Spring Versus Fall Nitrogen Fertilization and Take-All of Spring Wheat

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ABSTRACT

Application of 75 lb. nitrogen as ammonium sulfate in the spring increased wheat yields 51% over nonfertilized wheat. In contrast, application of the same amount of nitrogen in the fall resulted in 31% less yield than nonfertilized wheat, and 54% less yield than spring-fertilized wheat. A similar effect occurred for straw weights. The differences were attributable to take-all which was greatest with fall-applied nitrogen and least with spring-applied ammonium sulfate. Spring application of nitrogen to spring wheat plots fertilized the previous fall resulted in yields comparable to those of nonfertilized wheat.

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Application of nitrogen to low-fertility soils decreases the severity of take-all of wheat caused by *Ophiobolus graminis* Sacc. (4, 5, 7, 14). However, if subterranean clover or alfalfa, commonly used to increase soil fertility, precede wheat in the rotation, take-all may increase in severity (2, 3, 7, 10). This effect of specific crops on certain soil-borne diseases may be due to their influence on nitrification in soil (8, 9). By increasing nitrification, an alfalfa crop may provide a predominantly nitrate nitrogen regime available for the subsequent wheat crop (9). Even released ammoniacal nitrogen during residue decomposition may be rapidly converted to nitrate nitrogen (D. M. Huber, *unpublished data*).

Take-all developed to a greater extent in fall-seeded wheat plants fertilized in the spring with ammonium nitrate than with ammonium sulfate (7). Application of specific nitrogen forms has also had an effect on diseases of several other crops (8, 12).

Late fall applications of ammonium sulfate to dryland winter wheat in Eastern Idaho reduced take-all (7) as compared to nonfertilized wheat. In those trials, soil temperatures (1-4 C) were not conducive to nitrification, so that the nitrogen probably remained predominantly in the ammonium form. In the irrigated winter wheat areas, soil moisture and temperature are more conducive to nitrification. An increasing severity of take-all in the irrigated areas has been associated with annual cropping of high-yielding, semi dwarf wheat cultivars which respond to higher rates of nitrogen fertilizer (3).

Previous work with different forms of nitrogen (7, 8, 9) indicated that nitrate nitrogen stimulated

take-all development in winter wheat. This study was undertaken to determine the influence of fall- versus spring-applied nitrogen on take-all, yield, and growth of spring wheat.

Treatments consisted of a no-nitrogen check, 75 lb. N/acre spring-applied, 75 lb. N/acre fall-applied, and 75 lb. N/acre fall-applied + 25 lb. N/acre spring-applied in a split plot arrangement replicated four times. The fall nitrogen application was made prior to plowing under straw from the previous winter wheat crop. Lemhi 66 spring wheat was seeded 2 April 1969. Protein content of the harvested grain was determined by the modified dye absorption procedure (16). Soil analysis (0-70 cm depth) for nitrate nitrogen (1) and ammonia nitrogen (6) prior to fertilizer application in the fall was used to establish the existing soil nitrogen level. Analysis after harvest indicated residual nitrogen. Straw and grain nitrogen were determined by Kjeldahl procedures (11). The per cent nitrogen recovery was calculated as the per cent of total nitrogen (existing and applied) accounted for in the grain and straw. Residual soil nitrogen after harvest was comparable for all plots (4-5 μg/ml). Straw yield was obtained by cutting 30 ft^2 of each plot, weighing, threshing, and subtracting the weight of grain. Basal stem (foot), crown, and root infection by *O. graminis* was rated on a 0 to 5 scale, where 0 indicated no infection and 5, a nonfunctional root system with a girdled foot area.

Fall application of nitrogen for spring-seeded wheat resulted in severe take-all, lower grain yields, and less straw than nonfertilized plants (Table 1). Spring application of ammonium sulfate provided practical control of the disease, and increased the yield of grain and straw. The severity of take-all and the yield of grain and straw in plots receiving 25 lb. N/acre in the spring in addition to 75 lb. N/acre the previous fall were comparable to the nonfertilized check. Grain protein was 9.3 to 9.8% and was not affected by any of the treatments (Table 1). However, per cent nitrogen recovery was influenced by the time of fertilization and take-all severity.

The reduced grain and straw yield with no-nitrogen or fall-applied nitrogen are indicative of the severe effects of take-all under irrigation. This represents a grain yield reduction of over 50%, and supports previous observations of increased take-all under conditions where nitrogen is primarily in the nitrate form (7, 10). Where take-all has not been a problem, yield and plant growth (straw) are generally proportional to rate of nitrogen application.

Nitrogen application to low-fertility soils (4, 5, 7, 14) may reduce the effects of take-all by increasing root growth which partially offsets the reduced nitrogen efficiency of the infected plant (5), or by an effect of form of nitrogen on host physiology and disease severity (7). Smiley & Cook (13) postulated, on the basis of greenhouse results, that the lowered rhizosphere pH from selective absorption of nutrients after ammoniacal nitrogen applications provided a direct mechanism of control by limiting growth of *O. graminis*. This mechanism is probably not responsible for disease control observed in the field in this study because of the relatively low rates of nitrogen applied (broadcast) to the alkaline field soil (pH 8.2). This is especially true for nitrogen applied the previous fall which was subject to nitrification prior to seeding. pH ranges reported (pH 4.9-6.0) where take-all was reduced are also well within the growth range of *O. graminis*, pH 3.2-11.7 (15). Under dryland conditions, late fall-applied ammoniacal nitrogen nitrifies slowly because of low temperatures and limited soil moisture, resulting in reduced take-all (7). Late fall rains or moist soils early in the spring which enhance nitrification are associated with take-all epidemics (7). In the irrigated wheat areas, soil moisture in the fall is usually adequate, and nitrification is not inhibited for prolonged periods of time by low temperature. These data indicate that where take-all is a potential hazard, fall application of nitrogen before spring wheat may increase the disease. Although the actual mechanism of control is probably indirect, its practical significance through easily modified farming practices is worthy of further consideration.

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TABLE 1. The effect of nitrogen on the take-all disease, yield of grain and straw, and protein content of spring wheat

N application						
Fall, lb./acre	Spring, lb./acre	Take-all (0 to 5 scale)[a]	Yield, bu /acre	Straw, lb./acre	Protein, %	N recovery, %
0	0	1.5	38.5 b[b]	2,920 a	9.38 a	51
0	75	0.1	59.2 c	4,540 c	9.82 a	82
75	0	2.2	27.3 a	2,330 a	9.77 a	38
75	25	1.5	37.3 b	2,800 b	9.88 a	52

[a]Take-all index: 0 = no infection; 1 = root infection; 2 = extensive root and crown infection; 3 = root, crown, and foot infection; 4 = extensive root, crown, and foot infection; and 5 = nonfunctional crown and root system and girdled foot area.
[b]Duncan's multiple range tests applied at the .05 significance level. Numbers followed by different letters are significantly different.

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