EFFECT OF TILLAGE ON ALFALFA 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 to wheat 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 clover or vetch residue was not yet released by 1 June after spring burial. Since uptake of N by wheat may precede 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 for corn following alfalfa (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 the availability of legume N (Harris and Hesterman, 1987; Kelling et al., 1992). 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 difference 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 no-till (Dow et al., 1994). This may be particularly important where wheat is the following crop.

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. In

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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.

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

	Arlington 1997-98	Arlington 1998-99	Lancaster 1998-99
Soil	Plano sil (Typic Argiudolls)	Plano sil (Typic Argiudolls)	Fayette sil (Typic Hapludalfs)
Alfalfa condition			
! Stand age/stand density (plants/ft^2)	1.6	2.7	1.9
! Amount of regrowth (inches)	8	7	14
! Alfalfa kill date	24 Sept 1997	20 Aug 1998	4 Sept 1998
Wheat			
! Variety	Glacier	Dynasty	Pioneer 25R26
! Plant date	3 Oct 1997	21 Sept 1998	17 Sept 1998
! Fall N application	17 Oct 1997	7 Oct 1998	17 Sept 1998
! Spring N application	28 Apr 1998	31 Mar 1999	7 Apr 1999
! Harvest date	29 July 1998	15 July 1999	14 July 1999

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 presents the statistical analysis of variance for each of the three site years for grain yield, straw yield, or lodging percentage. As expected, tillage and the fall and/or the spring N treatments generally affected the measured parameters, but only in the 1997-1998 Arlington trial were the interaction terms of these ANOVA's significant. This means that while these variables each had an impact on yields and/or lodging, the general response to a variable was similar across the other treatments.

Table 2. Multifactor ANOVA for effect of tillage and N fertilizer management on wheat grain yield, straw yield, or lodging percentage at three Wisconsin locations.

Variable	Grain yield	Straw yield	Lodging percentage
	---------- Probability value (Pr > F) ----------		
Arlington 1997-98			
Tillage (T)	0.79	<0.01	<0.01
Fall N (FN)	0.30	0.03	0.01
Spring N (SN)	<0.01	0.21	<0.01
T x FN	0.01	0.22	0.55
T x SN	0.03	0.01	0.35
FN x SN	0.04	0.14	0.61
T x FN x SN	0.01	0.27	0.47
Arlington 1998-99			
Tillage (T)	0.03	0.07	<0.01
Fall N (FN)	<0.01	0.01	0.13
Spring N (SN)	<0.01	0.22	<0.01
T x FN	0.46	0.48	0.42
T x SN	0.34	0.28	0.09
FN x SN	0.86	0.44	0.86
T x FN x SN	0.37	0.79	0.35
Lancaster 1998-99			
Tillage (T)	<0.01	0.21	0.08
Fall N (FN)	<0.01	0.20	<0.01
Spring N (SN)	<0.01	0.69	0.02
T x FN	0.82	0.26	0.74
T x SN	0.30	0.30	0.38
FN x SN	0.98	0.03	0.76
T x FN x SN	0.47	0.70	0.81

As shown in Figures 1 and 2, all three sites the addition of fertilizer N, in general, decreased yields and increased lodging. Where a positive response to N addition was seen (Arlington 1997-98 and perhaps Lancaster 1998-99), it was usually only observed in association with the no-till system. Tillage also clearly influenced N availability in that more lodging was seen at the higher N rates with moldboard plowing than with no-till.

These results show that, in general, alfalfa preceding winter wheat provided sufficient nitrogen such that yield of the grain or straw was not increased by N fertilizer application.

Figure 1. Yield response of wheat following alfalfa as affected by tillage and fall and spring N rates at three Wisconsin locations.

Figure 2. Lodging response of wheat following alfalfa as affected by tillage and fall and spring N rates at three Wisconsin locations.

When some positive wheat yield response to N has been 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 crop responses. Overall wheat responses indicate that somewhat more legume N may be available when the alfalfa is plowed than when the succeeding crop is no-tilled. Previous experiments indicate that on these soils alfalfa would provide about 120 lb/acre N credit to corn. These experiments, compared to historic calibration trials, indicate that this credit may be only 40 to 60 lb N/acre for wheat, and it is likely tillage dependent. The generally negative response to applied fertilizer N for the 1998-99 trials at both Arlington and Lancaster may be due to the extremely long and warm fall in 1998. It may be that much of the legume N was released early enough that the date when the alfalfa was killed is not important. In a more typical growing season, this result might be different. This experiment will be continued for two more seasons.

Literature Cited

Badaruddin, M., and D.W. Meyer. 1990. Green-manure legume effects on soil nitrogen, grain yield, and nitrogen nutrition of wheat. Crop Sci. 30:818-825.

Bundy, L.G., and T.W. Andraski. 1994. Soil and plant nitrogen availability tests for corn following alfalfa. J. Prod. Agric. 6:200-206.

Dow, Z., R.H. Fox, and J.D. Toth. 1994. Tillage effect on seasonal nitrogen availability in corn supplied with legume green manures. Plant Soil 162:203-210.

Harris, G.H., and O.B. Hesterman. 1987. Recovery of nitrogen-15 from labeled alfalfa residue by a subsequent corn crop. p. 58-59. In J.F. Power (ed.) The role of legumes in conservation tillage systems. Proc. Natl. Conf., 27-29 April 1987, Athens, GA. Soil Conserv. Soc., Ankeny, IA.

Kelling, K.A., LG. Bundy, and R.P. Wolkowski. 1992. The research basis for Wisconsin's legume nitrogen credits. New Horizons in Soil Science no. 1-92.

Levin, A., D.B. Beegle, and R.H. Fox. 1987. Effect of tillage on residual nitrogen availability from alfalfa to succeeding corn crops. Agron. J. 79:34-38.

Morris, T.F., A.M. Blackmer, and N.M. El-Hout. 1994. Optimal rates of nitrogen fertilization for first-year corn after alfalfa. p. 295. In Agronomy abstracts. ASA, Madison, WI.

Stute, J.K., and J.L. Posner. 1995. Synchrony between legume nitrogen release and corn demand in the upper Midwest. Agron. J. 87:1063-1069.

Triplett, G.G., Jr., F. Haghhiri, and D.M. Van Doren. 1979. Plowing effect on corn yield response to N following alfalfa. Agron. J. 71:801-803.