EFFECT OF TILLAGE ON LEGUME N CREDIT TO WINTER WHEAT [1/]

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Introduction

Although there has been a significant amount of work done on the availability of legume-nitrogen for corn following alfalfa, several questions have arisen as to the sufficiency and availability of the legume N when winter wheat is raised as a following crop. This is especially true if the wheat is planted soon after the alfalfa is killed. The synchrony of nitrogen released from legumes with crop demand for N has been a concern even with crops such as corn, where N uptake can occur throughout the summer (Stute and Posner, 1995). Using mesh bags, these researchers found that 50% of the N from clover or vetch residue was not yet released by 1 June after spring burial. Since uptake of N by wheat generally precedes this time period, the residue decomposition and crop N need may be out of synchrony.

Some previous work has shown that wheat following forage legumes used as green manure results in increases in grain yield and quality (Badaruddin and Meyer, 1990), but little work has been done following legume forage crops. For corn, it has been shown that once killed, forage legume stands release mineralized N sufficiently rapidly that few N responses are seen (Kelling et al., 1992; Morris et al., 1994; Bundy and Andraski, 1994) and few differences have also been observed between fall or spring tillage on availability of legume N even in northern parts of the Corn Belt (Harris and Hesterman, 1987; Kelling et al., 1992).

Working with spring wheat following alfalfa in Manitoba, Mohr et al. (1999) showed N uptake continued until about 30 days before maturity, and at some sites, somewhat more N was taken up when the alfalfa was tilled. Some experiments have also been done on the influence of tillage systems on N availability to corn following alfalfa. These results have indicated no significant differences in crop performance when comparing no-till with conventional till (Triplett et al., 1979; Levin et al., 1987), although some cases showed that conventional tillage increased the total available N somewhat more rapidly than what was available under no-till (Dow et al., 1994). This may be particularly important where wheat is the following crop.

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Materials and Methods

This experiment was initiated at the Arlington Agricultural Research Station in September 1997, with the wheat harvested in July 1998. It was continued on new sets of plots at Arlington and Lancaster Agricultural Research Stations in September 1998 and 1999. In all cases, the fields had been harvested for alfalfa hay for the previous 2 to 4 years. The plots were split by tillage system (no-till versus moldboard plow) as the main plots and fall nitrogen treatments (± 30 lb N/acre) and spring nitrogen treatments (0 to 60 lb N/acre) were superimposed on the tillage split-split main plots. Additional details about the experiment are presented in Table 1.

The alfalfa stand was killed with glyphosate and tilled about 5 days later (where appropriate) and planted with no-till or conventional till on 6- to 7-inch centers. The N treatments were broadcast by hand as NH_4NO_3. The grain and straw were harvested by plot combine (Arlington) or three-row cutter/binder and threshed by stationary thresher (Lancaster). Lodging ratings were made by visual estimates from three individuals independently evaluating each plot. Data were analyzed using a split/split plot design that included tillage on the main plot and fall N as the first split and spring N as the final combination. Each treatment was replicated four times at each location.

Results and Discussion

Table 2 shows the effect of applied nitrogen fertilizer and tillage system on grain yield and observed lodging at harvest averaged across the respective site-years at each location. Within any of the site years, the effect of time of nitrogen fertilizer application was minor in comparison to the effects of the amount of N applied; therefore, the data are presented based on the total amount of fertilizer N applied.

It is clear from these data that little benefit in grain yield was realized from the application of N fertilizer to winter wheat following alfalfa. At both locations, yields generally decreased and the percent lodging at harvest generally increased as the total amount of N fertilizer applied increased. When the wheat was no-till planted, yields tended to remain stable up to about 40 lb N/acre applied and then decline linearly at higher rates of application. However, when the field was plowed prior to planting, the yield declines began with the first units of added N. These data suggest that tillage results in a higher and perhaps more rapid rate of N release from the legume than when no-till is used. These data are different from those where corn follows alfalfa and no differences were seen between no-till and plowing on the amount of N supplied (Triplett et al., 1979; Kelling et al., 1992).

In general, the average percent lodging at harvest at the two locations started to increase with the first units of N fertilizer applied, and the increase in lodging at both locations was directly proportional to the amount of N added. It is also apparent that more lodging was observed where the field was plowed prior to planting the wheat, especially on the higher organic matter soil at Arlington. Figure 1 plots the increases in lodging with increasing N rates for the two tillage systems for the three site years at Arlington. By comparing equivalent amounts of lodging resulting from a given amount of applied N within each tillage system, these data show that plowing resulted in about 40 lb/acre more of N fertilizer equivalent to the wheat.

Previous research has shown that alfalfa at these stand densities and with this amount of regrowth when killed will provide between 120 and 160 lb N/acre for corn on these soils (Kelling et al., 1992; Morris et al., 1994; Bundy et al., 1997). Nitrogen calibration studies at these locations with winter wheat following corn has shown positive responses to 60 to 90 lb N/acre (Kelling and Oplinger, 1984).

Although corn was not used as a comparative test crop for the current study, it does not appear that the legume was providing as large of a nitrogen credit to the wheat as would be expected for corn. In only one site year was positive wheat yield responses to N observed (Arlington 1998); the response was larger with no-till than the moldboard plow system, and yield was maximized by 40 to 50 lb N/acre. Fall- or spring-applied fertilizer N at the same rate appeared to result in similar corp responses. Based on these experiments, compared to historic calibration trials, the appropriate N credit to wheat may be only 40 to 60 lb N/acre and it is likely tillage dependent. The generally negative response to applied fertilizer N for the 1998-1999 trial and 1999-2000 trials at both Arlington and Lancaster may be due to the extremely long, warm fall in 1998 and 1999. In a more typical growing season, this result might be different. This experiment will be continued for two more seasons, and corn will also be included as a test crop.

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Table 1. Experimental details for the alfalfa N credit trial with wheat.

	Arlington 1997-98	Arlington 1998-99	Lancaster 1998-99	Arlington 1999-2000	Lancaster 1999-2000
Soil	Plano sil (Typic Argiudolls)	Plano sil (Typic Argiudolls)	Fayette sil (Typic Hapludalfs)	Plano sil (Typic Argiudolls)	Fayette sil (Typic Hapludalfs)
Alfalfa condition					
• Stand density (plants/ft^2)	1.6	2.7	1.9	4.5	3.5
• Amount of regrowth (inches)	8	7	14	8	9
• Alfalfa kill date	09/24/97	08/20/98	09/04/98	09/17/99	09/14/99
Wheat					
• Variety	Glacier	Dynasty	Pioneer 25R26	Glacier	Pioneer 25R26
• Plant date	10/03/97	09/21/98	09/17/98	09/30/99	09/24/99
• Fall N application	10/17/97	10/07/98	09/17/98	10/18/99	10/15/99
• Spring N application	04/28/98	03/31/99	04/07/99	05/04/00	05/10/00
• Harvest date	07/29/98	07/15/99	07/14/99	07/25/00	07/13/00

Table 2. Average effect of N treatment and tillage system on winter wheat grain yield and percent lodging at two Wisconsin locations.

Combined	No-till		Moldboard	
N rates †	Grain yield	Lodging	Grain yield	Lodging
lb/acre	bu/acre	%	bu/acre	%
		Arlington ‡		
0	57.5	4.3	62.0	15.0
20	60.4	11.4	57.0	30.7
30	57.2	10.3	58.8	28.2
40	59.0	18.2	57.6	41.4
50	58.1	15.6	52.7	38.3
60	54.5	25.9	52.7	57.5
70	50.3	38.9	50.1	47.9
90	51.6	43.7	41.7	64.9
		Lancaster ‡		
0	71.0	14.3	68.6	13.7
20	68.9	16.9	65.1	15.8
30	70.4	20.5	62.9	19.1
40	71.5	15.0	61.9	21.6
50	65.9	22.2	57.5	24.6
60	67.5	16.6	56.1	22.1
70	63.6	22.4	53.6	26.6
90	61.5	29.3	53.6	29.8

† Total of fall and spring fertilizer N applied.
‡ Average of three site-years at Arlington and two site-years at Lancaster.

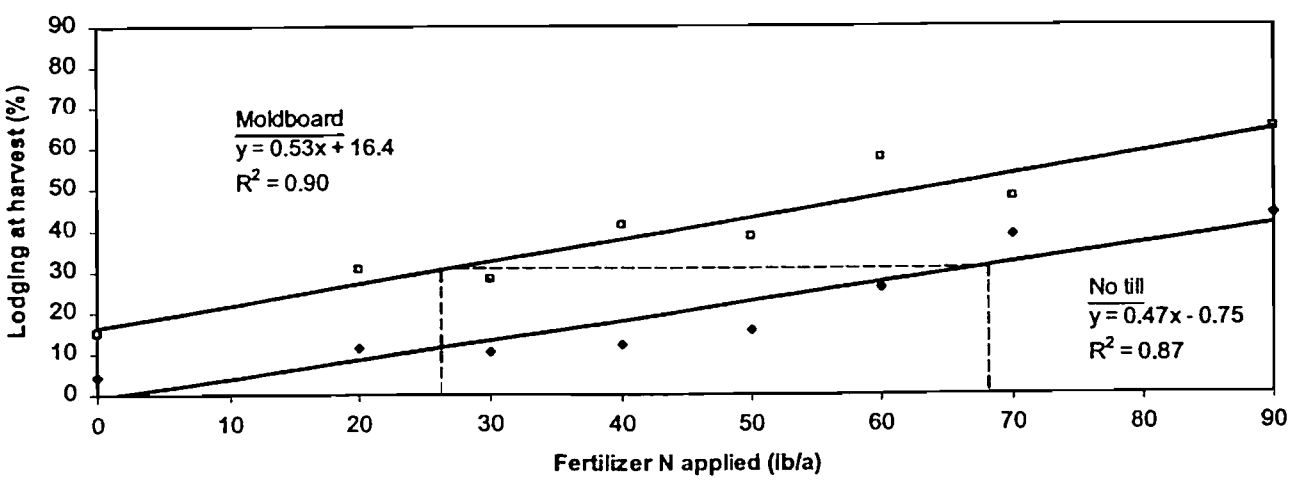

Figure 1. Effect of tillage system and total fertilizer N applied on wheat lodging at harvest (Arlington, WI, 3-year average).

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