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DRYLAND WHEAT
RESPONSE TO
NITROGENAND
PHOSPHORUS
FERTILIZATION

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Dryland Wheat Response to Nitrogen and Phosphorus Fertilization

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Summary

Growth characteristics and grain yield response of dryland wheat were compared between four levels of nitrogen (N) and four levels of phosphorus (P) fertilization. No plant responses to P fertilizer additions or to N-P combinations were observed, and N fertilization alone did not influence grain yields. N fertilizer levels of 0 and 20 lbs/A resulted in a 1 lb/bu higher test weight than did the 40-80 lbs N/A levels. Annual additions of fertilizer N did not result in increased soil profile N. With each successive crop, soil profile nitrates were reduced even with the annual addition of 80 lbs N/A. The 40 and 80 lbs N/A rates slowed soil profile nitrate depletion rate.

Introduction

Grower experiences generally dictate rates of N and P fertilizer on dryland wheat in the Texas Rolling Plains. Soil test recommendations have been largely developed by calibration studies outside the region. There are few published reports on effects of fertilizer N or P on dryland wheat in the Rolling Plains. Unpublished observations suggest that fertilizer increases grain yield of dryland wheat in some but not all sites and/or situations. The objective of this study was to examine the effects of N and P fertilizer on the grain yield of dryland wheat and to determine the effect of N fertilization on residual soil nitrate levels.

Methods and Materials

Fertilizer plots were established on a Miles fine sandy loam soil (Udic Paleustalf), during October of 1990 at the Texas Agricultural Experiment Station experimental farm near Munday, in Knox County, Texas. Knox County is located on the Seymour Aquifer. The Seymour Aquifer is characterized by shallow depth to water with the majority of wells drilled to a depth of only 29 to 69 feet. The Seymour Aquifer also contains a large amount of NO₃-N with individual wells ranging from 21-139 ppm (Wendt et al., 1976).

Each plot was 26.6 feet wide by 50 feet long. Dry granular N and P fertilizers were broadcast preplant and incorporated immediately with a disk to a depth of 6 inches at 0, 20, 40, 80 lbs and 0, 15, 30, 60 lbs respectively. N was applied as ammonium nitrate and P applied as triple super phosphate on October 29, 1990 and in early September in 1991 and 1992. In 1992 the N was applied in a split application with one-half broadcast preplant and incorporated, and one-half broadcast as a top dressing prior to jointing in early March 1993. All fertilizer applications were made using a four row spreader. Plots were maintained in the same location each year so that cumulative treatment effect could be examined.

Hard red winter wheat cultivar TAM W-101 (Porter, 1974) was planted on October 31, 1990. Due to unavailability and lack of popular use TAM W-101 was replaced by TAM W-200 (Worrall, 1994) in 1991 and 1992 and was seeded on October 15 and November 3, respectively. Seeding rate was 60 lbs/A, a common seeding rate in Knox County. A plot combine was used to harvest yield samples. The harvested area consisted of a single 51 inch swath 50 feet long. Measured plant response variables were plant height, grain yield, and grain test weight. Plant height was determined on an average of 10 plants/plot measured at harvest.

A baseline soil sample was taken in each plot in the fall of 1990. Soils were sampled again each year of the study after harvest. Single soil cores were taken at the approximate center of each plot at depths 0-6, 6-12, 12-24 and 24-36 inches. Samples were placed in paper bags and dried in a forced draft oven

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for 24 hours at 80° F. Dried samples were pulverized in a hammer mill, passed through a standard number 10 soil sieve and a sub-sample analyzed for NO₃-N using the Phenoldisulfonic Acid Method (Jackson, 1958; Dahnke and Vasey, 1973).

Tillage operations between crops were kept to the minimum required to control weeds and for land preparation only. Chlorsulfuron (2-Chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl]Benzenesulfonamide, or Glean herbicide was applied in February 1991 at .33 oz/A to control annual broadleaf weeds.

The study design was a randomized complete block with four replications per treatment. Soil and yield variables were analyzed in a two factor factorial with nitrogen and phosphorus rates as the factors. Treatment means were compared with Least Significant Difference tests at the .05 probability level (Steele and Torrie, 1960; Freed et al., 1985).

Results

No differences in grain yield, plant height, or seed test weights were detected among P applications or among any N-P combinations. Baseline soil phosphorus data is presented in Table 1. In addition no significant differences in grain yield or plant height among any of the N treatments were observed (Table 2). There was a trend toward a negative response for

TABLE 1. Residual Soil Profile Phosphorus, Dryland Wheat Fertilization Study, September 1990, Knox County, Texas.

	Depth of Soil Sample					
Phosphorus Treatment lbs/A	0-6" ppm P	6-12" ppm P	12-24" ppm P	24-36" ppm P		
0	33.5	13.0	7.3	5.4		
15	34.4	11.1	8.0	6.0		
30	36.5	13.3	7.3	5.4		
60	35.1	12.8	7.3	5.0		
Average	34.9	12.6	7.5	5.5		

grain yield to increasing N levels during all three years of the study, but these differences were not statistically different (a=0.05). The 0 lbs N/A averaged 6 percent more grain than the 80 lbs N/A plots in 1991, 26 percent more in 1992 and 10 percent more in 1993. The three-year grain yield average for the 0 N plots was 42.4 bu/A contrasted to 40.5, 38.8 and 38.4 in 20, 40 and 80 lbs N respectively. A 1 lb/bu higher test weight was obtained for the 0 and the 20 lb N/A treatments as compared to the 40 and 80 lbs N/A treatments. None of the treatments influenced plant height.

All treatment yields in 1992 were 40 percent below the three-year average for the study. Excellent growing conditions in 1992-93 with above average rainfall throughout the crop season resulted in above average grain yields across all the treatments and for most dryland wheat planted in Knox County in 1993. Mild winters were experienced throughout the three-year study period, and insect pressure and disease were not significant factors during the study.

Baseline residual soil nitrate levels averaged 16.4 ppm at 0-6 inches, 18.0 ppm at 6-12 inches, 11.6 ppm at 12-24 inches, and 6.3 ppm at 24-36 inches in the soil profile. High soil nitrates within test plots in the fall of 1990 reflect past use of this land which was in highly fertilized vegetable production. Soil nitrate levels were significantly reduced at all depths and in all fertility treatments after one crop year (Table 3). Rate of soil nitrate reduction decreased with increasing amount of N fertilizer. From September 1990 to July 1991, soil nitrogen declined 67 percent in the surface foot of the check treatment plots. Plots receiving 80 lbs N/A lost 57 percent of the residual soil nitrogen during the 1990-91 crop season. Depletion of soil nitrogen continued at approximately the same rate from July 1991 to July 1992 as in the previous year. Check plot residual soil nitrate in the surface foot was reduced 47 percent while the 80 lbs N/A treatment residual soil nitrate was reduced 27 percent. Residual soil nitrate in the 12-24 and the 24-36 inch depths of the 40 and the 80 lbs N/A treatments did

TABLE 2. Plant Height, Test Weight, and Yield of Dryland Wheat As Affected by Rates of Nitrogen Application in 1991, 1992, and 1993, Knox County, Texas.

	Mature Height, Inches		Test Weight, lbs/bu			Yield, bu/A			
Nitrogen Rate	1991	1993	1991	1992	1993	1991	1992	1993	Avg.
0	19.7	31	64	51	61	41.3	27.5	58.5	42.4
20	20.1	31	63	51	61	38.4	26.2	57.0	40.5
40	19.7	31.5	63	50	60	39.9	25.2	54.2	39.8
80	19.7	31	63	50	60	39.1	21.8	54.4	38.4
Average	19.8	31.3	63	51	61	40	25	56	
LSD.05α	N.S.	N.S.	N.S.	1.4	1.2	N.S.	6.1	6.5	

TABLE 3. Residual Soil Profile ${\rm N0_3\text{-}N}$ PPM 1990-1993, Dryland Wheat Fertilization Study, Knox County, Texas.

Nitrogen Treatment lbs/A	Sample Date						
	September 1990	July 1991	July 1992	June 1993			
THE STREET STREET	0-6" Depth						
0	18.1	7.4	4.4	1.0			
20	19.5	8.6	3.8	1.3			
40	12.7	7.4	4.4	1.5			
80	15.3	7.4	6.6	1.6			
Average	16.4	7.7	4.8	1.4			
	6-12" Depth						
0	17.8	4.9	2.1	1.5			
20	19.4	5.1	1.9	1.5			
40	19.8	4.3	2.1	1.5			
80	15.2	5.4	2.7	2.6			
Average	18.0	4.9	2.2	1.8			
	12-24" Depth						
0	12.5	2.0	1.5	1.4			
20	9.0	1.9	1.4	1.5			
40	12.1	1.8	1.8	1.4			
80	13.1	1.9	2.3	2.5			
Average	11.6	1.9	1.8	1.7			
	24-36" Depth						
0	7.8	2.5	1.9	1.5			
20	5.3	1.6	1.5	1.3			
40	5.8	1.5	1.6	1.3			
80	6.4	1.6	1.9	2.2			
Average	6.3	1.8	1.7	1.6			

not change during the second crop year. Soil nitrate levels at all depths declined to below 10 ppm after two wheat crops. Soil analysis in June 1993 revealed a continued decline in nitrate N in the surface foot of the soil profile.

The lack of grain yield response to fertilizer N might be explained by below normal or sporadic precipitation. In 1991, precipitation was 4 percent below normal for the crop season; however, the rainfall for the critical months of February-April was 84 percent below normal. Precipitation was above normal throughout the 1992 and 1993 growing seasons. Except for 1991, precipitation did not appear to be a primary factor influencing lack of response to fertilization. Below average grain yields in 1992 may have been the result of excessive rainfall in December of 1991.

There is little question that fertilization improves yield of irrigated wheat. Pope (1963) found in the Texas High Plains on Amarillo and Dalhart fine sandy loam soils that N and P alone did not affect yield of

irrigated wheat, but 80 lbs N/A in combination with either 40 or 80 lbs P/A stimulated grain production, and yields averaged 60-64 bu/A. No differences in grain yield were reported for preplant vs. split applications of nitrogen or for ammoniacal vs. nitrate formulations. Clark and Onken (1989) found N fertilizer increased irrigated wheat grain yields by 20-30 percent in two of three years on an Abilene clay loam near Chillicothe, Texas. No yield responses to additions of P fertilizer or to combinations of N and P were observed in this study. The 80 lbs N/A rate produced the highest yields of 58 and 85 bu/A in 1987 and 1988, respectively. N fertilizer above 80 lbs N/A did not improve yields. However, no differences were reported among any of the treatments in 1986.

Doyle and Holford, 1993 examined the results of 53 dryland fertilizer experiments on wheat in New South Wales and Southern Australia, where a small and infrequent response to fertilizer N was reported. They found that increasing increments of fertilizer N resulted in decreased N use efficiency (i.e., kg grain/kg N applied). However, the highest rate of N fertilizer resulted in the greatest physiological efficiency (grain protein/Kg N) which was sufficient to make the highest fertilizer additions profitable.

In studies where the N content of the forage and grain were examined and compared to residual soil $\mathrm{NO_3}$ from 0-36 inches, Doyle and Holford (1993) found that there was uptake of soil N above apparent available levels. In these cases, it was discovered that subsoil $\mathrm{NO_3}$ -N was elevated by fallow season rainfall leeching surface $\mathrm{NO_3}$ -N. Wheat was apparently recovering N from levels below 3 feet in the soil profile.

Shallow water table and high levels of NO₃ in water may be factors which have influenced the results of our study. Average depth to water in Knox County is 23 feet with individual wells ranging from 4 to 55 feet (Harden et al., 1978). Irrigation water samples taken from the TAES farm at Munday during the study period averaged 20 ppm NO₃-N.

Hough and Kolp (1978) reported disparate response to fertilizer N applications on dryland winter wheat among six locations in Wyoming. At one location grain yields consistently decreased with increased N applications regardless of application time; fall preplant vs. spring top-dress. At four locations fall preplant applications failed to improve yields. This study also reported a decrease in grain test weight with increase in N fertilization. Precipitation at these locations was 50 percent of that normally received in the Texas Rolling Plains.

Conclusions

While Clark and Onken (1989) reported an increase in yield of irrigated wheat at Chillicothe, Stephens (1962) reported that nitrogen fertilization of dryland wheat at Chillicothe failed to enhance yield. Our results concur with Stephens and suggest that annual fertilizer nitrogen applications on Miles soils in Knox County may not be necessary to increase grain yield, especially where shallow water tables, high in nitrates are found. Additions of nitrogen did reduce the rate of nitrogen loss from the upper soil profile when compared to the control, but soil N0₃-N did not reach a steady state in three consecutive crops, even at the 80 lbs N/A rate.

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