INFLUENCE OF SOIL NITRATE NITROGEN AND FERTILIZER NITROGEN ON WHEAT GRAIN YIELD AND PROTEIN

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Wheat producers have recently shown a great deal of interest in grain protein levels. This interest has developed primarily because of the relatively large protein premiums available the last several years (Table 1). Nitrogen is a primary component of protein and needs to be added for most soils to produce high yielding, high protein wheat. The objectives of this study were to determine the effects of soil nitrate nitrogen and fertilizer nitrogen on wheat grain yields and protein levels.

Procedures

Thirteen field experiments were conducted on Borolls in Northeastern South Dakota on hard red spring wheat in 1985. Soil textures across sites included sandy loam (1), loam (2), silty clay loam (4), silty clay (I) and clay loam (5). The range and average across the sites for selected soil tests are found in Table 2.

Past crop varied across sites and included wheat, flax, oats, corn, barley and sunflower. The most common tillage used was chisel and chisel-disc. Planting date was generalIy early to mid-April. Cultivars of hard red spring wheat used across sites are listed in Table 3 along with the relative protein ranking of each variety. Plot size was generally 10 feet by 20 feet. Row spacing was 6 or 7 inches. Various herbicides were used for weed control as deemed necessary by the cooperator. Phosphorus was drill applied by the cooperator on those sites that tested low or medium in soil test phosphorus. Nitrogen treatments consisted of 0, 25, 50, 75, 100 and 125 lb/A N that was broadcast on the soil surface as two weeks after plot seeding.

Experiments wereconducted in a randomized complete block design with four replications. Soils were sampled within two weeks of seeding by one foot increments to four feet. Grain yields were determined with a small plot combine. Grain nitrogen was determined by macro-Kjeldahl and protein estimated by a factor of 5.7 x grain N.

Results

The growing conditions were almost ideal for small grains for most of the study sites. Two sites west of the James River did have drought stress. One Hamlin county site was not used in the analysis because of plot variability.

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The average grain yield for each treatment across sites is shown in Table 4. The sites are grouped according to yield response from added nitrogen. The excellent yields are a reflection of the timely rainfalls received. The sites that responded to added nitrogen had an average nitrate-nitrogen soil test of 44 lb/A; whereas, those sites that didn't respond had an average soil nitrate test of 106 lb/A.

This data indicates that the soil test is of value in predicting response to fertilizer nitrogen. The mean yields of the high fertility sites and low fertility sites are plotted in Figure 1. It can be seen from this graph that an average of approximately 75 pounds of fertilizer nitrogen was needed to achieve highest yields for the low fertility sites.

The mean grain protein levels for each treatment across all sites are shown in Table 5. The sites are grouped as in Table 4. The low fertility on the check treatments of the high fertility sites. This comparison points out the importance of residual soil nitrogen in wheat protein levels. This point is also expressed in Figure 2. The grain protein from each treatment that received no added nitrogen was plotted against the residual nitrate-nitrogen from that site. The grain protein tends to increase as residual soil nitrogen increases.

The mean protein value for each treatment of the high and low fertility groups is plotted in Figure 3. Added nitrogen increased grain protein levels for both groups. However, added N increased protein levels at a greater rate on the low fertility fields. It appears that with higher rates of applied N the two groups would eventually meet. A higher rate of fertilizer nitrogen is needed to reach maximum protein levels than maximum yield levels (Figure 1, Figure 3). This is often noted with nitrogen response trials.

This point brings up the question "Do we fertilize for yield or protein?". To answer this question, the economics of nitrogen application for wheat has to be addressed.

Economics

Approximately 75 lb/A of N maximized average yields for the low fertility group (Figure 1) and the 75 lb/AN rate maximized grain protein content for the high fertility group (Figure 3). If the 75 lb/A N rate is used for both the low and high fertility groups for calculating economics, Table 6 is generally with the assumptions as listed. The return over fertilizer costs for the low fertility sites was $48.62 while the return on the high fertility sites was only $-.18. Much more profit can be realized per acre by fertilizing the low fertility fields.

The question needs to be asked that if additional fertilizer N is applied to the low fertility sites (beyond maximum yield) and protein is increased, will the added protein value pay for the added N. If the same calculations as above are made with the low fertility sites only, assuming:

1) an additional 50 lb/A N is needed to reach a maximum grain protein level of 15.7%;
2) that no increase in yield is realized over the original 75 lb/A N rate; and
3) other assumptions as per Table 6, then the return is calculated as $49.84, a very small increase over the $48.62 value that was previously calculated (Table 6).

Futhermore, if the same calculations are made only assuming a protein premium of $0.10 per percent, the return is reduced to $36.00/A. Therefore, fertilizing for maximum protein over and above maximum yield offers little increased return if protein premiums are high and a substantial decrease in return if protein premiums are low.

Conclusions

Yield increases from added N to wheat was dependent on residual soil nitrogen. On the average, as soil nitrate levels increased, response to added N decreased. The data also indicated that wheat grain protein increased with added nitrogen regardless of residual soil nitrogen. However, the rate of protein increase was much greater on the low fertility sites. In addition, higher fertilizer nitrogen levels were needed to produce maximum grain protein over and above the amount nedded for maximum yield. However, present economics favor applying recommended N rates for an optimistic yield goal and not applying additional nitrogen to increase protein content.

Table 1. Protein premiums paid for hard red spring wheat over the past 6 years.

Year*	Protein Content 11%	Protein Content 17%	Price Spread	Price per 1% protein
	-price paid $--		---$--	- cents --
1981	4.30	4.57	0.27	4.5
1982	3.85	4.30	0.45	7.5
1983	4.36	4.55	0.19	3.2
1984	3.65	4.62	0.97	16.3
1985	2.94	4.64	1.70	28.3
1986	2.82	3.92	1.10	18.3

* Taken in November or December from Minneapolis.

Table 2. Summary of spring soil tests, N-wheat sites.

	NO_3-N 0-6"	NO_3-N 0-24"	NO_3-N 0-48"	P	K	O.M.	pH
	lb/A					%	
Range	10-48	27-236	60-473	16-200+	290-1900	1.4-5.1	6.2-7.6
Average	23	91	170	56	689	3.6	6.8

Table 3. Varieties used in wheat - N experiments.

Variety	Relative Protein Ranking	No. of Sites
Len	16.0	3
Butte	15.2	2
Erik	15.1	1
Guard	14.6	4
Wheaton	14.0	1
Apex	13.9	1
Oslo	13.9	1

Table 4. Mean wheat yields for N-wheat studies.

Site	NO_3-N	Rate of N: 0	25	50	75	100	125	F	C.V.
	lb/A-2'	yield, bu/A							%
N Responsive* Sites									
Deuel	38	22	29	37	43	48	58	.0001	10.8
Grant 2	53	46	49	51	49	47	52	.01	4.3
Roberts	53	50	54	57	60	57	56	.04	7.0
Marshall 1**	27	26	34	38	43	45	42	.0001	9.7
Marshall 2	40	54	59	63	65	63	59	.002	4.8
Brown	51	42	43	47	49	47	45	.06	6.7
Mean	44	40	45	48	51	51	52	——	——
No N Response									
Brookings	105	61	65	62	59	63	60	.12	5.1
Grant 1	84	91	86	85	84	81	78	.04	5.7
Codington	107	66	69	65	63	65	60	.30	8.2
McPherson***	43	20	21	19	18	18	22	.38	15.6
Spink	236	49	49	48	48	49	48	0.99	6.9
Hamlin	62	56	52	52	64	58	59	0.11	10.9
Mean	106	57	57	55	56	56	55	——	——

* If treatment F test for yield was below 0.10.
** Slightly drought stressed.
*** Severely drought stressed.

Table 5. Mean grain protein content for N-wheat studies.

Site	0	25	50	75	100	125	F	C.V.
	Rate of N							
	% Protein							%
N Responsive Sites*								
Deuel	10.0	9.4	9.8	10.8	11.5	12.6	.0001	3.2
Grant 2	13.7	15.6	16.0	16.0	17.1	17.3	.001	6.0
Roberts	14.5	14.2	15.2	16.3	16.5	17.5	.0001	4.0
Marshall 1	13.3	13.5	13.7	14.2	14.3	14.5	.01	3.2
Marshall 2	12.4	12.5	13.5	14.0	14.7	15.3	.0001	5.1
Brown	14.3	14.9	15.6	16.4	16.9	17.2	.0001	5.1
Mean	13.0	13.4	14.0	14.6	15.2	15.7	—	—
No N Response**								
Brookings	15.0	15.7	15.9	16.6	16.0	16.7	.006	3.4
Grant 1	14.6	14.7	14.9	15.3	15.7	15.9	.21	5.7
Codington	13.8	13.8	14.0	14.6	14.5	14.5	.15	3.8
McPherson	15.7	16.8	18.5	18.5	18.7	18.2	.007	4.7
Spink	16.8	17.1	17.5	17.4	17.6	17.6	.001	1.3
Hamlin	13.3	13.6	14.3	14.9	15.1	15.5	.0001	2.9
Mean	14.9	15.3	15.9	16.2	16.3	16.4	—	—

* N responsive for yield.
** No N response for yield.

Table 6. Economics from nitrogen addition to wheat*.

N Rate	Yield	Protein	Gross Return From Fert. Yield	Gross Return From Fert. Protein	Gross Return From Fert. Total	Cost	Return Over Fert. Costs
lb/A	bu/A	%	$/A				
Low Fertility Sites							
0	40	13.0	—	—	—	—	—
75	51	14.6	47.30	16.32	63.62	15.00	48.62
125	51	15.7	47.30	27.54	74.84	25.00	49.84
High Fertility Sites							
0	57	14.9	—	—	—	—	—
75	57	16.2	0	14.82	14.82	15.00	-.18

*Assuming: $0.20/lb N
$4.30/bu wheat (program participation)
$0.20/% protein premium (13.0% base)

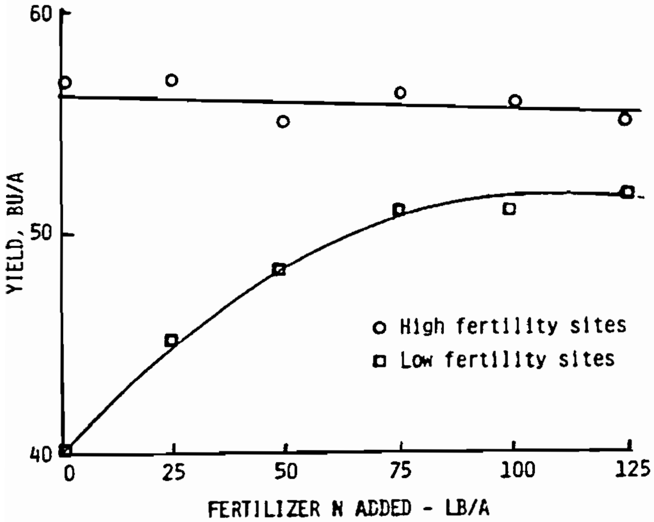

Fig. 1. Wheat yield response from added N.

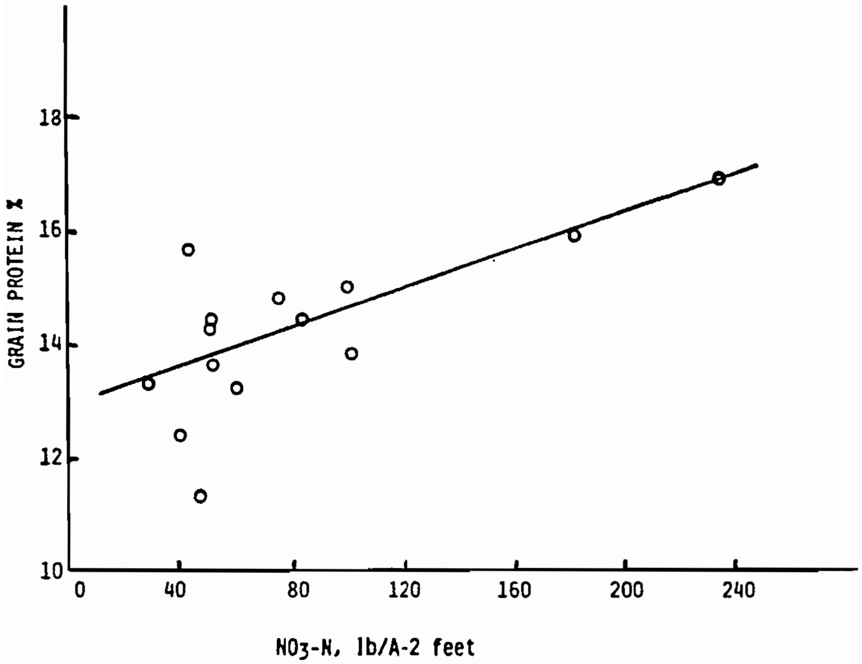

Fig. 2. Influence of soil nitrate-N level on wheat grain protein.

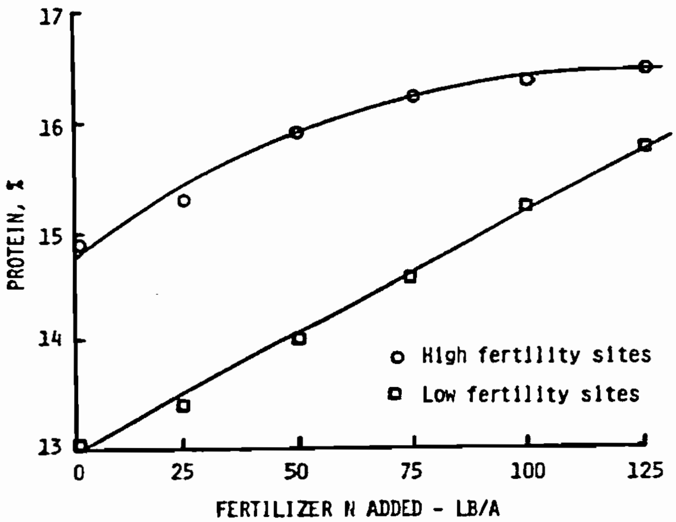

Fig. 3. Influence of added N on wheat grain protein.

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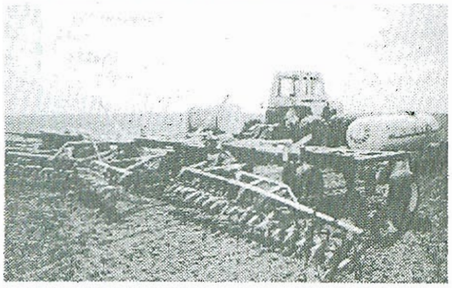
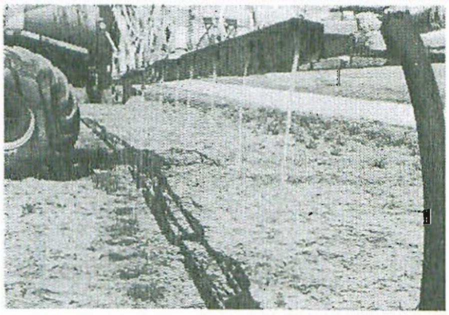

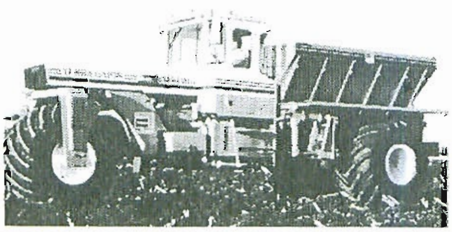
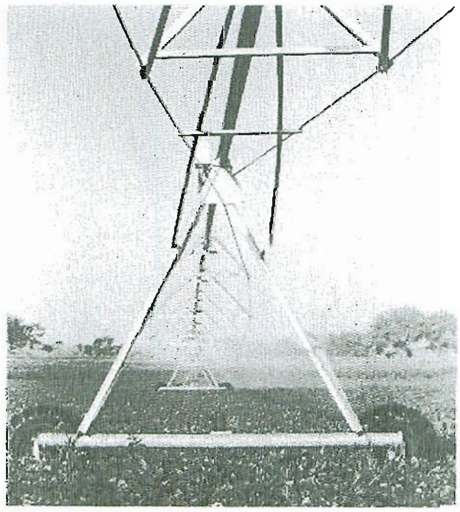
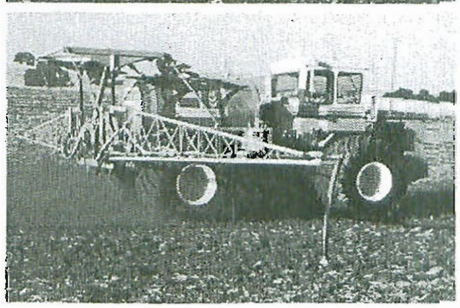

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