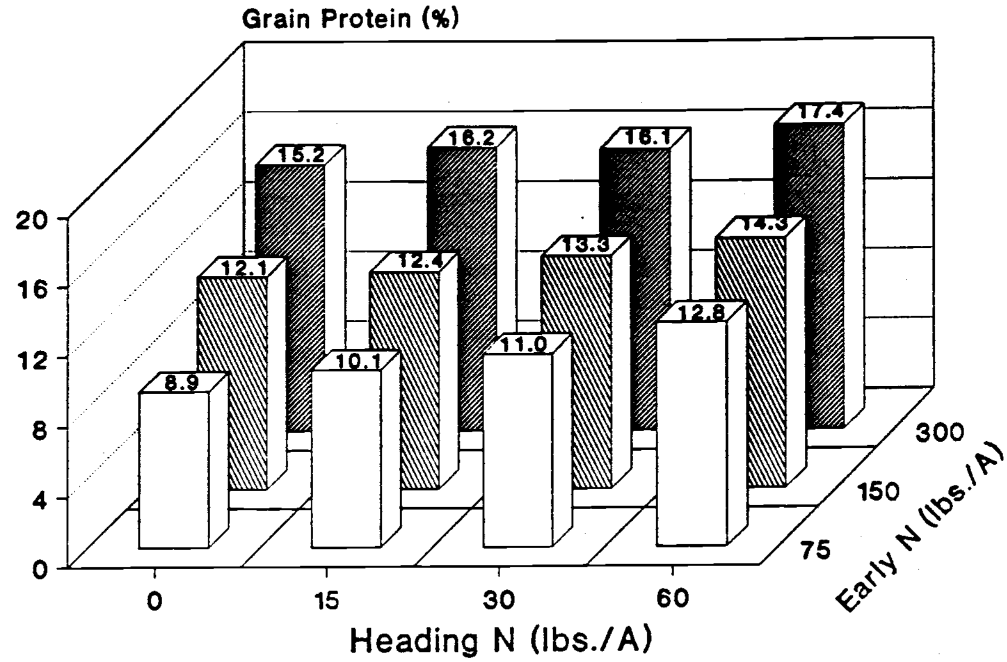

Figure 4. Estimated incidence of nonvitreous kernels (yellowberry) in 'Aldura' wheat receiving three rates of early-season N and four rates of N applied at heading. The $LSD_{0.05}$ for comparing individual mean values is 10.9%.