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Winter Wheat and Cheat Seed Response to Foliar Nitrogen Applications

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ABSTRACT

Growing winter wheat (*Triticum aestivum* L.) cultivars in a weed-free environment is necessary for optimum grain yield. Cheat (*Bromus secalinus* L.) is an important grass weed in winter wheat and can cause grain yield loss in excess of 40% in heavily infested fields. Two field experiments were conducted during the 1994-95 and 1995-96 crop years to evaluate the effect of foliar nitrogen (N) fertilizer on wheat grain yield and quality, and cheat seed reduction in winter wheat. Foliar fertilizer solutions were urea ammonium nitrate (UAN), ammonium hydroxide (NH_4OH), and ammonium sulfate [$(NH_4)_2SO_4$]. Wheat varieties were 'Tonkawa', 'Longhorn', and 'Jagger'. Foliar N was applied after winter wheat had completed flowering, but one to two wk prior to cheat flowering in an attempt to desiccate immature cheat heads. Wheat grain yield, grain protein, and cheat seed yield were determined after harvest. Wheat grain yield was not affected by foliar applied N following wheat flowering, while wheat grain protein increased 1 to 4%. Foliar N applications significantly reduced cheat seed production. Linear-plateau

models indicated that cheat seed reduction (percent germination * cheat yield versus check) ranged from 41.7 to 70.3% when foliar N was applied at rates between 0.4 and 19.4 lb N acre^{-1} prior to cheat flowering. Average cheat seed reduction over years, N source, and variety was 54.9% when N was foliar applied at an average rate of 6.7 lb N acre^{-1}. This reduction in the cheat population could prove to be beneficial to subsequent winter wheat crops. Similar differences in flowering between weed and crop in other production systems may reveal additional windows of opportunity for applying foliar N fertilizers aimed specifically at weed control.

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) is one of the most important crops in Oklahoma. Increasing the yield and grain protein of winter wheat depends on careful N management. Soil fertility research programs have successfully developed improved methods of N fertilizer application in winter wheat that affect both crop yield and N uptake efficiency. Numerous studies show that fertilizer N applications at flowering can increase grain protein (Pushman and Bingham, 1976; Strong, 1982, 1986; Morris and Palson, 1985; Smith et al., 1989, 1991), one of the most important characteristics in determining baking quality. Wuest and Cassman (1992) found that N fertilizer applied at anthesis had the greatest influence on postanthesis N uptake, and that grain protein content increased at rates between 15 and 69 lb N acre^{-1}.

In addition to an adequate fertility program, growing winter wheat cultivars in a weed-free environment is necessary for optimum production. Cultural practices and herbicides are the most common methods of weed control in winter wheat production. However, much of the wheat produced in Oklahoma is continuous wheat produced for both forage and grain and this limits the possibilities for cultural weed control methods such as crop rotation and delayed planting.

Various researchers have evaluated fertilizer N applications as an alternative method of weed control. Sexsmith and Pittman (1963) found that early spring N fertilizer application increased wild oat (*Avenafatua* L.) seed germination. The use of nitrate fertilizer was recommended to induce germination of dormant wild oat seeds in fallow years to reduce the supply of available seed. Banks et al. (1976) demonstrated that evening primrose (*Oenothera laciniata* Hill) produced fewer seeds with increased fertilizer treatment. Nitrogen fertilizers, unlike some herbicides, leave no restrictive residues in the soil and can provide nutritional benefit to the crop.

Donnelly et al. (1977) demonstrated that foliar N fertilizer applied before physiological maturity of grain sorghum (*Sorghum bicolor* L.) accelerated grain drying and reduced grain yield. Foliar N fertilizer also significantly decreased grain moisture. Smith et al. (1991) reported that foliar N applied after wheat flowering had no negative effect on wheat grain yield.

Cheat (*Bromus secalinus* L.) is an extremely important grass weed species in winter wheat in Oklahoma that can result in wheat grain yield losses exceeding 40% (Ratliff and Peeper, 1987). Since wheat flowers one to two wk earlier than cheat, foliar N applied after wheat flowering and before cheat flowering should desiccate immature cheat heads and reduce cheat seed production without affecting wheat grain yield. Although the effects of N fertilizer on the growth and composition of winter wheat and several weed species have been studied, foliar fertilizer applications have not been evaluated for their effectiveness to simultaneously increase winter wheat grain protein and control weeds. Therefore, the objective of this research was to assess the effect of foliar N fertilizer on wheat grain yield and quality and the concomitant reduction in cheat seed in winter wheat.

MATERIALS AND METHODS

Two field experiments were conducted during the 1994-95 and 1995-96 (one each year) crop years at Stillwater, OK, on a Norge loam (fine mixed, thermic Udertic Paleustoll). Initial surface soil samples (O to 6 in) indicated that phosphorus (P), potassium (K), and pH were adequate (83 lb acre^{-1}, 342 lb acre^{-1}, and 5.4, respectively) for winter wheat production. Initial levels of NH_4-N and NO_3-N in the soil surface (0 to 6 in) were determined to be 16 and 13 lb N acre^{-1}, respectively. The experimental design employed each year was a randomized complete block with two replications. Main plots were 8.5 by 100 ft, divided into 8.5 by 10-ft subplots. In the fall of 1994, the entire experimental area was fertilized with 90 lb N acre^{-1} as diammonium phosphate (18-46-0), broadcast and incorporated preplant. Cheat seed was broadcast to the entire area at a seeding rate of 45 lb acre^{-1}. Two winter wheat varieties 'Tonkawa' (early maturity) and 'Longhorn' (late maturity) and one foliar N application [urea ammonium nitrate (UAN)] were used in a complete factorial arrangement of treatments. Wheat seed was sown in the fall using a 'John Deere 450' grain drill at a seeding rate of 80 lb acre^{-1}, while foliar N applications were made in the spring using a logarithmic sprayer equipped with 6 nozzles set on 1.7-ft centers. The sprayer boom was offset to prevent the plots from receiving any traffic during application, thus simulating an aerial application. By constantly diluting the liquid fertilizer in a fixed volume canister while traveling at a speed of 3.1 mi hr^{-1}, rates were reduced by half every 10 ft, thus delivering an N rate to each mm subplot that ranged from 0.3 to 128.2 lb N acre^{-1}. For all foliar applications, the spreader 'X-77', manufactured by ORTHO, St. Paul, MN, was applied at a rate of 0. 1 3 oz gal^{-1} of solution. Foliar N application date for each wheat variety was determined by collecting 20 random wheat heads from each variety and 20 random cheat heads and examining them under a microscope to assess complete wheat flowering, but incomplete cheat flowering (Table 1). Each subplot was harvested using a Massey-Ferguson 8XP plot combine with the blower and sieve set to collect all the cheat seed and other fine materials. The harvested samples were cleaned with a small seed cleaner to separate cheat seed, wheat seed, and other

TABLE 1. Treatment structure and field activities, Stillwater, OK, 1995 and 1996.

N rate range —lb acre^{-1}—	Treatment[a]	Winter wheat variety	Foliar N application date
0.3 - 128.2	Urea Ammonium Nitrate	Tonkawa	5/11/95
0.3 - 128.2	Urea Ammonium Nitrate	Longhorn	5/16/95
0.2 - 97.7	Urea Ammonium Nitrate	Tonkawa	5/09/96
0.1 - 56.8	Ammonium Hydroxide	Tonkawa	5/09/96
0.1 - 71.7	Ammonium Sulfate	Tonkawa	5/09/96
0.2 - 97.7	Urea Ammonium Nitrate	Jagger	5/09/96
0.1 - 56.8	Ammonium Hydroxide	Jagger	5/09/96
0.1 - 71.7	Ammonium Sulfate	Jagger	5/09/96

[a]Log sprayer used to apply solutions whereby N rates were cut in half every 10 ft. Plots harvested every 10 and 5 ft in 1995 and 1996, respectively.

material. Wheat grain yield and cheat seed yield were determined after cleaning. Total N analyses of wheat grain samples were accomplished using dry combustion (Schepers et al., 1989). Grain protein content was calculated by multiplying percent N in the grain by 5.7 (Martin del Molino, 1991). Cheat seed reduction was calculated as the following:

$$\text{Cheat seed reduction (\%)} = 1 - CG (\%) * CY/B$$

where CG is the percentage of cheat germination, CY is the yield of cheat seed, B is the product of the highest percentage cheat germination and the yield of cheat seed where no foliar N was applied. Cheat seed germination was determined as per the work of Copeland (1978). One hundred seeds from each treatment were placed in wet paper and refrigerated at 39°F for 5 days, then placed in a germination chamber (77°F). A germination count was performed after 7 days. Wheat grain yield, wheat grain protein, and cheat seed reduction were evaluated using the NLIN procedure (SAS, 1988).

In the 1995-96 crop year, changes were made to the treatment structure. The late-maturing winter wheat variety 'Longhorn' was replaced with another early-maturing variety 'Jagger'. Two foliar N applications (ammonium hydroxide (NH_4OH), and ammonium sulfate [$(NH_4)_2SO_4$] were added to the treatment structure. The seeding rate for winter wheat was reduced to 70 lb acre^{-1} while the seeding rate for cheat remained at 45 lb acre^{-1}. There were no preplant fertilizer treatments applied in the fall of 1995. Spring-applied foliar N rates of UAN were adjusted to 0.2 to 97.7 lb N acre^{-1}, while NH_4OH, and $(NH\ )_2SO_4$ were applied at rates of 0.1 to 56.8, and 0.1 to 71.7 lb N acre^{-1}, respectively. In the 1995-96 crop year, subplots were harvested every 5 ft.

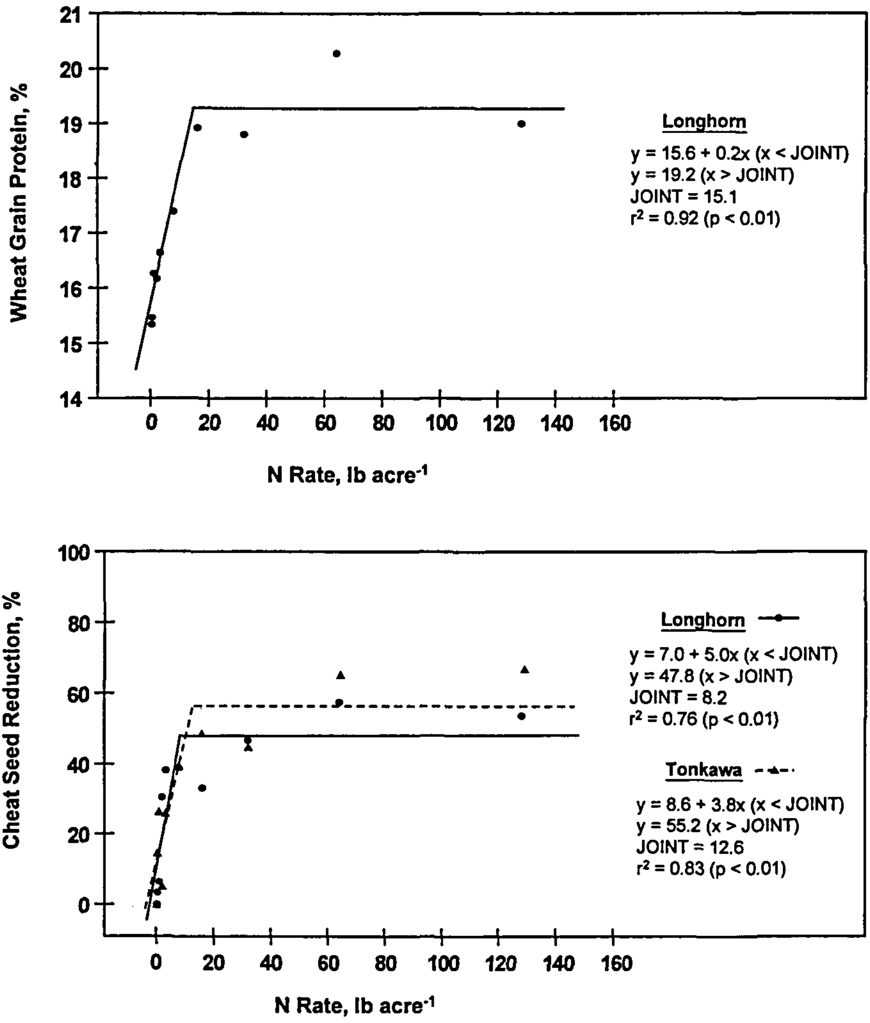

FIGURE 1. Wheat grain protein and cheat seed reduction response to foliar UAN application, 1995.

RESULTS AND DISCUSSION

Foliar applied N had no effect on wheat grain yields. Previous studies also have reported no grain yield response to foliar applied N at or near anthesis (Smith et al., 1991; Strong, 1982). However, foliar applied N did affect wheat grain protein content.

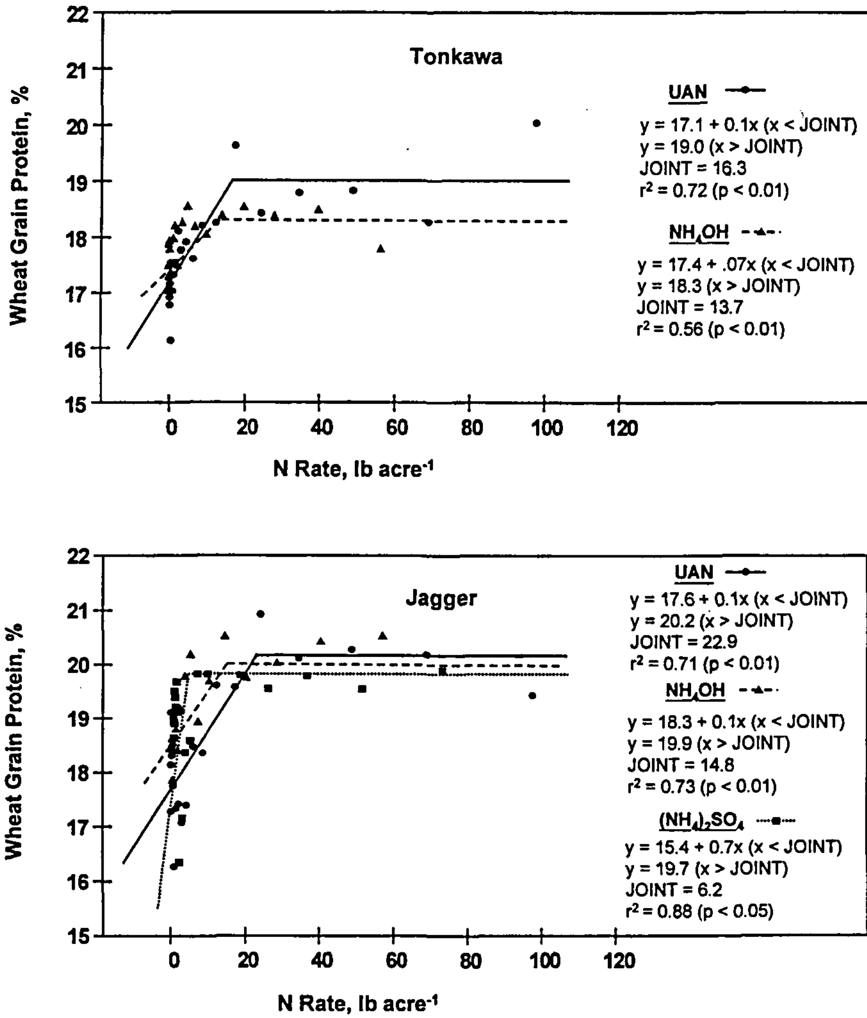

FIGURE 2. Wheat grain protein response to foliar N application, 1996.

Initial protein contents ranging from 15 to 17% were significantly increased to 18 to 20% when N was foliar applied at rates ranging from 6.2 to 22.9 lb N acre^{-1} (Figures 1 and 2). These results agreed with Pushman and Bingham (1976), Strong (1982, 1986), Morris and Palson (1985); Smith et al. (1989, 1991) who found that grain protein significantly increased when foliar N applications were made close to wheat flowering. Source of applied N had no effect on increased protein content. The

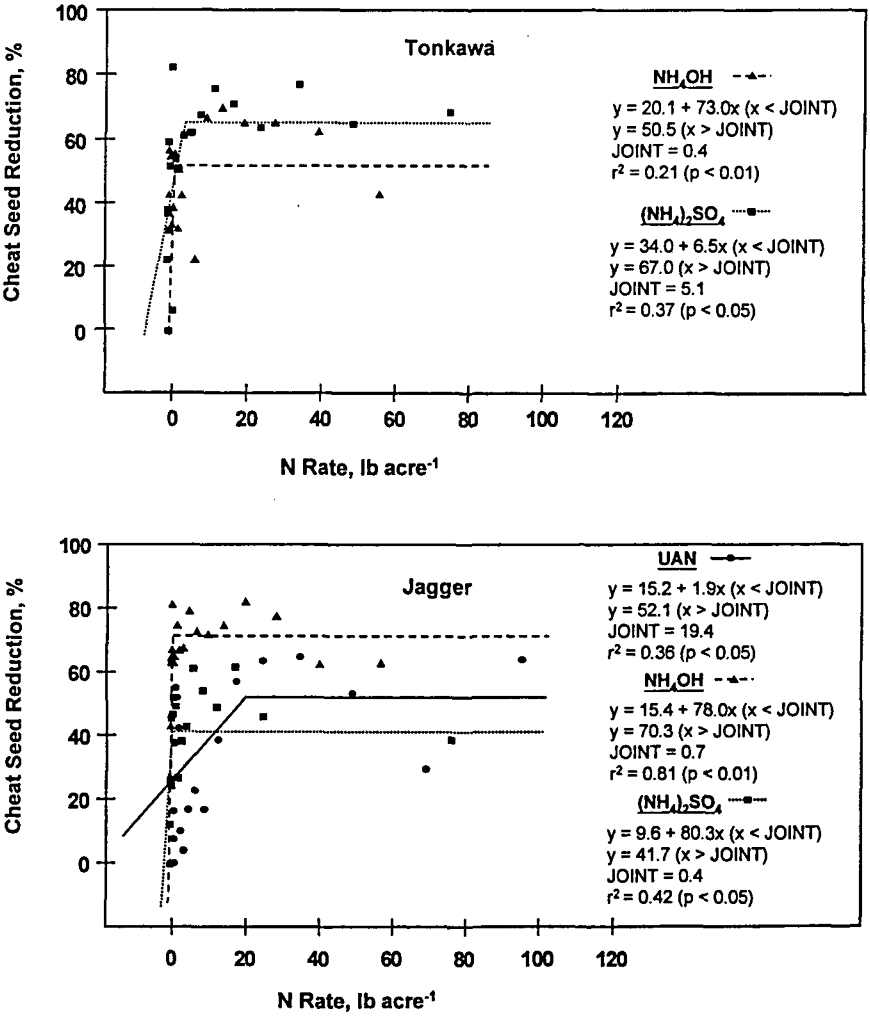

FIGURE 3. Cheat seed reduction response to foliar N application, 1996.

protein contents of all varieties (excluding 'Tonkawa' in 1995) increased as a result of foliar applied N, however, the average maximum protein content of 'Jagger' was greater than 'Tonkawa' or 'Longhorn' (Figures 1 and 2).

Significant cheat seed reduction was achieved when N was foliar applied after wheat flowering. Three days after foliar N solutions were applied, dissected cheat heads revealed substantial desiccation of stamens and stigma branches. Desiccation hastened cheat physiological maturity, which reduced harvestable cheat seed, thus confirming our hypotheses that foliar applied N fertilizer I to 2 wk before cheat flowering could desiccate immature cheat heads and reduce seed set. Cheat seed reduction ranged from 41.7 to 70.3% when foliar N was applied at rates between 0.4 and 19.4 lb N acre^{-1} prior to cheat flowering (Figures 1 and 3). When averaged over years, N source, and variety, cheat seed reduction was 54.9% when N was foliar applied at an average rate of 6.7 lb N acre^{-1}. Critical N rates were highest when UAN was the foliar applied N source, as indicated by the joint values in Figures 1 and 3. Application of low rates of foliar N fertilizer (<20 lb N acre^{-1}), prior to cheat flowering, generally increased wheat grain protein and increased cheat seed reduction. The response of wheat and cheat to foliar applied N indicates that foliar application of N fertilizer can be used to effectively increase winter wheat protein, while simultaneously reducing viable cheat seed. This decrease in cheat seed yield should be beneficial to subsequent winter wheat crops. Similar differences in flowering between weed and crop in other production systems may reveal additional windows of opportunity for applying foliar N fertilizers aimed specifically at weed control.

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