ND-1

ANNUAL REPORT

1981

NITROGEN AND PHOSPHORUS MANAGEMENT FOR RECROP WHEAT PRODUCTION

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Introduction

Eight experiments were established in western ND on non-fallowed (recrop) fields. The purpose of these experiments was to measure the effects of nitrogen (N) rate, N source, and phosphorus (P) placement on wheat yield and composition. One site was abandoned due to a herbicide failure.

The climatic conditions which prevailed in 1981 were, in general, adequate to produce moderate recrop yields. Moisture at seeding was below normal and growing season precipitation was normal or above at most sites. Very hot winds (108 F) at anthesis limited yields at one site (Dickinson). Precipitation data is presented in Table 1.

Methods

A non-factorial arrangement of four N rates (0, 34, 68, 101 kg N/ha), three N sources (anhydrous ammonia, urea-ammonium nitrate, and ammonium nitrate) and two liquid fertilizer placements (surface and deep knifed) were used. Specific treatment combinations are shown in Table 2. Phosphoric acid was used as the P source. The N rate of 101 kg/ha was not included at Dickinson.

Treatments were set out in the spring of 1981 before planting, with three exceptions. The Minot and Williston winter wheat sites were fertilized prior to seeding in September 1980. The Williston spring wheat site was fertilized in the spring of 1980. Poor germination occurred in 1980 at that site and so the site was subsequently sprayed with Roundup and chemical fallowed in 1980. Agronomic data is presented in Table 3.

Yields, test weight, grain protein, grain N uptake, grain P uptake, boot-stage tissue N and boot-stage tissue P were taken at all sites.

Additional measurements were taken at two other sites (Williston SW and Dickinson SW) at early dough stage. These measurements were: total forage yield, total forage N uptake, total forage P uptake, tillers per square meter, thousand kernel weight, and kernels per tiller.

Statistical analyses of the data are being performed at the time of this writing by Brian Johnson, who will use these experiments in his M.S. thesis. Copies of this thesis will be provided to PPI. Water use efficiency data and residual NO_3-N data will be documented in this thesis.

Results

The summary of pre-plant soil tests are presented in Table 4. All sites were low to medium in nitrates and Olsen P levels ranged from low to high. Available K was high, and all soils were non-saline.

The average effect of N on grain yields is presented in Table 5. Nitrogen increased yields substantially at all sites except the two Minot locations. The reason for the lack of response at these sites is not known, as both sites had low enough initial NO_3-N levels that a response to at least 34 kg/ha would have been expected. This indicates an unusual amount of nitrification during the growing season -- especially at the Minot winter wheat location. The problem of occasional sites with low to medium NO_3 levels which do not respond to N is of concern to soil fertility workers in ND. At present no soil test exists for identification of these sites before the growing season. Research is being done by Bill Dahnke in the area of soil testing for potential N mineralization in North Dakota. The lack of N response at the two Minot locations illustrate the need for this research.

Table 6 illustrates that the majority of the yield increases came from increased tillering and more kernels/tiller. Increasing N rates above that needed to maximize yield increased tillering and decreased kernel weight. Nitrogen fertilization increased grain protein content (Table 7). Winter wheat contained less protein than spring.

This year's data for Len wheat (Figure 1) strongly suggests that a protein "critical level" approach could be used in North Dakota as a post-harvest evaluation of N sufficiency for yield. This approach has proven successful in Colorado. Great variation exists in the grain protein contents of popular spring wheat varieties. More research is warranted in this area, however, as protein "critical levels" are useful extension tools.

Nitrogen increased tissue N contents (Table 8) at all sites except the Minot winter wheat site. This was probably due to the very early sampling date for this site.

Yield and composition responses to N, in general, were fairly typical for recrop wheat with the exceptions of the Minot sites. These data are being used for soil test calibration.

N Source

Ammonia volatilization from surface fertilization of urea-based fertilizers is of concern to farmers. The possibility of these losses is enhanced by the heavy surface residues present in no-till and conservation tillage systems. Previous work with no-till wheat in western ND showed significantly less response from non-incorporated urea (relative to ammonium nitrate) with heavy surface residues.

The average effect of N sources on wheat yields is shown in Table 9. No single source proved consistently superior or inferior. Anhydrous ammonia and surface UAN gave identical average yields. The average yield from ammonium nitrate was slightly less (~40 kg/ha) but this was probably not significant.

Nitrogen uptake in grain and/or forage with respect to N source is presented in Table 10. Averaged across all sites, the grain N uptakes were similar for all sources.

Forage N uptake data was, in general, more variable than grain N uptake data. There was little difference between sources when averaged across both sites. No consistent effects of N sources on yield components could be detected (Table 11).

P Placement

Interest in P placement has flourished during the past few years. These experiments compared surface versus deep placement of phosphoric acid. The average effects of P placement on yield is shown in Table 12. On the average it would appear that there was no effect of placement on yield. A significant effect was noted at the Williston winter wheat location, however. Increased plant growth from deep placement was visually obvious at this site. No visual growth effects of deep placement could be detected at other sites. The Williston WW site had a low P soil test. It is not known why a yield response from deep placement was not obtained at the other low-testing sites.

Deep-placement did not appear to increase grain or forage P uptake substantially, except at the Williston WW site (Table 13). Deep-placement did not appear to increase tissue P contents, except at the Williston WW site (Table 14).

It is not known why deep-placement increased wheat yield, P uptake, and P concentration at only one site. There were three low-testing sites and two medium-testing sites and it is not known why deep placement did not appear more advantageous at these sites.

Future research concerns

This research has brought up several questions which warrant future study:

1) More study is needed on P placement. This year's work did not demonstrate a general superiority of deep-placement over surface P, except for at one site in seven. This is puzzling, since many studies in Manitoba, Montana, Nebraska, Kansas, and even in eastern ND have shown a more consistent deep placement advantage on low and medium testing soils.

2) The nitrogen sources gave essentially the same response in this study, although opposite results have been obtained in western ND in other years. Practical "rules of thumb" have not been elucidated as to when urea-based fertilizers need incorporation (with respect to soil temp, stubble load, stubble geometry, etc.).

3) Preliminary data indicate that yield:protein critical levels can be obtained for specific varieties of wheat. This fits into a larger problem in ND - the "yield versus protein" dilemna. Currently, recommended varieties differ widely in their protein contents -- as much as 3-4% protein at equal N nutrition. The lower protein wheats virtually always have a sizable yield advantage over high protein wheats. Quantification of protein "critical levels" is a very useful tool for post-harvest evaluation of a grower's N program.

Another future research concern is the effect of chloride fertilization on cereal disease severity.

Table 1. Precipitation from spring soil sampling until fall soil sampling.

Site	A	M	Month J	J	A	Total
	cm					
Fortuna SW	0.58	4.01	9.47	2.62	2.54	19.22
Stanley SW	0.94	4.78	12.37	6.10	3.86	28.05
Minot WW	2.11	2.01	9.75	4.27	1.65	19.79
Minot SW	2.11	2.01	9.75	4.27	1.65	19.79
Williston WW	1.35	1.55	15.16	5.97	1.57	25.60
Williston SW	1.35	1.55	15.16	5.97	1.57	25.60
Dickinson SW	1.68	3.30	9.42	3.99	4.95	23.34

Table 2. Treatment combinations used in N-P management experiments.

Treatment Number	N Source	N Rate	P Placement
		- kg/ha -	
1	-	0	sfc
2	-	0	deep
3	AA	34	deep
4	AA	68	deep
5+	AA	101	deep
6	AA	34	sfc
7	AA	68	sfc
8+	AA	101	sfc
9	UAN-sfc	34	sfc
10	UAN-sfc	68	sfc
11+	UAN-sfc	101	sfc
12	UAN-deep	34	deep
13	UAN-deep	68	deep
14+	UAN-deep	101	deep
15	AN	34	sfc
16	AN	68	sfc
17+	AN	101	sfc
18	AN	34	deep
19	AN	68	deep
20+	AN	101	deep

+Not included at Dickinson.

P rate was 34 kg/ha of P_2O_5.

Table 3. Crop varieties and dates of significant field operations.

Site	Variety	Fertilization	Seeding	Spring Soil Sampling	Tissue Sampling	Harvest	Fall Soil Sampling
Fortuna SW	Len	4-22-81	5-11-81	4-21-81	7-7-81	8-13-81	9-2-81
Stanley SW	Len	4-22-81	5-13-81	4-21-81	7-6-81	8-26-81	9-1-81
Minot WW	ND7481+	9-8-81	9-16-81	4-8-81	5-26-81	8-4-81	8-10-81
Minot SW	Len	4-9-81	4-10-81	4-10-81	6-15-81	8-5-81	8-10-81
Williston WW	Roughrider	9-16-80	9-18-80	-	6-16-81	7-23-81	8-11-81
Williston SW	Len	5-2-80	4-10-81	4-2-81	6-16-81 7-10-81	8-6-81	8-12-81
Dickinson SW	Coteau	4-1-81	4-8-81	3-31-81	6-17-81 7-10-81	8-4-81	8-12-81

+An experimental line.

Table 4. Soil tests from the experimental sites.

Site	0-60 cm+	0-30 cm+			
	NO_3-N	Olsen P	K	pH	EC
	kg/ha	kg/ha	kg/ha		mmho/cm
Fortuna SW	24	11	610	7.5	0.1
Stanley SW	16	7	500	7.1	0.1
Minot WW	31	10	520	6.9	0.4
Minot SW	47	18	490	6.3	-
Williston WW	17	8	470	7.2	0.4
Williston SW	51	40	440	7.1	0.3
Dickinson SW	28	47	560	5.7	-

+Data from NDSU soil testing lab, using routine procedures.

Table 5. Average effect of N on grain yields.

Site	N rate, kg/ha 0	34	68	101
	kg/ha			
Fortuna (SW)	963	1227	1341	1165
Stanley (SW)	1681	2383	2685	2913
Minot (WW)	2488	2457	2425	2356
Minot (SW)	2319	2418	2365	2151
Williston (WW)	1151	1871	2016	2016
Williston (SW)	1628	2124	2248	2247
Dickinson (SW)	643	887	893	---

Table 6. Average effect of N on yield components at two locations.

Site and component	N rate, kg/ha 0	34	68	101
Williston SW				
Tillers/m^2	682	752	900	936
TKW[+], g	32.7	29.7	27.9	25.3
Kernels/tiller	7.6	9.8	9.3	9.6
Yield, kg/ha	1628	2124	2248	2247
Dickinson SW				
Tillers/m^2	463	611	668	-
TKW, g	22.4	20.5	18.5	-
Kernels/tiller	6.1	7.4	7.4	-
Yield, kg/ha	643	887	893	-

[+]Thousand kernel weight.

Table 7. Average effect of N on grain protein.

Site	N rate, kg/ha 0	34	68	101
	%			
Fortuna SW	10.5	12.1	14.3	15.8
Stanley SW	11.6	11.6	12.6	13.2
Minot WW	10.6	11.2	12.3	12.6
Minot SW	13.3	15.2	16.7	17.7
Williston WW	10.1	10.7	12.4	13.6
Williston SW	12.8	13.5	14.0	15.0
Dickinson SW	13.5	14.5	16.0	-

Table 8. Average effect of N on wheat forage N content.

Site	Stage	N rate, kg/ha 0	34	68	101
		% N			
Fortuna SW	boot	1.3	1.6	2.0	2.2
Stanley SW	boot	2.0	2.2	2.7	2.9
Minot WW	boot	3.2	3.5	3.6	3.6
Minot SW	boot	2.6	2.9	3.3	3.4
Williston WW	boot	1.5	2.0	2.2	2.2
Williston SW	e. dough	1.2	1.4	1.4	1.5
Dickinson	e. dough	1.2	1.3	1.4	-

Table 9. Average effect of N sources on wheat yields.

Site	N Source+ AA	UAN	AN
	kg/ha		
Fortuna SW	1317	1280	1172
Stanley SW	2513	2645	2728
Minot WW	2420	2599	2436
Minot SW	2263	2304	2303
Williston WW	1953	1688	1665
Williston SW	2260	2261	2133
Dickinson SW	878	870	897
Average	1943	1950	1905

+AA - anhydrous ammonia, UAN - urea-ammonium nitrate solution, surface applied, AN - ammonium nitrate surface applied. Yields averaged across N rates greater than zero. Data from P surface treatments.

Table 10. Average effect of N sources on N uptake.

Site	Plant Portion	N Source+ AA	UAN	AN
		kg/ha		
Fortuna SW	grain	37	32	31
Stanley SW	grain	61	61	66
Minot WW	grain	54	61	58
Minot SW	grain	69	72	75
Williston WW	grain	49	39	40
Williston SW	grain	64	63	57
Dickinson SW	grain	27	25	26
Average grain		52	50	50
Williston SW	forage	146	159	137
Dickinson SW	forage	116	90	108
Average forage		131	125	123

+AA - anhydrous ammonia, UAN - urea-ammonium nitrate solution, surface applied, AN - ammonium nitrate surface applied. Yields averaged across N rates greater than zero. Data from P surface treatments.

Table 11. Average effect of N sources on yield components.

Site and component	N Source⁺ AA	UAN	AN
Williston SW			
Tillers/m^2	861	913	889
TKW, g	26.3	26.6	29.0
Kernels/tiller	10.2	9.6	8.5
Dickinson SW			
Tillers/m^2	664	625	634
TKW, g	18.2	20.1	19.1
Kernels/tiller	7.5	7.0	7.6

+AA - anhydrous ammonia, UAN - urea-ammonium nitrate solution, surface applied, AN - ammonium nitrate surface applied. Yields averaged across N rates greater than zero. Data from P surface treatments.

Table 12. Effect of P placement on wheat yields.

Site	P Placement+ sfc	deep
	kg/ha	
Fortuna SW	1245	1209
Stanley SW	2621	2672
Minot WW	2426	2350
Minot SW	2283	2362
Williston WW	1809	2119
Williston SW	2197	2225
Dickinson SW	888	891
Average	1926	1975

+Average across N rates. Data from AA and AN sources only to avoid possible N placement effects from UAN.

Table 13. Effect of P placement on wheat P uptake.

Site	Plant Portion	P Placement sfc	P Placement deep
		kg/ha	
Fortuna SW	grain	4.7	4.6
Stanley SW	grain	9.1	9.2
Minot WW	grain	8.8	8.2
Minot SW	grain	9.0	8.9
Williston WW	grain	7.1	7.9
Williston SW	grain	8.5	8.3
Dickinson SW	grain	4.6	4.5
Average grain		7.4	7.4
Williston SW	forage	23.6	22.0
Dickinson SW	forage	18.9	18.4
Average forage		21.3	20.2

+Average across N rates. Data from AA and AN sources only to avoid possible N placement effects from UAN.

Table 14. Effect of P placement on tissue P content.

Site	Stage	P Placement+ sfc	P Placement+ deep
		% P	
Fortuna SW	boot	0.21	0.23
Stanley SW	boot	0.30	0.29
Minot WW	boot	0.21	0.21
Minot SW	boot	0.28	0.29
Williston WW	boot	0.12	0.15
Williston SW	boot	0.27	0.26
	e. dough	0.24	0.23
Dickinson SW	boot	0.30	0.29
	e. dough	0.23	0.23
Average		0.24	0.24

+Averaged across N rates. Data from AA and AN treatments only. UAN not included to avoid possible N placement effects on data.

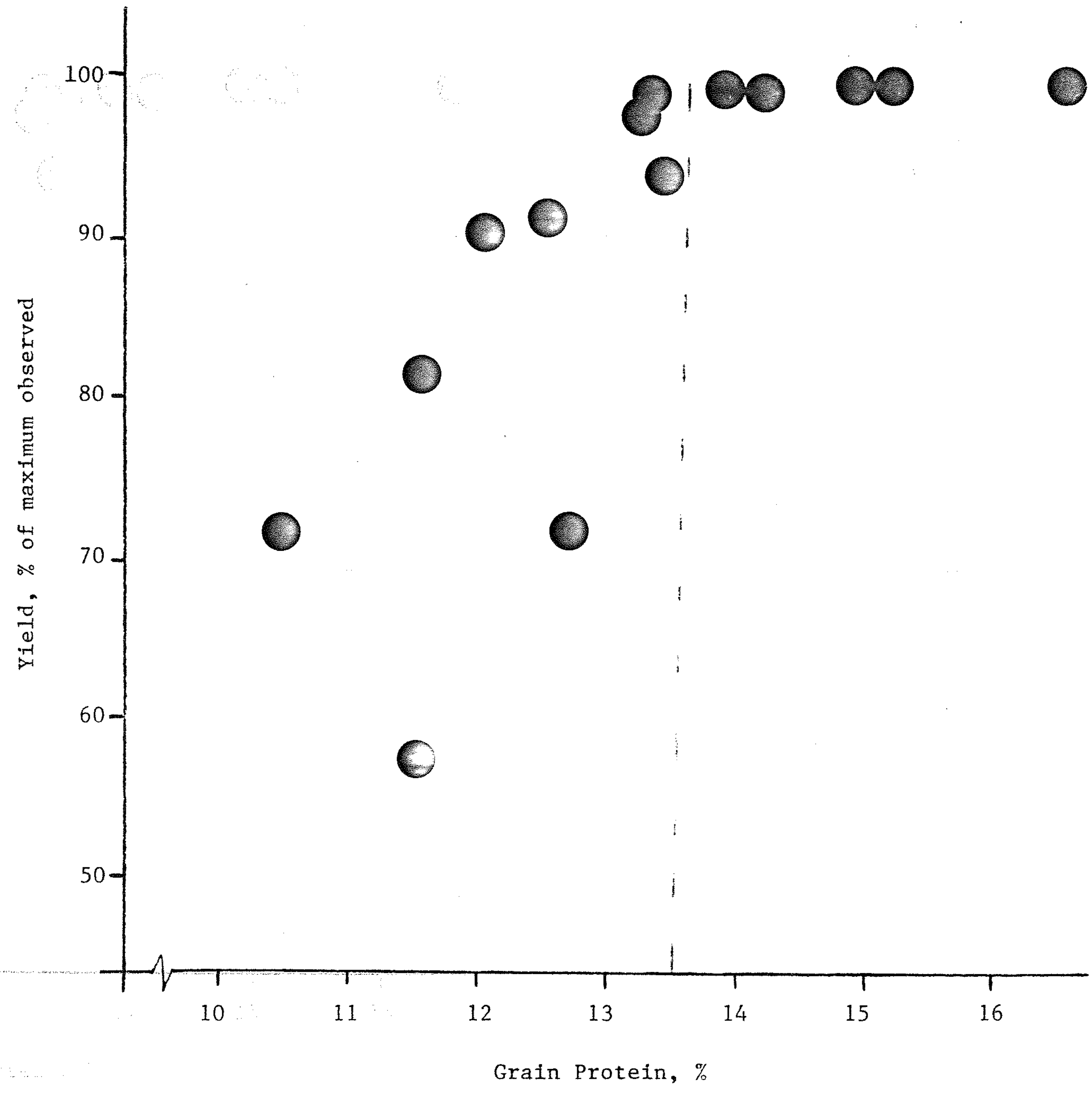


Figure 1. Relationship between yield and protein in Len wheat.
Western ND, 1981.

FERTILIZER STUDIES ON RECROPPED SMALL GRAIN IN WESTERN ND, 1981

R. Jay Goos, Brian Johnson, Frank Sobolik

Spring wheat/fallow is the most commonly practiced rotation in western ND. This rotation provides for dependable wheat production, improved weed control over continuous cropping, and normally high protein grain (due to nitrate accumulation during fallow). The great disadvantage of this rotation is that since there is no crop on the land for about 21 months out of 24, the land is susceptible to erosion and saline seep development. Longer rotations, if economically feasible should help limit erosion and seep development.

Farmers in western ND are trying differing recrop schemes. Corn or sudan grass are used in SW ND as an alternative to fallow. Sunflowers are also used in longer rotations, as is recropped small grain. Currently, this research project is concerned with the fertilizer needs of recropped small grain and sunflowers. This report will deal with our 1981 recropped small grain experiments.

I. Nitrogen rates

Small grains are very effective in extracting nitrates from the top 2-3' of soil. When soils are recropped rather than fallowed, there are usually low amounts of nitrate-nitrogen in the 0-2' profile, unless the previous crop was heavily fertilized or a crop failure.

Table 1 shows the nitrate-nitrogen levels in the recrop sites discussed in this report.

Nearest town	Nitrate-Nitrogen in 0-2' lb/A
Battleview	16
Dickinson	25
Fortuna	21
Minot	23
Minot	42
New Town	33
Stanley	14
Williston	45
Williston	15
AVERAGE	26 lb/A

Using this average figure and current NDSU recommendations, we can estimate that about ~35 lb fertilizer N would be needed for a yield goal of 25 bu/A wheat or durum.

Figure 1 shows the average yield response of these nine locations. A large average yield response (5.6 bu/A) was noted from 30 lb N/A. The average response was 2.3 bu/A from the next 30 lb N/A and only an average of 0.4 bu/A increase was given from the last 30 lb increment of N. This was the average response to N and not typical for every site.

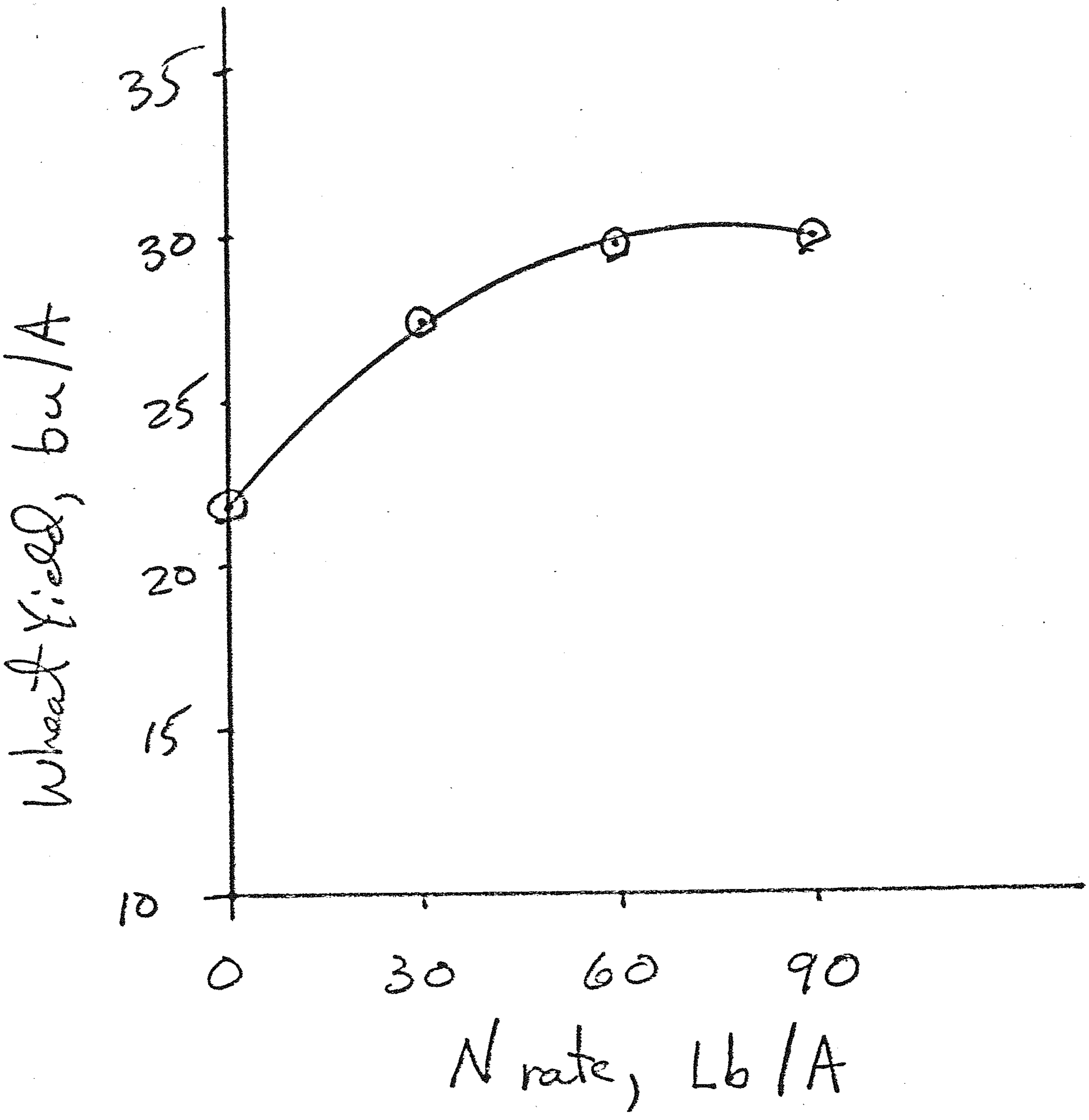
Table 2 summarizes the data in perhaps a clearer way:

Table 2.

Nitrogen Rate lb/A	Percentage of sites giving a profitable* yield response over the next lower rate %
30	78
60	33
90	22

*Yield response was considered to be profitable if the yield response was at least 3 bu/A over the next lower rate.

Our data from this year has also indicated that current NDSU soil test N recommendations are adequate for recropped wheat in western ND. Comparing our response data to current NDSU recommendations (which are based on about 2.5 lb soil + fertilizer N per bushel of yield goal), we



Average effect of N on wheat yields at 9 recrop sites in Western ND, 1981.

found that NDSU recommendations when averaged over all sites, were in line with the actual N need. The two Minot locations were particularly non-responsive to N, perhaps due to in-season N mineralization. There is much that remains to be learned about the dynamics of N nutrition in ND.

Table 3. A comparison of 1981 N response data to NDSU N fertilizer equation.

Site	Maximum Profitable* Yield	Actual Soil + Fertilizer N need** A	Predicted Soil + Fertilizer need+ B	B-A
	bu/A	lb/A		
Stanley	43.3	104	108	4
Fortuna	18.2	51	46	-5
New Town	26.2	93	66	-27
Dickinson	13.2	55	33	-22
Williston	33.4	75	84	9
Minot	37.0	23	93	70
Minot	34.5	42	86	44
Williston	31.6	75	79	4
Battleview	34.9	106	87	-19
			AVERAGE	+6

*Taken to mean the yield at the highest N rate where another 30 lb increment of N would not increase yield at least 3 bu/A.

**Spring NO_3-N (0-2 foot) plus the fertilizer N needed to produce the maximum profitable yield.

+Calculated by: Maximum profitable yield x 2.5 lb N/bu.

II. Nitrogen management

This year's research also included N source comparisons. Figure 2 shows the results of these comparisons for spring-applied N from six locations in 1981.

All sources and placements promoted excellent N response. It is possible that the surface-applied and unincorporated UAN liquid gave slightly less (1-1½ Bu/A) yield response than UAN deep or the other sources at higher N rates. The amount of this difference, if real, is

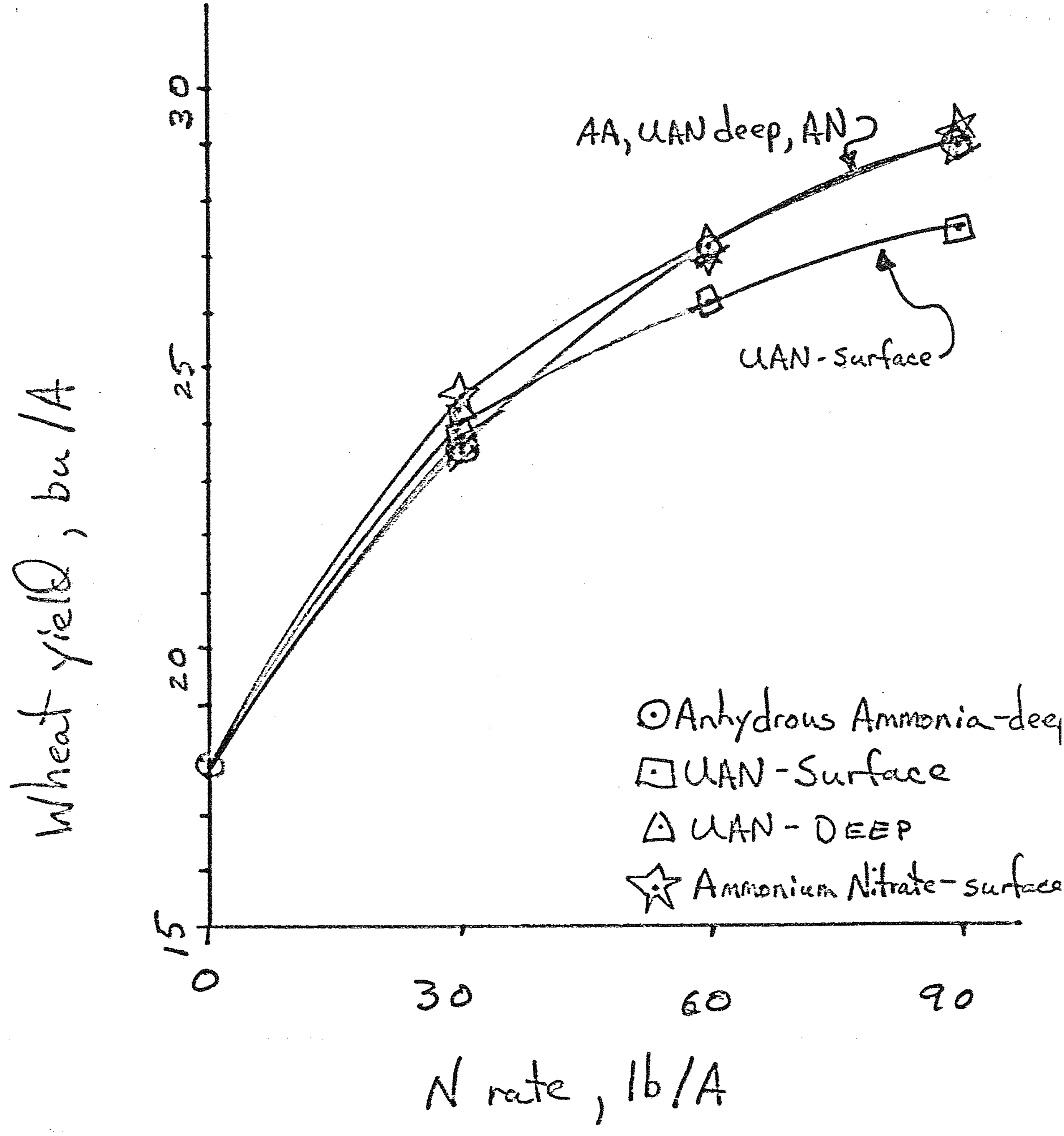


Figure 2. Effect of N rate, ~~and~~ N source and UAN placement on wheat yields. Average of six locations, western ND. 1981.

small compared to the overall magnitude of the N response. Surface-applied UAN would be the treatment most prone to ammonia volitilization, however. Research is continuing in this area, and also in the area of fall versus spring N applications.

III. Phosphorus placement.

Much interest has been generated concerning "deep placement" or "dual placement" of liquid phosphorus sources. This year was our first year of study in this area. We compared surface and deep applications of P. Next year we hope to add drill-row applications of P as a variable.

Table 4 summarizes our first year's study in this area.

Table 4. Effect of P placement on wheat yields in western ND, 1981.

Location	Olsen P soil test	P surface A	P deep B	B-A
	lb/A	Bu/A		
Stanley	6 L	37.6	38.6	+1.0
Williston	7 L	23.8	28.5	+4.7
Minot	9 L	36.9	35.0	-1.9
Fortuna	10 M	20.2	17.9	-2.3
Minot	16 M	34.2	34.7	+0.5
Williston	36 H	31.2	30.3	-0.9
Dickinson	42 H	11.7	12.3	+0.6

A significant response from deep P placement over surface-incorporated P was only noted at one site. This one response from P placement was visually obvious in plant growth also. This response to deep-placement was observed on a soil with a low P test. All sites with a medium or high soil test did not respond to deep-placed P over surface P. Some have promoted the idea that deep P applications will lead to P responses otherwise unattainable on medium to high testing soils. This research would refute this idea.