NITROGEN RATES FOR WINTER WHEAT FOLLOWING SOYBEANS

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Introduction

Winter wheat has a strong tradition in Wisconsin, particularly in the south central and eastern counties. It fits well in rotations with canning crops which are popular there. But in recent years, corn and soybean growers who are looking to diversify their rotation also find winter wheat attractive. Wheat typically follows soybeans in the rotation and can be drilled no-till into the soybean residue. This leads to the question: What is the optimum nitrogen (N) application rate for wheat following soybeans?

Methods

Studies were conducted in 2005 and 2006 which compared N rates on winter wheat at two locations in southern Wisconsin: Arlington in Columbia County and Lancaster in Grant County. At the UW-Arlington Ag Research Station, winter wheat was grown in three rotations: following soybeans; following corn harvested as silage; and following corn harvested for grain. Wheat was planted no-till on the same date within each year in all systems. Six rates of N were then applied the following spring: 0, 25, 50, 75, 100 and 125 lb/a.

In a separate study, wheat was planted no-till following soybeans at the UW-Lancaster Ag Research Station. Four N rates were spring-applied: 0, 30, 60 and 90 lb/a. The N source at both locations was ammonium nitrate and it was applied before April 15 in all years.

Results and Discussion

At Lancaster, there was a significant grain yield increase from 0 to 30 lb N/a in both years, but no further response occurred at higher N rates even at very high yield levels (Table 1). Wheat yields at Arlington did not significantly increase above 50 lb N/a in 2005 or above 25 lb N/a in 2006 (Table 2).

Plateau N rate (PNR), the point where wheat yields begin to level off with increasing N rates, ranged from 30-74 lb N/a following soybeans in these studies (Table 3). The PNR averageed 59 lb N/a over the two years and two locations.

The economic optimum N rate (EONR) averaged 34 lb N/a when wheat was priced at $2.90/bu and N was $0.36/lb (Table 3). These prices were typical during the 2006 harvest season. The EONR increased to 42 lb N/a when prices were updated to $4.70/bu for wheat and $0.30/lb for N.

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Comparing N Recommendation Methods

The standard N recommendation for wheat in Wisconsin has recently been revised to 70 lb N/a (Laboski et al., 2006). The book value N credit (BVNC) for soybeans is 40 lb N/a, resulting in a recommended N application of 30 lb/a. This amount matches very closely with the observed EONR using $2.90/bu wheat (Table 5). When the wheat price was $4.70, however, two of the four tests showed responses to N rates above the BVNC.

The preplant soil nitrate test (PPNT) did not identify an N credit at Lancaster in either year (Table 5). PPNT results must exceed 50 lb nitrate-N/a before a credit is applied. For example, if the PPNT totaled 60 lb/a, the N credit would be 10 lb/a. At Arlington the soil nitrate results were not statistically different following soybeans and corn (Table 4). The test did identify a large N carryover (108 lb/a) following corn for grain in 2006. The N recommendation there was close to the EONR (Table 5).

This example compares to previous studies in Wisconsin (Bundy and Andraski, 2004) that showed the PPNT is a useful predictor of N needs when wheat follows a nonlegume crop. It is less accurate and less useful following soybeans.

Conclusions

- When winter wheat follows soybeans, a nitrogen credit should be taken.
- The book value N credit of 40 lb/a results in an N application (30 lb/a) that compares well with the EONR. When wheat prices are higher ($4.70/bu), growers can justify higher N rates, up to ~50 lb/a.
- The PPNT is less reliable in predicting the optimum N rate when wheat follows soybeans than when it follows corn or another nonlegume crop.

Questions for Future Research

- When is the optimum time to apply N in the spring in Wisconsin? Is there an advantage for a later application?
- Do yields respond to split N applications, including a fall treatment?
- Is the N response following soybeans consistent across widely different soil types, such as the red- clay soils of eastern Wisconsin?

References

Bundy, L.G., and T.W. Andraski. 2004. Diagnostic Tests for Site-Specific Nitrogen Recommendations for Winter Wheat. Agron. J. 96:608-614.

Laboski, C.A.M., J.B. Peters, and L.G. Bundy. 2006. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. UWEX Publ. A2809. Univ. of Wisconsin-Extension, Madison, WI.

Table 1. Effect of N rate on no-till winter wheat grain yield where the previous crop was soybean at Lancaster, 2005 and 2006.

	Year	
N rate	2005	2006
lb/a	---------- grain yield, bu/a ----------	
0	65 b †	87 b
30	78 a	105 a
60	82 a	105 a
90	83 a	106 a
Mean	77	101
p	<0.01	<0.01
CV, %	8	7

† Values for each location and year followed by the same letter are not significantly different at the 0.05 probability level.

Table 2. Effect of previous crop/management and wheat N rate on no-till winter wheat grain yield at Arlington, 2005 and 2006.

		Previous crop/management			
Year	N rate	Soybean	Corn silage	Corn grain	Mean
	lb/a	---------- yield, bu/a ----------			
2005	0	65	48	40	51 c † ‡
	25	72	56	52	60 b
	50	74	66	52	64 ab
	75	71	67	57	65 a
	100	77	67	53	66 a
	125	73	68	53	65 a
	Mean †	72 a	62 b	51 c	
2006	0	70	61	65	65 c §
	25	74	74	64	70 ab
	50	76	73	63	71 ab
	75	77	72	74	74 a
	100	77	74	68	73 a
	125	71	65	62	66 bc
	Mean §	74 a	70 ab	66 b	

† 2005: Previous crop $p < 0.01$; N rate $p < 0.01$; Previous crop x N rate $p = 0.07$ (NS); CV, 9%.
‡ Mean values for each year followed by the same letter are not significantly different at the 0.05 probability level.
§ 2006: Previous crop $p < 0.01$; N rate $p < 0.01$; Previous crop x N rate $p = 0.30$ (NS); CV, 10%

Table 3. Plateau (PNR) and economic optimum N rate (EONR) for no-till winter wheat grain yield following soybean at Lancaster and following soybean, corn harvested as silage, and corn harvested as grain at Arlington determined using regression analysis, 2005 and 2006.

					PNR		EONR ‡	
Location	Previous crop / management	Year	Equation (method †)	R^2	N rate	Yield	N rate	Yield
					lb/a	bu/a	lb/a	bu/a
Lancaster	Soybean	2005	$y = 65.1 + 0.602x - 0.00517x^2$ (QRP)	0.99	63	83	46 52	82 82
		2006	$y = 87.2 + 0.614x$ if $x \leq 30$ (LRP)	0.99	30	105	30 30	105 105
Arlington	Soybean	2005	$y = 64.6 + 0.455x - 0.00577x^2$ (QRP)	0.80	74	74	29 34	73 73
		2006	$y = 69.3 + 0.225x - 0.00162x^2$ (Q)	0.88	69	77	31 50	75 77
	Corn silage	2005	$y = 47.6 + 0.357x$ if $x \leq 56$ (LRP)	0.99	56	68	56 56	68 68
		2006	$y = 62.5 + 0.372x - 0.00277x^2$ (QRP)	0.81	67	75	45 56	74 75
	Corn grain	2005	$y = 40.0 + 0.657x - 0.00779x^2$ (QRP)	0.93	63	55	34 38	53 54
		2006	$y = 66 + 0x$ (NS)	-	0	66	0 0	66 66

† QRP, quadratic-response plateau; LRP, linear-response plateau; Q, quadratic; NS, not significant.
‡ Economic optimum N rate determined at \$0.36/lb N fertilizer and \$2.90/bu wheat grain within the **left** side of the N rate and yield columns and \$0.30/lb N fertilizer and \$4.70/bu wheat grain within the **right** side of these columns.

Table 4. Soil NO_3-N content (0-2 ft) in the control (no N) in fall (preplant) and/or spring (GS25) where the previous crop was soybean at Lancaster and soybean, corn harvested as silage, and corn harvested as grain at Arlington, 2005 and 2006.

Location	Year	Previous crop / management	Time of sampling	
			Fall preplant	Spring GS25
			---------- soil NO_3-N, lb/a ----------	
Lancaster	2005	Soybean	34	33
	2006	Soybean	37	52
Arlington	2005	Soybean	-	44
		Corn silage	-	37
		Corn grain	-	37
		p	-	0.24 (NS) †
	2006	Soybean	61	-
		Corn silage	78	-
		Corn grain	92	-
		p	0.28 (NS) †	-

† The effect of previous crop / management at Arlington was not significant (NS).

Table 5. Preplant soil NO_3-N test (PPNT) contents and N recommendations for winter wheat based on the standard N rate (70 lb N/acre), the standard N rate adjusted for the PPNT, and the standard N rate adjusted using a book value N credit (BVNC) compared with the observed economic optimum N rate (EONR) for several previous crop / management systems at Lancaster and Arlington, 2005 and 2006.

				N recommendation method				
Location	Year	Previous crop / management	PPNT (0-3 ft) †	Standard	PPNT ‡	BVNC §	Observed EONR*	
			lb NO_3-N/a	lb N/a				
							Low	High
Lancaster	2005	Soybean	43	70	70	30	46	52
	2006	Soybean	46	70	70	30	30	30
Arlington	2005	Soybean	-	70	-	30	29	34
		Corn silage	-	70	-	-	56	56
		Corn grain	-	70	-	-	34	38
	2006	Soybean	73	70	47	30	31	50
		Corn silage	82	70	38	-	45	56
		Corn grain	108	70	12	-	0	0

† At Lancaster, soil NO_3-N content at the 2-3 ft depth increment was predicted from the 1-2 ft depth increment based on the equation $y = 5.8 + 0.51x$ as determined from 21 winter wheat trials in Wisconsin conducted from 1996 to 1999 (Bundy and Andraski, 2004) where: x, soil NO_3-N (lb/a) at 1-2 ft depth; y, predicted soil NO_3-N (lb/a) at 2-3 ft depth.
‡ PPNT N recommendation = 70 – (PPNT – 50).
§ Book value N credit recommendation = 70 – 40.
* EONR determined for "Low"-- \$0.36/lb N and \$2.90/bu wheat and "High"-- \$0.30/lb N and \$4.70/bu wheat.