Effects of Early Season Nitrogen Rates on Stem Nitrate Levels and Nitrogen Fertilizer Requirements During Grain Filling for Irrigated Durum Wheat

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ABSTRACT

A field experiment was conducted on a Pima clay loam at the Safford 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) 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, 175 and 350 lbs. N/a during vegetative growth resulted in wheat with deficient, sufficient 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 N-deficient wheat and 15-20 lbs. N/a to N-sufficient wheat resulted in grain protein levels above 14%, but the applications had little effect on grain yield. Applications of N at heading to wheat which had previously received excessive N did not affect grain yield or quality. 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.

INTRODUCTION

The adequacy of nitrogen (N) supplies during the vegetative growth of durum wheat has the greatest effect on biomass accumulation and grain yield; however, 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 little of the information currently available helps to 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 the potential to be a useful tool in assessing the N status of the crop immediately prior to the grain-filling period. A field experiment was conducted at the Safford Agricultural Center in 1988-89 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 Pima clay loam (fine silty, mixed, thermic, Typic Torrifluvent). The chemical characteristics of this site were; NO_3-N, 10 ppm; pH, 8.1; electrical conductivity, 2.9 dS/m; and computed exchangeable sodium percent (ESP), 27.3%. On 7 December, 1988, 'Aldura' wheat was drilled into flat basins at the rate of about 150 lbs./a and irrigated. A uniform application of 50 lbs. P_2O_5/a was banded with the seed as triple superphosphate (0-45-0). 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 12 x 45 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 irrigations.

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

Treatment	Nitrogen Applied			
	Preplant	5-6 Leaf	Boot	Total
	lbs./a			
Deficient N	20	35	20	75
Sufficient N	40	95	40	175
Excessive N	80	190	80	350

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, 175 or 350 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 22 February at the 4-leaf stage, and then again at the jointing (24 March) and boot (10 April) growth stages according to the method described by Knowles et al. (1989). Tissue samples were dried, ground to pass a 30-mesh sieve and analyzed for NO_3-N content (Knowles et al., 1989).

Approximately 27 inches of water, containing approximately 30 lbs. NO_3-N/a, was applied in 5 irrigations. Rainfall during the growth period was 1.7 inches.

Grain yields were estimated by harvesting a 175 sq. ft. area in each plot using a plot combine with a 7 ft. swath on 14 June. 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 6.25. 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.

RESULTS AND DISCUSSION

As intended, the application of 75, 175 and 350 lbs. N/a during vegetative growth resulted in plots with deficient, sufficient 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 appreciable increases in grain yield were measured in response to N applied at heading, except when early-season N was deficient (75 lbs. N/a treatment).

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

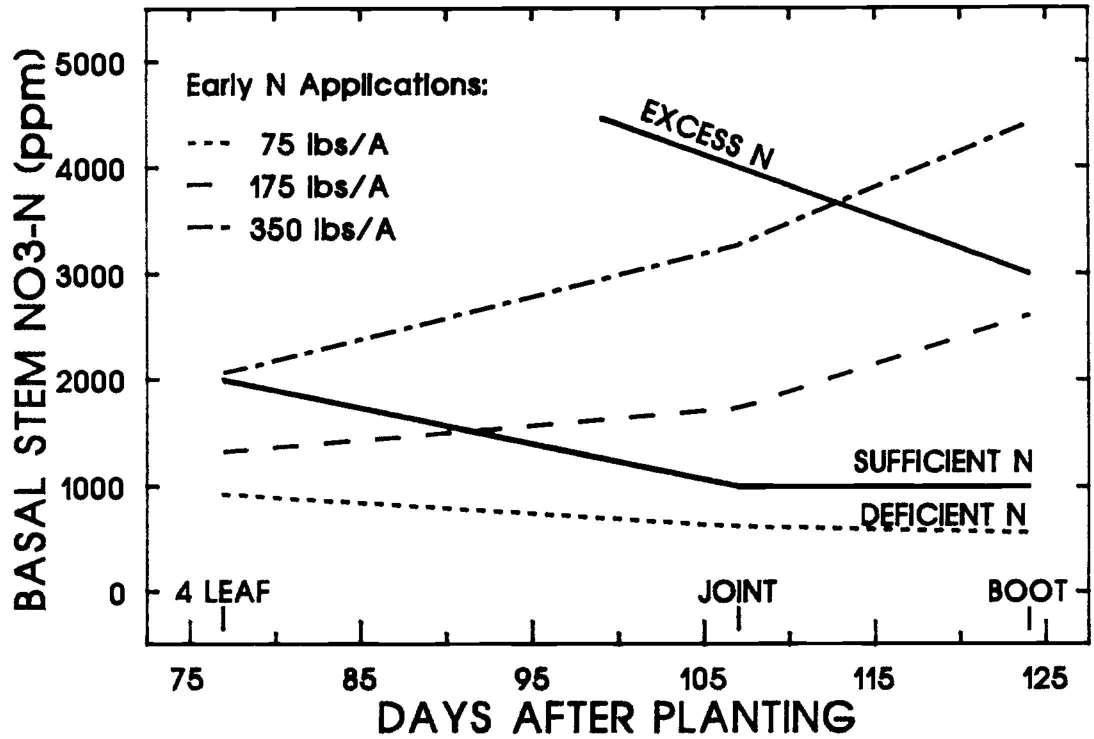
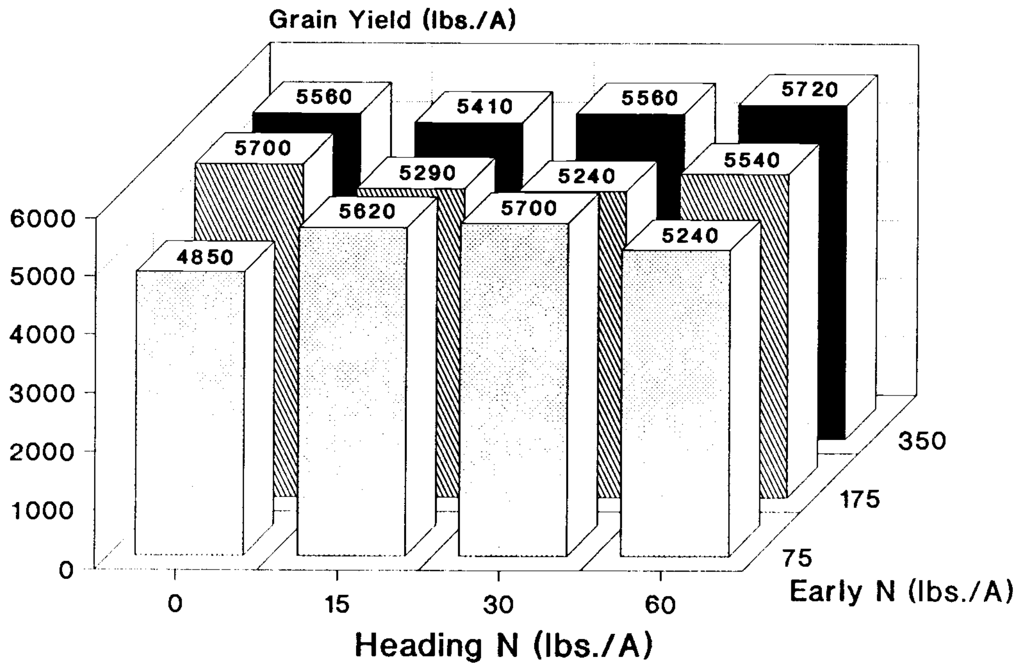


Figure 2. Grain yields of 'Aldura' wheat receiving three rates of early-season N and four rates of N applied at heading. The $LSD_{0.05}$ value for comparing individual mean yields is 733 lbs. grain/a. The reported yields have been adjusted to 10% moisture content and represent clean grain weights.



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 adequate levels of early season N, applications of N at heading consistently increased grain protein content. In contrast, grain from plots receiving excess N fertilizer during vegetative growth showed no significant change in protein content in response to N applied at heading. These results strongly indicate that the need for late season N to boost protein content to an acceptable level, usually $\geq$ 14%, 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 or no 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%.

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 1.03%.

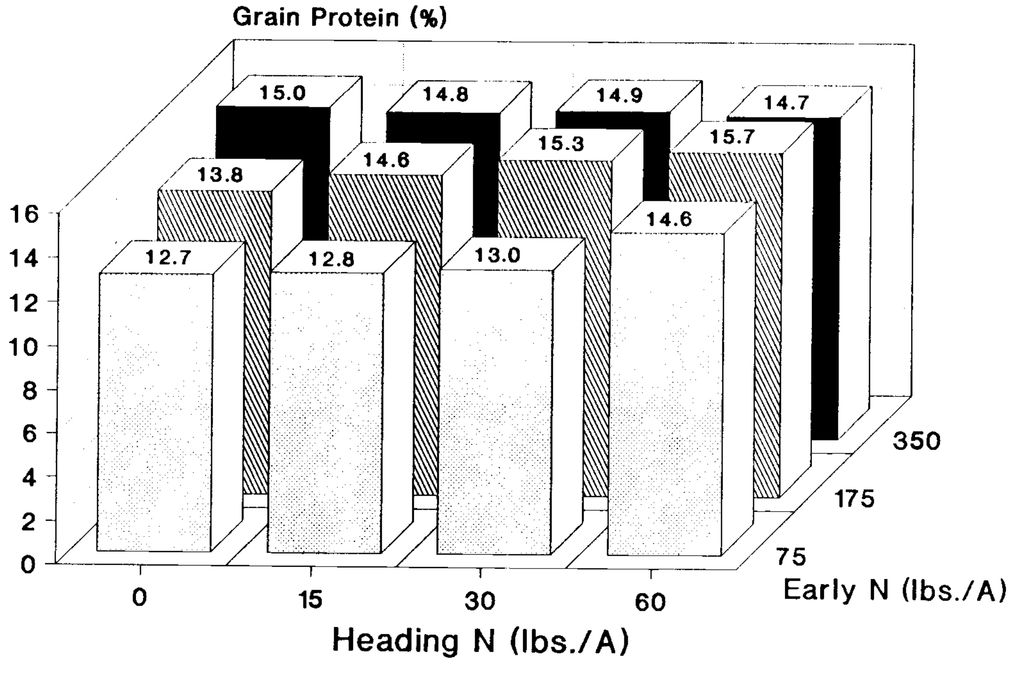
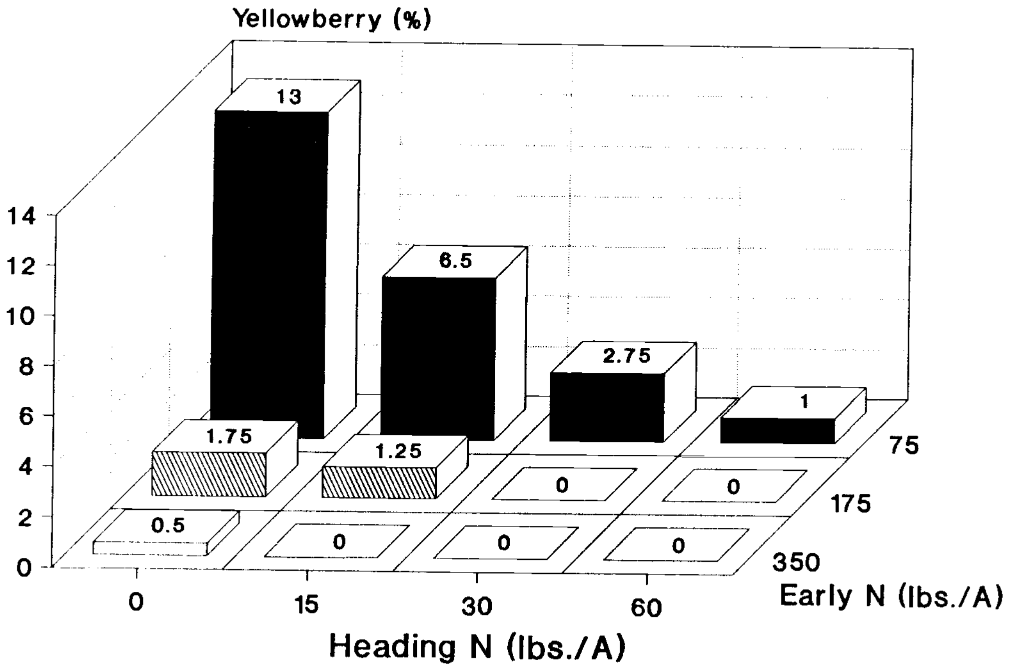


Figure 4. Estimated incidence of nonvitreous kernels (yellowberry) in 'Aldura' wheat receiving three rates of early-season N and four rates of N applied at heading. The $LSD_{0.05}$ for comparing individual mean values is 1.66%.



CONCLUSIONS

The application of 75, 175 and 350 lbs. N/a to 'Aldura' durum wheat during the vegetative growth period resulted in deficient, sufficient 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. (1989). Applications of 60 lbs. N/a at heading to N-deficient wheat and 15-20 lbs. N/a to N-sufficient wheat resulted in grain protein levels above the accepted quality threshold of 14% but had little effect on increasing grain yields. Applications of N at heading to wheat previously supplied with excessive N did not result in improved 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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