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Residual Soil Nitrate Responses to Early and Late-Season Nitrogen Applications in Irrigated Spring Wheat

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Spring wheat grain protein is consistently increased by 0.5 to 2% with the application of late-season N under irrigated conditions when early-season N fertility is optimum for grain yield. An effective and efficient approach to N fertilization for yield and protein is to make an early-season N application targeted for a yield potential in consideration of soil analysis, followed with an application of N at heading to increase grain protein. This kind of fertilization program, because it relies on N application late in the season, may lead to high levels of residual soil nitrate following harvest and therefore pose an environmental risk to ground water. Our objective was to document the effects of late-season N applications on residual soil nitrate following irrigated spring wheat production at several sites and with varying rates of early-season N fertilization.

Irrigated studies consisted of growing three hard red spring wheat varieties (Len, Newana, and Hi-Line) with four rates of early-season N applied as granular urea at rates ranging up to 150 to 300 lbs N/a depending on soil N analysis and yield potential for the site. Three sites were included in 1994 and four sites in 1995 (Tables 1 and 2). At heading, half of each N rate plot received an additional 40 lbs N/a as granular urea and the other half remained without further N application. Grain yield and protein responses are reported in Fertilizer Facts #11. After grain harvest, soil samples were taken to a depth of four feet. These samples were analyzed for nitrate concentration in two-foot increments in 1994 and one-foot increments in 1995.

Nitrogen fertilization had no significant effect on residual soil nitrate levels at Conrad in 1994 (Table 1). At Bozeman, early-season application of 120 lbs N/a resulted in elevated residual nitrate levels in the upper two feet of the soil profile and the 180 lb N/a rate caused increases throughout the sampling depth of four feet. These initial fertilization rates were in excess of the optimum for yield and protein. Late-season N application did not increase residual soil nitrate levels at this site. At Kalispell, late-season N application significantly elevated residual soil nitrate levels in the upper two feet when initial N application rates were excessive; at optimum or sub-optimum initial N rates, the effects of late-season N on residual soil nitrate were slight.

Table 1. *Effects of initial N fertilization rate and late-season N application on residual soil nitrate (NO_3-N) following harvest of irrigated hard red spring wheat at four locations in 1994.*

Location	Initial N rate	N applied at heading	Soil NO_3-N	
			Soil Depth (ft)	
			0 - 2	2 - 4
	------- lbs N/a -------		-------- ppm --------	
Bozeman	*0*	*0*	*4.6*	*4.8*
		40	*4.4*	*6.1*
	*60**	*0*	*4.9*	*5.1*
		40	*5.4*	*6.2*
	120	*0*	*7.0*	*5.9*
	180	*40*	*11.0*	*6.6*
		0	*12.9*	*12.0*
		40	*11.9*	*9.7*
Conrad	*0*	*0*	*12.0*	*2.4*
		40	*3.3*	*2.0*
	20	*0*	*3.9*	*2.7*
	*95**	*40*	*7.9*	*5.4*
	170	*0*	*2.3*	*2.7*
		40	*2.8*	*2.5*
		0	*5.6*	*4.5*
		40	*4.0*	*4.6*
Kalispell	*0*	*0*	*4.4*	*3.2*
		40	*7.7*	*3.6*
	*50**	*0*	*3.8*	*3.9*
	100	*40*	*6.5*	*4.2*
	150	*0*	*4.9*	*3.7*
		40	*10.0*	*3.8*
		0	*5.6*	*3.7*
		40	*10.1*	*4.7*

**Denotes optimum N fertilization for grain yield and protein.*

Results were similar in 1995 (Table 2). At Bozeman and Huntley, both initial N and late-season N significantly increased residual soil nitrate levels, but only in cases where initial N rates were excessive. At Kalispell, late-season N had no significant effect on residual soil nitrate regardless of early-season N, but the two highest rates of early-season N did increase nitrate in the lower two feet of the sampled soil profile. Only at Corvallis was there a consistent and significant effect of late-season N; at the 1 to 2 foot soil depth, late-season N increased residual soil nitrate levels by about 3 ppm regardless of early-season N application rate. However, it is worth noting that this effect was small

compared to the greater effects of excessive early-season N, which increased soil nitrate concentration by 4 to 9 ppm at the 1 to 2 foot depth compared to the optimum rate of 60 lbs N/a.

Table 2. *Effects of initial N fertilization rate and late-season N application on residual soil nitrate (NO_3-N) following harvest of irrigated hard red spring wheat at four locations in 1995.*

			Soil NO_3-N			
			Soil Depth (ft)			
Location	Initial *N rate*	N applied at heading	*0 - 1*	*1 - 2*	*2 - 3*	*3 - 4*
	-------- lbs N/a -------		*---------- ppm ----------*			
Bozeman	*0*	*0*	*4.7*	*5.2*	*5.5*	*3.7*
		40	*5.1*	*6.3*	*5.7*	*3.8*
	*60**	*0*	*3.9*	*5.8*	*4.7*	*3.8*
		40	*3.8*	*5.8*	*5.4*	*3.7*
	120	*0*	*3.8*	*6.9*	*6.5*	*4.1*
	180	*40*	*8.8*	*7.4*	*6.6*	*5.3*
		0	*5.4*	*6.5*	*6.3*	*5.4*
		40	*13.9*	*8.9*	*7.4*	*9.1*
Corvallis	*0*	*0*	*2.9*	*3.8*	*3.4*	*3.0*
		40	*3.3*	*6.6*	*4.3*	*3.6*
	*60**	*0*	*5.2*	*7.5*	*5.1*	*3.9*
	120	*40*	*6.6*	*10.7*	*5.5*	*4.8*
	180	*0*	*5.5*	*11.6*	*6.7*	*5.6*
		40	*6.6*	*14.7*	*9.1*	*6.4*
		0	*7.5*	*16.4*	*7.7*	*5.7*
		40	*6.4*	*18.5*	*9.7*	*6.3*
Huntley	*0*	*0*	*2.0*	*1.7*	*1.5*	*1.5*
		40	*1.7*	*1.3*	*1.3*	*1.8*
	20	*0*	*1.9*	*1.6*	*2.4*	*2.3*
	*95**	*40*	*2.2*	*1.6*	*1.5*	*1.4*
	170	*0*	*1.5*	*1.2*	*1.1*	*1.4*
		40	*2.7*	*1.7*	*1.5*	*1.9*
		0	*4.8*	*2.1*	*1.7*	*1.9*
		40	*7.9*	*2.7*	*2.3*	*2.0*
Kalispell	*0*	*0*	*1.4*	*2.3*	*1.9*	*2.3*
		40	*1.7*	*3.2*	*1.6*	*2.2*

	50	*0*	*1.5*	*1.8*	*1.1*	*1.1*
		40	*1.3*	*2.5*	*1.3*	*1.2*
	*100**					
		0	*1.3*	*2.9*	*2.4*	*2.0*
	150	*40*	*1.7*	*3.4*	*3.6*	*1.8*
		0	*1.6*	*2.5*	*3.7*	*3.3*
		40	*1.6*	*5.8*	*2.7*	*3.0*

**Denotes optimum N fertilization for grain yield and protein.*

Fertilizer Facts:

- *The most important factor contributing to elevated residual soil nitrate levels in irrigated spring wheat production is early-season N fertilization in excess of the optimum for grain yield and protein considerations.*
- *When early-season N fertilization is optimum, late-season N applications generally do not increase residual soil nitrate levels; where increases do occur, they are slight.*
- *When early-season N fertilization is excessive, late-season N applications are inefficiently used and can contribute to elevated residual soil nitrate levels.*
- *We recommend that late-season N be applied only after careful consideration of early-season N fertilization, crop yield potential and analysis of crop N status at the time of application.*

Edited by Jeff Jacobsen, Extension Soil Scientist