Spring Soil Test N for Irrigated Winter Wheat

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Abstract

Fall preplant or spring soil test N (NO3-N and NH4-N) was combined with fertilizer N and related to the irrigated winter wheat relative yield response at several sites receiving factorial combinations of fall (0 or 100 lb N acre-1) and spring N (0, 50, 100, 150, or 200 lb N acre-1). Fall residual N was generally greater than spring residual N, except where manuring increased fall N mineralization. Spring soil test N accounted for as much of the relative yield variability ($R2=.73$) as fall soil test N ($R2=.71$). Coefficients from a quadratic best fit of relative yield to available N did not differ when fall or spring test N was included, but including the spring test N resulted in a higher intercept (50.1 vs 40.3% relative yield). A higher intercept may reflect N already in the plant at the time of the spring sampling. Spring soil test N serves as well as fall preplant measured residual N for predicting irrigated winter wheat N requirements. In cases where significant leaching or N mineralization occurs after the fall measurement the spring test may provide a more accurate measure of N available for the remainder of the season.

Introduction

UI recommendations for irrigated winter wheat (1) were based on fall preplant soil test inorganic NO3-N and NH4-N measured to 24 inches. The data on which the N recommendations were based reflected the wheat response to N on primarily silt loam soils. Less data was available for coarser textured, less productive soils. These soils are lower in organic matter and conceivably mineralize less N during winter wheat growth. Coarser textured soils involve greater risk of N leaching during winter when most of the precipitation is received. Even southern Idaho low rainfall environments (<12inches) may involve wetting events during winter that effectively move readily available N beyond young and shallow wheat root systems. Previous research indicated that early spring N uptake by wheat was limited when most available N was moved into the 12-24 inch depth (2). Limited N uptake during vegetative growth can limit tillering and yield potential.

Moreover, local research has shown that early fall preplant applied N is frequently less effective than spring top-dressed N in silt loam soils (3). Whereas most N applied to winter wheat was once applied preplant, more of the N is currently spring applied. We speculated that late winter or early spring measured soil test N may be more appropriate for winter wheat, especially in coarser textured soils. The objective of this study was to compare fall and early spring soil test N for predicting irrigated winter wheat N requirements.

Methods

Fifteen irrigated winter wheat field experiments (1994-98) were conducted in southern Idaho on primarily coarse textured soils involving spring topdressed N rates of 0, 50, 100, 150, or 200 lb acre-1. The N was applied as either ammonium nitrate or urea. At some sites N (0 or 100 lb acre-1) was applied in the fall and the spring N rates applied to both the fall treated and untreated areas. Treatments were evaluated with a randomized complete block design using four replications.

Sites were soil sampled (0-12" and 12-24") preplant in the fall and/or prior to spring topdressing N (Table 1) and the NO3-N and NH4-N determined. Soil test N values for each 12 inch depth increment were converted from N concentrations (ppm) to lb per acre using a factor of 4. The NH4-N was generally low and was not used in the regressions.

Grain yield was measured with a small plot combine from at least 120 ft2. Relative yield (% of maximum yield) of the unfertilized wheat was related to the fall or spring soil test N using regression. Relative yield was also related to the soil test N and fertilizer N combined.

Results

Maximum grain yield among the sites ranged from 65 to 171 bu per acre. Sandy loams were quite productive when well managed. The less productive sites were limited in yield due to poor stands (from broadcast seeding), soil compaction, poor weed control, or moisture stress.

Fall preplant and spring soil test N did not differ appreciably at most sites but there were notable exceptions (Fig. 1). The Jerome 94 site had been manured in previous years and spring soil test N was considerably higher than the fall preplant measured residual N. Conversely, the non-manured Jerome 95 site, on the same farm but more distant from feeding facilities, received enough rainfall to cause leaching of N and the spring values were significantly lower. Spring soil test N averaged almost 9 ppm lower than fall soil test N for all non-manured sites. Even where 100 lb N acre-1 were applied fall preplant there was never more than 75% recovery of the N added as measured by the spring soil test.

Residual N measured fall preplant and the following spring can differ for any number of reasons. Lower spring values can reflect wheat uptake of N. . Immobilization of N by soil microflora would also reduce the residual inorganic N measured in late winter or early spring. Leaching may also be a factor.

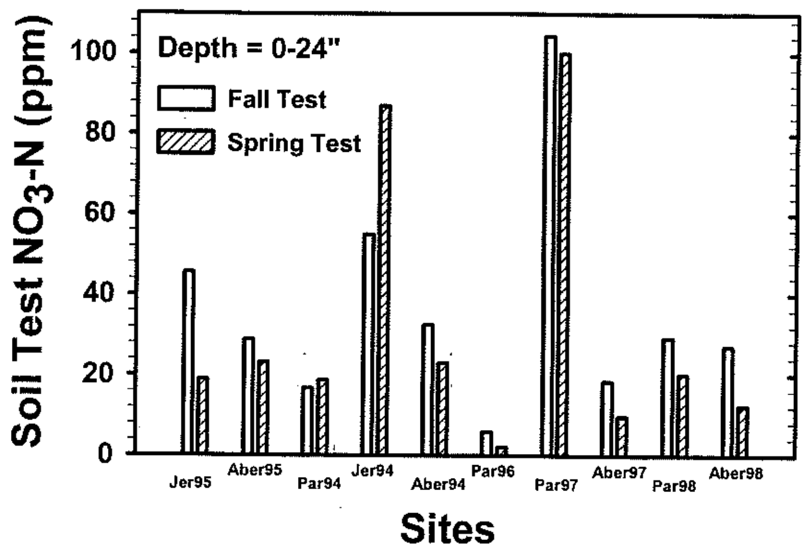

Fig. 1. Fall and spring soil test inorganic N..

Relative yield of unfertilized wheat was related to soil test N for all sites where inorganic N was obtained both in the fall and spring (10 sites). The fall and spring measured N data were fit to a linear plateau function (Fig. 2a-b). Only the linear portion of the function is shown which represents the N limited response. The linear functions for fall and spring measured N share essentially the same intercept but the slopes differ. Relative yield increased more rapidly with increase in spring soil test N than with fall soil test N. Moreover, the join point for the spring relation was about 160 lb N per acre. In contrast, the join point for fall measured N was about 240 lb N per acre.

The apparent greater effectiveness of spring measured residual N may be due to several factors. The spring test does not account for wheat N uptake. Poorer efficiency of fall preplant measured residual N is consistent with previous

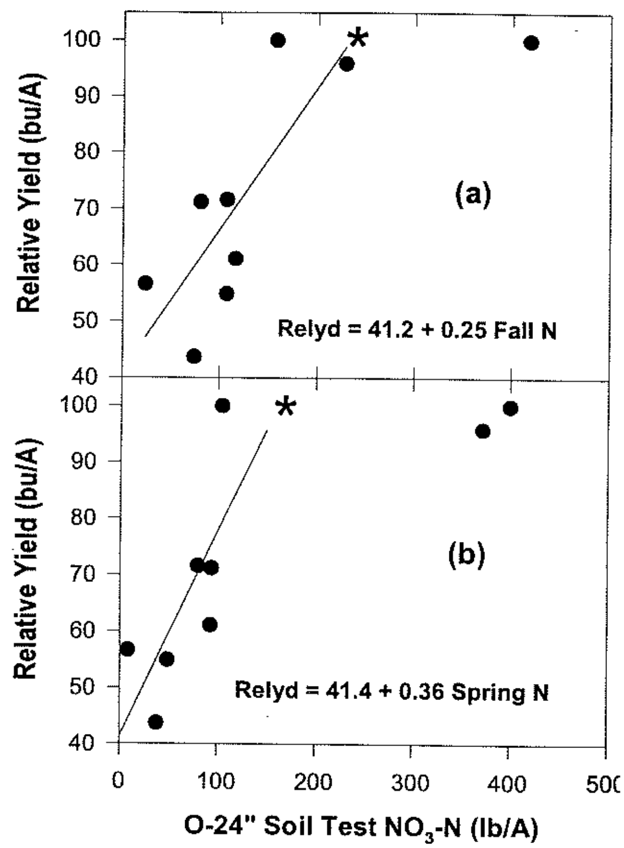

Fig. 2. Relative yield of unfertilized wheat as affected by fall (a) or spring (b) soil test N.

reports of fall pre-plant applied N frequently less effective than spring topdressed N (3).

The relation of relative yield to available N, using either fall or spring soil test N with fertilizer N applied (Fig. 3) included data only from N responsive sites where both fall preplant and spring soil test data were measured (8 of the 15 sites). Spring soil test and fertilizer N accounted for as much of the

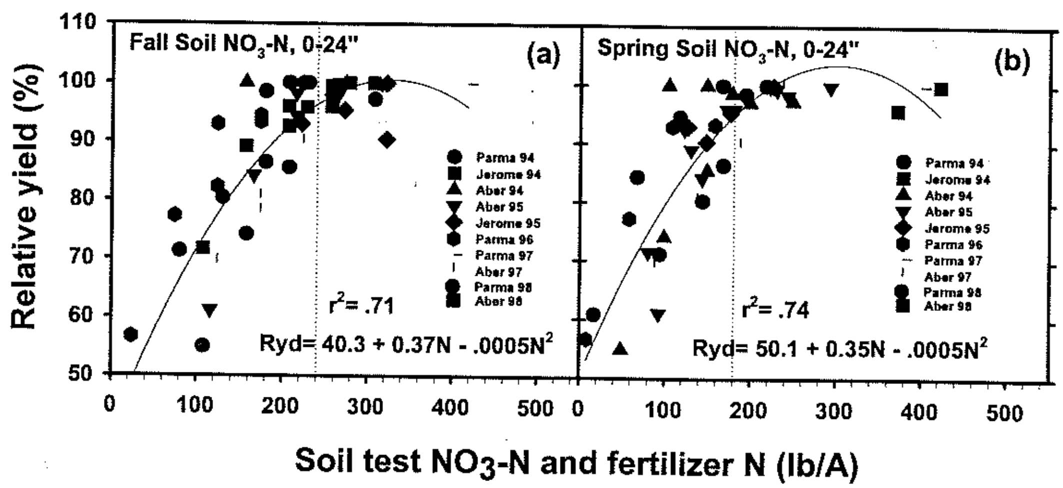

Fig. 3a-b. Relative yield as affected by the soil test and applied N combined. Only the data from sites with both fall (a) and spring (b) soil test N measures are included.

relative yield variability (r2=0.73) as fall preplant soil test plus fertilizer N (r2=0.71). Coefficients for the two functions used to describe the relations were nearly identical and did not differ, with the exception of the Y or relative yield intercepts. The relative yield intercept for the spring available N relation (Fig. 3b) was almost 10% higher than with the fall test and was significantly different (P=0.0001). The available N related to 95% relative yield was about 45 lb per acre higher using the fall soil test than the spring test (223 vs 178 lb N per acre). Spring topdressed N for the seven N responsive sites averaged over 5% higher relative yield (93 vs 87.6%) than fall preplant applied N. Spring topdressed N tended to be more effective than fall applied N, especially in western Idaho.

The results have significant implications for southern Idaho N recommendations. Previous southern Idaho N recommendations for irrigated winter wheat were generally based on both fall preplant applied N and the preplant measure of residual N. There is ample evidence that fall applied N is frequently less effective. If early fall applied N and early fall measured residual N are equally less effective than spring applied N and spring measured residual N, then recommendations based on fall applied and measured N may be higher than necessary for wheat that is spring fertilized. Much of the irrigated winter wheat is spring fertilized. The N recommendations could conceivably be reduced to reflect the greater effectiveness of spring applied N.

The N per bushel of wheat produced was calculated for fall available N (fall soil test and fall fertilizer N applied) and spring available N (spring soil test and spring fertilizer N topdressed) for the N responsive sites that had both fall and spring rates of 100 lb per acre evaluated (Fig. 4). The nitrogen per

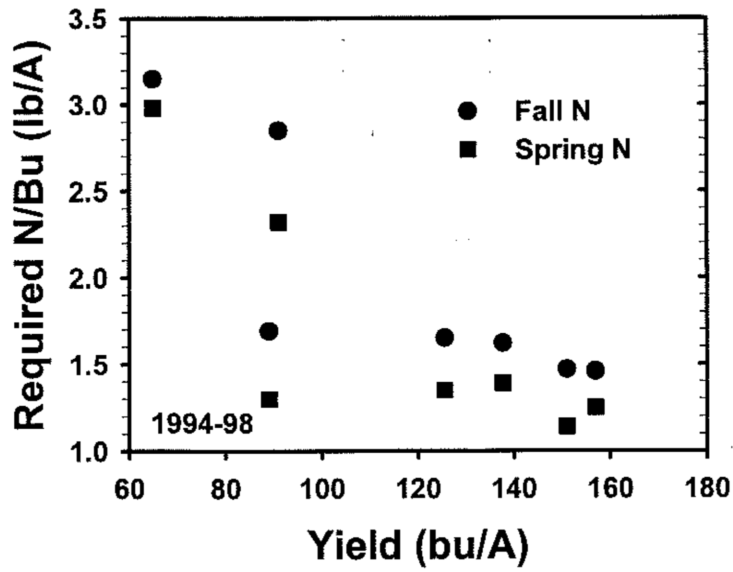

Fig. 4. Nitrogen required per bushel for fall applied and fall residual N (circle symbols) or spring topdressed N and measured residual N (square symbols) as affected by yield.

bushel values were invariably higher (less efficient) with N available in the fall than in the spring. Spring available N averaged 0.31 lb per bu less than fall available N. In addition, the N per bu was influenced by yield. When yields are low and limited due to factors other than N, the N per bu values increase regardless of the timing of N availability. The apparent greater efficiency of N available in the spring should be considered when formulating N recommendations based on expected yields.

In summary, spring soil test N accounted for as much of the relative yield variability as fall soil test N, but provided improved estimates of available N at sites where either previous manuring increased fall N mineralization or N was leached over winter. Spring soil testing for available N is as useful as the fall preplant test but different functions should be used for estimating the yield response.

Acknowledgement

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