DIRECT COMPARISON OF ALFALFA NITROGEN CREDITS TO CORN AND WHEAT [1/]

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The ability of legumes to supply nitrogen to succeeding crops has been recognized for many years. The actual amount of N available will depend on the amount of N in the alfalfa and its availability, and any additional soil N that may be released due to the growth of the legume. From a practical standpoint, farmers need to know how much nitrogen fertilizer they should apply when the crop is grown following the legume. This approach, commonly called the nitrogen fertilizer replacement value, integrates the N directly made available from the legume with the nitrogen provided from other sources, such as the stimulation of easily released soil N, into a single value.

For legumes to be considered effective N sources for succeeding corps, they must release the legume N in a sufficiently timely manner to fill the demand. If the mineral N is released too early, it can potentially be lost to leaching and/or denitrification. If released too late, it will not benefit the crop, and poses a potential threat to groundwater quality via leaching. This may be a particular problem for winter wheat if the wheat is planted soon after the alfalfa is killed or if the wheat is no-till planted (Kelling et al., 2000). 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).

Our previous work showed that we rarely saw beneficial responses to applied fertilizer N when rotating from alfalfa to wheat and that substantial risk from lodging may occur if nitrogen is applied in this situation (Kelling et al., 2001). Furthermore, this work showed that the appropriate N credit to wheat may be only 40 to 60 lb N/acre and it is very likely tillage dependent. Killing the alfalfa following second cutting rather than following third cutting was distinctly no advantage to the following wheat. This and the negative response to applied fertilizer N for the 1998-1999 and 1999-2000 trials at both Arlington and Lancaster may have been due to the extremely long, warm fall in 1998 and 1999. In a more typical growing season, these results might be different.

[1/] Research support provided by the Wisconsin Fertilizer Research Council, the UW Consortium for Extension and Research in Agriculture and Natural Resources, and UW-Madison the College of Agricultural and Life Sciences is gratefully acknowledged.

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In none of these trials was corn used as a comparative test crop, but these studies do not appear to show that the legume was providing as large of a nitrogen credit to the wheat as would be expected for corn. To test this hypothesis, we established trials at Lancaster and Arlington where corn and wheat following alfalfa were directly compared.

Methods and Materials

In 2001, this experiment was conducted at Arlington, Lancaster, and Ashland Agricultural Research Stations on fields that had been harvested for alfalfa hay for the previous 2 to 3 years. Following the second forage harvest in 2000 (mid-August), the alfalfa in half of the plots was killed, whereas the other half was killed in early September). This meant the early-killed area underwent about 4 weeks of warm weather before the wheat was planted. These plots were split by tillage system (no-till versus moldboard plow) and crop (corn versus wheat) except at Ashland. Spring nitrogen treatments (0 to 80 lb N/acre) were superimposed on the alfalfa kill time and tillage split-split main plots. Additional experimental details 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 drill on 6- to 7-inch centers. The N treatments were broadcast by hand as NH_4NO_3. The grain and straw were harvested with a three-row cutter/binder and threshed by stationary thresher. Lodging rates were made by visual estimates from three individuals independently evaluating each plot.

Mineralization of soil N (legume N) was monitored by taking periodic soil samples to 1 to 2 feet and measuring for inorganic N. Whole plant samples were also taken in the late spring. Analyses of these samples are not yet complete; therefore data for 2001 are not presented in this report.

2001 Results

As in previous years, at Arlington and Lancaster (Table 2), the addition of fertilizer N, in general, decreased wheat yields and increasing lodging. Tillage also clearly influenced N availability in that more lodging was seen at the higher N rates with moldboard plowing than with no-till. With some exceptions, the interaction terms of the statistical evaluation were significant. At both sites, the earlier kill date also resulted in significantly lower yields. This is likely due to increased mineralization of the alfalfa N in that lodging tended to be higher with the earlier kill date. These results are particularly important because the fall and early spring temperatures at both sites were not unusually warm. Average temperatures for the September to December 2000 period were 2.1 and 3.1^{o}F below normal for Arlington and Lancaster, respectively.

At Arlington, the kill date, tillage, and N interaction terms were generally significant, indicating that there was some positive response to applied N when the plots were no-till planted, but very negative responses to N when plowed. These interactions did not seem to be as apparent on any of the measured parameters at Lancaster. Clearly, the extra fertilizer N had a larger negative impact where the plots were plowed or where they were killed earlier. This excessive N was obviously a larger problem where greater amounts of mineralization had occurred.

At Ashland (Table 3), it is obvious that the colder environment results in an advantage to killing the alfalfa earlier in the season and that we got positive yield responses to the highest rate of N fertilizer applied. Lodging data are not presented since no lodging was observed. Overall wheat yields are surprisingly high considering the amount of winter kill seen in the plots. It is possible that the benefits from N may have been associated with N stimulation of tillering. Unfortunately, we did not evaluate heads per unit area.

The corn responses to alfalfa kill date, tillage, and applied fertilizer N are seen in Table 4 for both Arlington and Lancaster. In general, corn grain yields appeared to benefit from some fertilizer N (40 lb N/acre at Lancaster and 80 lb N/acre at Arlington). Overall, yields of the no-till system were negatively affected by weed pressure in this system, especially at Arlington. These data are somewhat unusual in that we have rarely seen N responses following this good of a stand of alfalfa where the top growth was not removed. None of the interactions were significant at either locations.

These results show that, in general, alfalfa preceding winter wheat provided sufficient or excess nitrogen such that yield of the grain or straw was not increased by N fertilizer application, but in 2001, not enough N for corn. When some positive wheat yield response to N has been observed (Arlington 1998 and Ashland 2001), 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 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 and this year's trial indicate that on thee soils, alfalfa would provide about 120 to 150 lb N/acre 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. This work also shows that kill date may substantially affect the amount of N available to the wheat and that there is no advantage to killing the alfalfa earlier. Clearly, the forage is more valuable than the extra N.

Reference

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Table 1. Experimental details for the alfalfa/wheat experiment, 2000 to 2001.

Site	Ashland	Arlington	Lancaster
Treatment variables	Alf kill time (2)	Alf kill time (2)	Alf kill time (2)
	---	Tillage (2)	Tillage (2)
	Fall N (2)	Spring N (5)	Spring N (5)
	Spring N (4)		
Soil	Allendale ls	Plano sil	Fayette sil
	(Alfic Epiaquods)	(Typic Argiudolls)	(Typic Hapludalfs)
Soil sample dates	19 Sept. 2000	12 Oct. 2000	13 Oct. 2000
	17 Oct. 2000	28 Nov. 2000	10 Nov. 2000
	3 Nov. 2000	18 Apr. 2001	24 Apr. 2001
	18 Apr. 2001	2 May 2001	8 May 2001
	30 May 2001	4 June 2001	
	2 Aug. 2001		
Whole plant samples	24 May 2001	2 May 2001	3 May 2001
<u>Alfalfa condition</u>			
Stand age/stand density (plants/ft^2)	3.5	4.5	3.8
Amount of regrowth (inch)	8.0	9.0	15.0
Alfalfa kill dates	31 July 2000	10 Aug. 2000	11 Aug. 2000
	14 Aug. 2000	13 Sept. 2000	18 Sept. 2000
<u>Wheat</u>			
Variety	Glacier	Kaskaska	Pioneer 25R26
Plant date	31 Aug. 2000	26 Sept. 2000	26 Sept. 2000
Fall N application	19 Sept. 2000	3 May 2001	24 Apr. 2001
Spring N application	19 Apr. 2001	20 July 2001	30 July 2001
Harvest date	---		
<u>Corn</u>			
Plant date	---	27 Apr. 2001	2 May 2001
PSNT	---	4 June 2001	4 June 2001
N fertilization	---	4 June 2001	7 June 2001
Silage harvest	---	14 Sept. 2001	28 Sept. 2001
Grain harvest	---	1 Nov. 2001	8 Nov. 2001

Table 2. Effect of alfalfa kill date, tillage, and fertilizer N rates on wheat yield at Lancaster and Arlington, 2001.

			Arlington		Lancaster	
Kill date	Tillage	N rate	Grain yield	Lodging	Grain yield	Lodging
		lb/acre	bu/acre	%	bu/acre	%
August	NT	0	38	10	74	1
		20	36	26	74	2
		40	38	18	75	2
		60	39	41	56	16
		80	36	52	57	28
	Mb	0	53	9	68	3
		20	34	13	49	6
		40	42	20	45	29
		60	43	23	52	22
		80	33	21	52	24
September	NT	0	46	5	75	1
		20	58	7	76	1
		40	58	7	74	4
		60	41	23	74	4
		80	43	32	66	7
	Mb	0	49	11	70	2
		20	45	19	61	2
		40	42	26	50	12
		60	37	37	49	17
		80	36	35	52	10
Statistically significant factors at Pr # 0.05:						
			K †	N	K	N
			N	K x T	T	
			K x T	T x N	N	
			K x N		T x N	
			T x N			

† K, kill date; N, nitrogen rate; T, tillage.

Table 3. Effect of alfalfa kill date, tillage, and fall- and spring-N rates on wheat yield at Ashland, 2001.

Kill date	Fall N	Spring N	Yield
	---------------- lb/acre	--------------	bu/acre
August	0	0	50
	0	20	53
	0	40	56
	0	60	61
	30	0	46
	30	20	58
	30	40	47
	30	60	63
September	0	0	41
	0	20	45
	0	40	49
	0	60	48
	30	0	54
	30	20	40
	30	40	52
	30	60	49
Statistically significant factors at Pr # 0.05:			K † K x SN

† K, kill date; SN, spring N.

Table 4. Effect of alfalfa kill date, tillage, and fertilizer N rates on corn grain and silage yields at Lancaster and Arlington, 2001.

			Arlington		Lancaster	
Kill date	Tillage	N rate	Grain yield	Silage yield	Grain yield	Silage yield
		lb/acre	bu/acre	T/acre	bu/acre	T/acre
August	NT	0	163	9.1	118	5.6
		20	151	9.1	134	5.9
		40	160	10.0	146	5.4
		60	155	9.8	137	6.6
		80	200	9.7	140	8.4
	Mb	0	208	8.7	129	8.1
		20	217	9.3	135	9.1
		40	219	8.9	143	7.6
		60	221	9.5	127	7.4
		80	224	9.4	142	10.5
September	NT	0	175	8.5	116	7.2
		20	169	8.6	125	6.2
		40	181	8.0	142	6.8
		60	179	10.0	121	6.5
		80	179	9.4	136	7.6
	Mb	0	209	8.4	124	7.7
		20	202	9.4	147	8.3
		40	212	9.6	153	7.7
		60	221	9.5	147	7.5
		80	221	9.0	143	8.8
Statistically significant factors at Pr # 0.05:						
			T †	N	N	T
			N			N

† T, tillage; N, nitrogen rate.