SMALL GRAIN SOIL FERTILITY INVESTIGATIONS, 1979-1983

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INTRODUCTION

Hard red wheat, barley, durum wheat and oats are the mainstays of North Dakota crop production; they currently account for approximately 70 percent of the annual crop acreage in North Dakota. A major concern of the small grain producer is fertilizer management. The fertilization decision involves many factors: How much fertilizer is needed? What elements must be added? What source of fertilizer is best? When should the fertilizer be applied? What happens to excess fertilizer if there is a crop failure? These are just a few of the fertilizer management questions that are commonly asked.

Researchers with the Department of Soil Science have been researching these and other questions concerning small grain soil fertility management for many years. Extension soil specialists have also been active in extending research results to producers through educational meetings and shortcourses. For a historical perspective, see the articles by Dr. Zubriski and Dr. Dahnke in this same issue. This article emphasizes research done in the past five years.

Research Effort

Several members of the soil science staff are conducting practical and theoretical research with soil fertility and small grains. A listing of the experiments from the past five years is presented in Table 1. These experiments have explored a wide range of topics: nitrogen rates, phosphorus placement, fertilization/root disease trials, copper fertilization of oats, etc. Figure 1 presents the distribution of these trials by county. Most production areas of the state currently have active field study, or have been covered by past research.

Highlights of Research Results.

Nitrogen Rates for Wheat

Currently, nitrogen (N) fertilizer recommendations are made on the basis of the amount of soil nitrate-N in the soil and the farmer's future yield goal. Recommendations are based on a "rule of thumb" that it takes 2.5 pounds of available N per bushel of wheat. In other words, a 40 bushel per acre crop will require 40 × 2.5 = 100 pounds per acre of soil + fertilizer N. The 2.5 factor came from research experience over many years, but most of the sites were in eastern and central ND. Table 2 shows that this figure is also a good approximation for western ND.

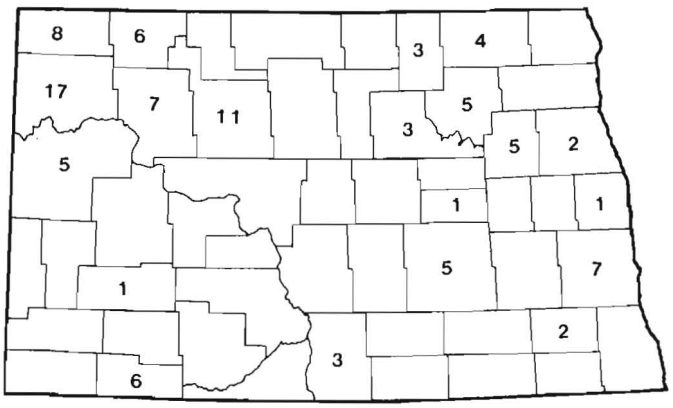

Figure 1. Number, by county, of small grain soil fertility experiments conducted by the Department of Soil Science, 1979-1983.

Nitrogen deficiency and grain quality

When N is limiting for a crop, the grain produced is low in protein. Figure 2 shows that grain protein can be used to judge whether or not N was limiting to the harvested crop. In this case, grain protein contents less than 14 percent are associated with yield loss from N deficiency. Farmers producing hard red spring wheat with lower protein levels are advised to pursue a more vigorous N fertilization program for future crops.

Nitrogen deficiency also affects the quality of durum wheat. Limited research suggests that if Cando durum wheat will not make hard red amber grade (greater than 80 percent hard and vitreous kernels) because of "yellowberry," the yield was also lost from N deficiency.

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Table 1. Summary of small grain soil fertility investigations by the Soil Science Department, 1979-1983.

Experiment	Crop	Number of Locations	Location (County)	Researchers
1979				
Soil test calibration and fertilizer placement	barley	5	Nelson, Ramsey, Benson, Cavalier, Towner	Dahnke/Swenson/Johnson
N rate, N source, N placement, N-serve	HRSW	5	Cass, Adams (2), McKenzie, Williams	Schneider/Johnson/Sobolik
Residue management and N management	HRSW	2	Adams, Williams	Schneider/Johnson/Sobolik
N rates and water use	HRSW	4	Mountrail (2), Divide, Burke	Sobolik/Schneider
1980				
NP fertilizer placement	durum or HRSW	6	Ramsey, Towner, Benson, Nelson, Traill, Cavalier	Dahnke/Swenson/Johnson
Soil test calibration	durum	3	Cavalier, Nelson, Ramsey	Dahnke/Swenson/Johnson
P placement, dual placement	HRSW	3	Williams (2), Ward	Johnson/Sobolik/Goos
N rates, N sources	HRSW	5	Divide, Mountrail, Burke, McKenzie	Sobolik/Johnson/Goos
1981				
Air seeder, fertilizer placement	HRWW	1	Cass	Dahnke/Spilde
Fertilizer placement and soil test calibration	durum	5	Nelson, Cavalier, Ramsey, Towner, Benson	Dahnke/Swenson/Johnson
P source comparison	durum	2	Nelson, Ramsey	Dahnke/Swenson/Johnson
Cold Flo, depth of application	HRSW or durum	2	Williams, Divide	Sobolik
Dual NP placement	HRSW or HRWW	8	Ward (2), Mountrail, Divide, Williams (2), Stark, Adams	Goos/Johnson/Sobolik
N sources, N rates, time of application	HRSW	3	McKenzie, Mountrail, Burke	Goos/Johnson/Sobolik
Tillage system, N placement	HRSW	2	Ward, Williams	Deibert/Goos/Johnson
1982				
Soil test calibration, fertilizer placement, spacing of placement	barley or HRSW	6	Stutsman (5), Emmons	Dahnke/Johnson/Swenson
Dual NP placement	HRSW	3	Ward, Williams, McKenzie	Goos/Johnson/Sobolik
N source and placement	HRSW	5	Mountrail, Divide, Williams, Burke, Adams	Goos/Sobolik/Johnson
N rates, fertilizer and root disease trials	HRSW, or durum, or barley	8	Ward, Williams (2), Divide, McKenzie, Mountrail, Burke, Adams	Goos/Sobolik/Johnson
Tillage system, N placement	HRSW	2	Ward, Williams	Deibert/Goos/Johnson
Fertilizer rates, maximum yield	durum	1	Ward	Deibert/Goos/Johnson
1983				
Copper fertilizer	oats	4	Grand Forks, Cass (2), Ransom	Dahnke/Swenson/Johnson
Fertilizer and root disease	barley	5	Grand Forks, Cass (2), Ransom, Emmons	Dahnke/Swenson/Johnson
Residual nitrogen and sulfur	durum	1	Emmons	Dahnke/Swenson/Johnson
Fertilization and root disease	barley	5	Foster, Ward, Williams Divide, Burke	Goos/Johnson/Sobolik
Tillage system, N placement	HRSW	2	Ward, Williams	Deibert/Goos/Johnson
Fertilizer rates, maximum yield	HRSW	2	Ward, Williams	Deibert/Goos/Johnson
Time of P applciation on fallow	HRSW	1	Williams	Goos/Johnson
Air seeder, urea rates	HRSW	1	Cass	Deibert/Giles
TOTAL		102		

Table 2. Soil plus fertilizer N needs for spring wheat, western ND, 1981-82.

Site	Maximum yield	Minimum soil + fertilizer N needed for maximum yield*	lb N/bu
	bu/A	lb/A	lb N/bu
1982			
Bowbells	17	43	2.5
Fortuna	35	69	2.0
Minot	34	98	2.9
Rawson	35	48	1.4
Stanley	31	95	3.1
Williston E	18	54	3.0
1981			
Stanley	43	104	2.4
Fortuna	18	51	2.8
New Town	26	93	3.5
Dickinson	13	55	4.2
Willlston	33	75	2.2
Minot	37	23	0.6
Minot	35	42	1.2
Williston	32	75	2.4
Battleview	35	106	3.0
Average and 95% confidence interval			2.5 ± 0.5

*Initial nitrate-N in top two feet of soil plus fertilizer N. Researchers: Goos, Johnson, Sobolik.

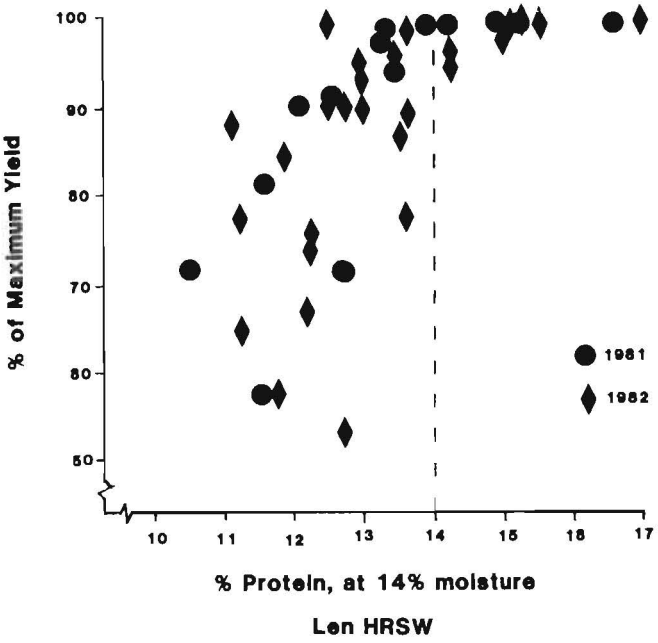

Figure 2. The relationship of the grain protein content of 'Len' HRSW and yield loss from N deficiency, Western ND, 1981-82. Researchers: Goos, Sobolik, Johnson.

Nitrogen placement in reduced tillage

Data collected over the past two years strongly suggest an advantage of deep N placement over surface N placement under reduced tillage systems. Table 3 indicates an increase in plant utilization of applied N fertilization from deep placement over surface application under conditions of heavy stubble.

Table 3. Grain nitrogen yield as a function of N placement. Western ND, 1982.

Site	Source and method of placement +				
	No N	UAN surface	UAN ceep	Urea surface	Anhydrous ammonia, deep
	lb N/Acre*				
Fortuna	23	36	45	32	42
Stanley	31	28	27	25	30
Williston	23	32	38	34	35
Average	26	32	37	31	36
Minot	—	49	54	—	—
Williston	—	44	47	—	—
Average		47	51		

+ N rate was 60 lb/A.

*Grain yield (bu/A) x .6 x % protein.

Researchers: Goos, Deibert, Johnson, Sobolik.

Depth of application of "Cold-Flo" anhydrous ammonia

Research has demonstrated an application depth of 4 inches is necessary to prevent ammonia loss (see Table 4).

Table 4. Effect of depth of "Cold-Flo" N application on wheat yields, western ND, 1981.

Depth of application inches	N rate, lb/A	
	0	30
	bu/A*	
2	17	24
4	15	29
6	16	29

Average of two sites. Researcher: Sobolik.

Phosphorus placement

Much interest has been aroused in new methods of phosphorus (P) placement. Among these is the method of "dual palcement" or "deep placement," where P fertilizer is injected 5-6 inches deep behind an anhydrous ammonia or liquid N knife. Research has been conducted throughout North Dakota with deep placement. Table 5 typifies the results of these investigations. Research in North Dakota has shown no

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16. Giles, J. F., E. J. Deibert, J. B. Fitts, J. Enz and L. Smith. 1981. **Sugarbeet production with reduced primary tillage.** In 1980 Sugarbeet Research and Extension Reports. Vol. 9, pp. 95-102.

17. Giles, J. F., E. J. Deibert, L. J. Smith, N. R. Cattanach and D. A. Lizotte. 1983. **Sugarbeet production with reduced primary tillage.** In 1983 Sugarbeet Research and Extension Reports. Vol. 13, pp. 111-118.

18. Giles, J. F., E. J. Deibert, L. Smith, J. B. Fitts and J. Enz. 1982. **Sugarbeet production with reduced primary tillage.** In 1981 Sugarbeet Research and Extension Reports. Vol 12, pp. 116-122.

19. O'Brien, D. L. 1979. **No-tillage spring wheat: A comparison with conventional tillage systems.** M.S. Thesis. North Dakota State University. Fargo, N.D. 152 p.

20. Sojka, R. E., F. B. Arnold, E. J. Deibert and J. Enz. 1979. **Sugarbeet production under reduced tillage.** Agronomy Abstracts. p. 211.

21. Sojka, R. E., F. B. Arnold, E. J. Deibert and J. Enz. 1979. **No-till sugarbeet production — prospects and problems.** In 1978 Sugarbeet Research and Extension Reports. Vol. 9, pp. 100-107.

22. Sojka, R. E., E. J. Deibert, F. B. Arnold and J. Enz. 1980. **Sugarbeet production under reduced tillage-prospects and problems.** North Dakota Farm Research. Vol. 38:14-18.

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superiority of "deep" P placement over the conventional drill-row band method of placement, although both of these two methods of "banding" can give yields which are greater than obtained with broadcast and incorporated P fertilization on low testing soils.

Table 5. Effect of phosphorus placement on small grain yield, eastern ND, 1981.

Placement method	Average yield 1981*	1982**
	----bu/A----	
Phosphorus surface incorporated	47	47
Phosphorus deep band	52	50
Phosphorus drill applied	53	50

*Three locations, durum wheat.

**Six locations, barley or spring wheat. Researchers: Dahnke, Swenson, Johnson.

FUTURE RESEARCH

Current fertilizer recommendations of N and P for small grains have a strong research base in North Dakota. Yet, many questions lie unanswered. For example, significant yield increases of barley to potassium (K) fertilization were observed in North Dakota in the 1960s. What is the reason for these responses since most soils in North Dakota have very high native K levels? Research is currently underway to test a fertilization-root disease theory as an explanation.

Other questions remaining are: Can the conditions conducive to ammonia loss from urea-based fertilizers be further understood? How widespread are deficiencies of sulfur or micronutrients? How should fertilizer be applied for no-till production? How rapid is the conversion of anhydrous ammonia conversion to nitrate in the fall in North Dakota? Can even more accurate soil tests be devised? Many other questions doubtless exist, and researchers from the Soil Science Department at NDSU will attempt to answer these questions as they arise.