Wheat Fertilizer Experiments in Northwestern Oklahoma

by
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Winter wheat is the most important cash crop in western Oklahoma and surrounding areas. Prior to 1950, fertilizer was seldom used on wheat in western Oklahoma but since then it has been used in increasing amounts.

The research reported herein was made to determine the fertilizer needs for maximum winter wheat yields; the proper time for applying nitrogen; the effect of broadcast and row application of phosphorus on yields; and the response of wheat to fertilizer with variations in residue management.

The experiments were conducted at the Southern Great Plains Field Station near Woodward, Oklahoma. Three separate tests were made, started in 1950, 1951 and 1957.

Precipitation and Soils

The longtime average annual wheat-crop-year precipitation (1915-1962, June through May) was 23.74 inches (Figure 1). The 1950-57 average annual precipitation for the wheat-crop-year was 21.44 inches. Precipitation during these tests varied from a low of 11 inches to a high of 35.6 inches, which is almost the extreme range for the area.

Average annual precipitation for the 1957-1962 wheat-crop-years was 27.64 inches, 3.85 inches above the longtime average. It was slightly below average in 1962 and above average in all other seasons.

Soils of the experimental sites were predominantly Pratt and Enterprise fine sandy loams. Small areas of Pratt loamy fine sand occurred with the Pratt fine sandy loam, and some Woodward fine sandy loam occurred with the Enterprise fine sandy loam.

Pratt soils are neutral to slightly acid in the surface and alkaline in the lower layers, but contain no free calcium carbonates in any part of the solum. The subsoil of Pratt ranges from loamy fine sand to loam. Soil analysis data are not available for the Pratt fine sandy loam soil at the experiment site; however, soil from the same general area

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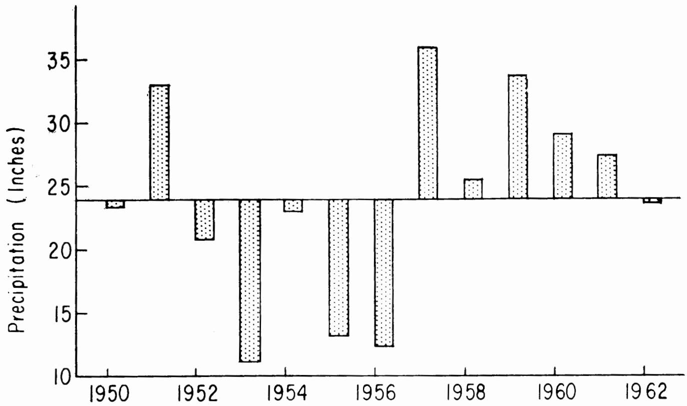

Figure 1.—Departure of crop year precipitation (June-May) from the 48-year average (23.74 inches), Woodward, Oklahoma, 1950-1962.

contained 0.41 percent organic matter, 0.029 percent nitrogen, 10.9 pounds of sodium bicarbonate—extractable phosphorus per acre (2 x 10^6 lb.), and 210 pounds of exchangeable potassium per acre.

Enterprise soils have neutral surfaces and calcareous subsoils. The Enterprise subsoil ranges from the fine sandy loam to light clay loam. The Enterprise soil at the experiment site contained 1.08 percent organic matter, 0.061 percent nitrogen, 7 pounds of $NaHCO_3$ extractable phosphorus per acre, and 420 pounds of exchangeable potassium per acre. Because of its finer texture, Enterprise soil can store more water and is inherently more productive than Pratt soil.

Methods and Procedures

Experiment numbers, major variables studied, soil series, and duration of experiments were as follows:

I. Rate and time of nitrogen application, Pratt soil, 1950-1957 (Appendix Table 1).

II. Rate of phosphorus application, Pratt soil, 1950-1957 (Appendix Table 2).

III. Placement of phosphorus fertilizer, Pratt soil, 1951-1957 (Appendix Table 3).

IV. Tillage practices and rates of nitrogen, phosphorus, and potassium fertilizers, Enterprise soil, 1958-1963 (Appendix Table 4-6).

V. Time of nitrogen application, Enterprise soil, 1957-1963. (Appendix Table 7-8).

All dates refer to the year the crop was harvested. Specific treatments studied in each experiment are listed in the respective appendix tables. Winter wheat was grown each year and the same treatments were applied to the same plots throughout the study. The experimental sites were cultivated immediately after harvest each year and kept weed free until replanted in the fall. In the three Pratt soil experiments (I, II, and III) and in part of the tillage-fertilizer study on Enterprise soil (IV), initial tillage was done with a one-way plow. On the stubble mulch portion of the tillage-fertilizer study and the time-of-N—application study on Enterprise soil (V), initial cultivation was done with a large, V-shaped sweep blade cutting four to six inches deep. On the one-wayed sites, various implements were used for weed control after initial cultivation, with no regard for residue conservation. Later cultivations on the stubble mulch plots were made with a weeder blade on a sweep machine and a rod weeder that conserved the surface stubble.

Concentrated superphosphate was used in all studies. Phosphorus was applied with the seed at planting in all studies, except the phosphorus experiment (III) in which row application (with the seed at planting) and broadcast application (broadcast on the surface before planting) were compared.

Ammonium nitrate, broadcast, was used in all experiments.

Fertilizer was not applied during the final crop year in order (experiments I-III in 1957 and experiments IV and V in 1963) to determine the one-year residual effect of the previously applied fertilizer.

All experiments except the one involving tillage practices and rates of fertilizer (IV) were arranged in randomized block designs. The tillage-fertilizer experiment was arranged in a split-plot, randomized block design in which tillage treatments occupied main plots and fertilizer treatments occupied subplots. Treatments in all experiments were replicated three or more times. Number of replicates in each experiment are given in the respective appendix tables.

Individual plots were 8 feet wide by 132 feet long in experiments on Pratt soil (I-III). On the tillage-fertilizer and time-of-nitrogen application-studies on Enterprise soil (IV, V) the plots were 16 feet wide by 132 and 110 feet long, respectively.

Grain yields were obtained in all experiments. Grain protein content was determined in experiments IV and V, and grain phosphorus content was determined in experiment IV.

Results

Nitrogen and phosphorus were the principal fertilizer elements studied. One potassium[1] treatment was included as an indicator treatment in one experiment on Enterprise soil. The 3.4 bushels per acre advantage for the potassium treatment was not statistically significant. (Compare 40-17.5-0 and 40-17.5-33.2 treatments, Figure 3).

Rate of Nitrogen Application

Pratt Soil. Figure 2 shows that nitrogen fertilizer did not significantly affect wheat yields on Pratt soil.

First year residual effects were measured in 1957. Spring precipitation was favorable and yields were relatively high. Also, 1957 followed a four-year period of below average rainfall and wheat yields. Respective yield increases over the 0-17.5 treatment were as follows: 10-17.5, 0.2 bushel per acre; 20-17.5, 3.6 bushels per acre; and 40-17.5, 0.9 bushel per acre. Only the increase from the 20-pound nitrogen treatment was statistically significant.

[1] In this report, plant nutrient composition of fertilizers is expressed on an elemental rather than on the oxide basis.

1 pound of P is equal to approximately 2.29 pounds of P_2O_5.

1 pound of K is equal to approximately 1.20 pounds of K_2O.

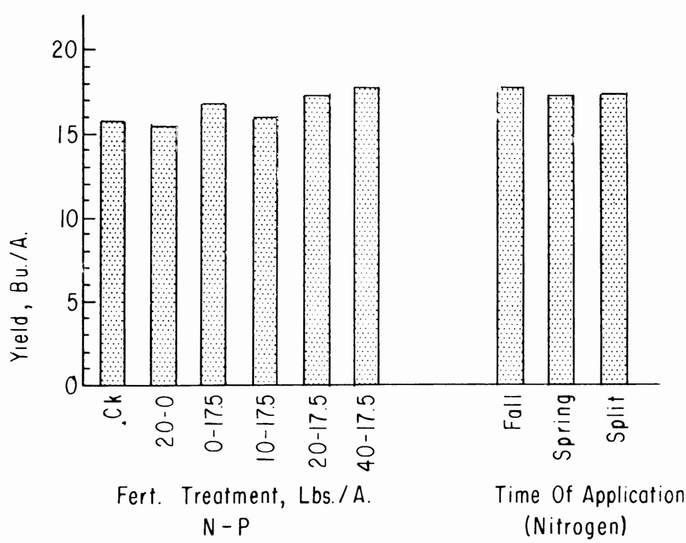

Figure 2.—Effect of various fertilizer treatments and time of application of nitrogen on wheat yields, Pratt Soil, Experiment I, Woodward, Oklahoma, 1950-1956.

Enterprise Soil. Nitrogen alone or combined with phosphorus increased grain yields on Enterprise soil (Figures 3 and 4). In the tillage-fertilizer study, average yield increases over the unfertilized (check) treatments were as follows: 40-0, 5.4 bushels per acre; 40-17.5, 3.8 bushels per acre; and 80-17.5, 8.5 bushels per acre. The check and 40-0 treatments on one-way tillage are shown in Figure 5. In the time-of-nitrogen-application-study (Figure 4), the 40-17.5 treatment averaged 7.0 bushels per acre more than the unfertilized (check) treatment.

Forty pounds of nitrogen per acre increased grain protein from 10.4 to 12.0 percent (Figure 6). When nitrogen was applied with 17.5 pounds of P per acre, only the 80-pound nitrogen rate produced grain protein as high as that produced by the 40-0-0 treatment. In the time-of-nitrogen-application-study (Figure 4) the 40-pound nitrogen rate with 17.5 pounds of P increased grain protein over that on the check and 0-17.5 treatments.

First year residual effects were measured in 1963. Growing season precipitation was less than half the average (6.64 inches compared average of 13.41 inches) and yields were low. All plots which had received 40 or 80 pounds of nitrogen per acre per year during the course of the experiment produced significantly higher yields as a residual effect than the unfertilized check plots.

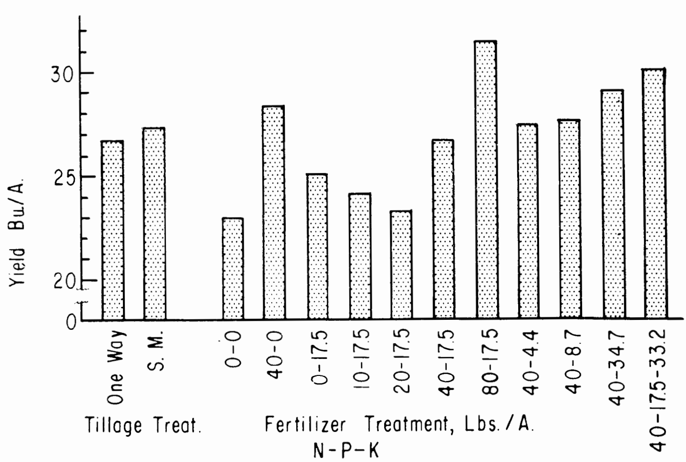

Figure 3.—Effect of one-way and stubble-mulch tillage and fertilizer treatments on wheat yields, Enterprise Soil, Experiment IV, Woodward, Oklahoma, 1958-1962.

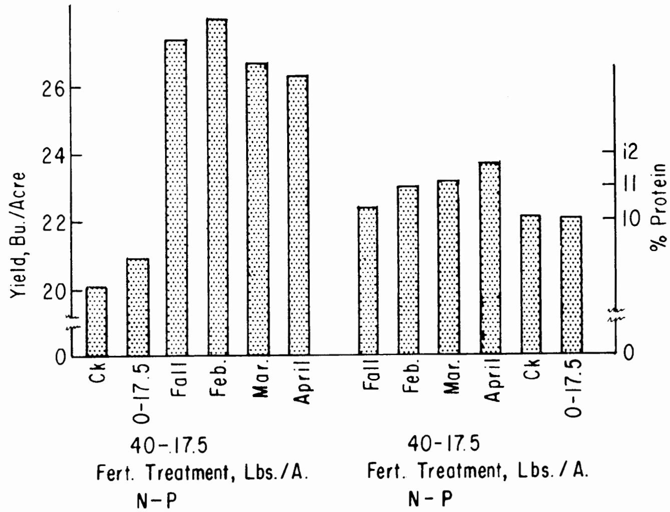

Figure 4.—Effect of time of application of nitrogen on wheat yields and grain protein content, Enterprise Soil, Experiment V, Woodward, Oklahoma, 1957-1962.

Time of Nitrogen Application

Pratt Soil. There was no response to nitrogen fertilizer on Pratt soil; thus, information on effect of nitrogen application time was not obtained (Figure 2).

Enterprise Soil. Effects of nitrogen fertilizer application time on Enterprise soil are shown in Figure 4. All treatments receiving nitrogen fertilizer produced yields significantly higher than the check. There were no significant differences in yield due to date of nitrogen application. There was, however, a definite trend toward highest yields from nitrogen applied in mid-February. The February nitrogen treatment gave the highest yields in four of the six years.

Grain protein increased as date of nitrogen applications progressed from planting through mid-April (Figure 4).

Rate of Phosphorus Application

Pratt Soil. Effects of phosphorus rates on grain yields are presented in Figure 7. Phosphorus fertilizer did not have a significant effect on grain yields on either of the Pratt soil experiments. Comparison of the 40-0 and 40-17.5 phosphorus treatments in the two experiments indicates a trend toward increased yield with a 1.5 bushels per acre increase.

In 1957, when first year residual effects were measured, responses to phosphorus were realized. The 40-0 treatments yielded an average of 24.0 bushels per acre while the 40-8.7 and 40-17.5 treatments yielded 28.1 and 29.9 bushels per acre, respectively.

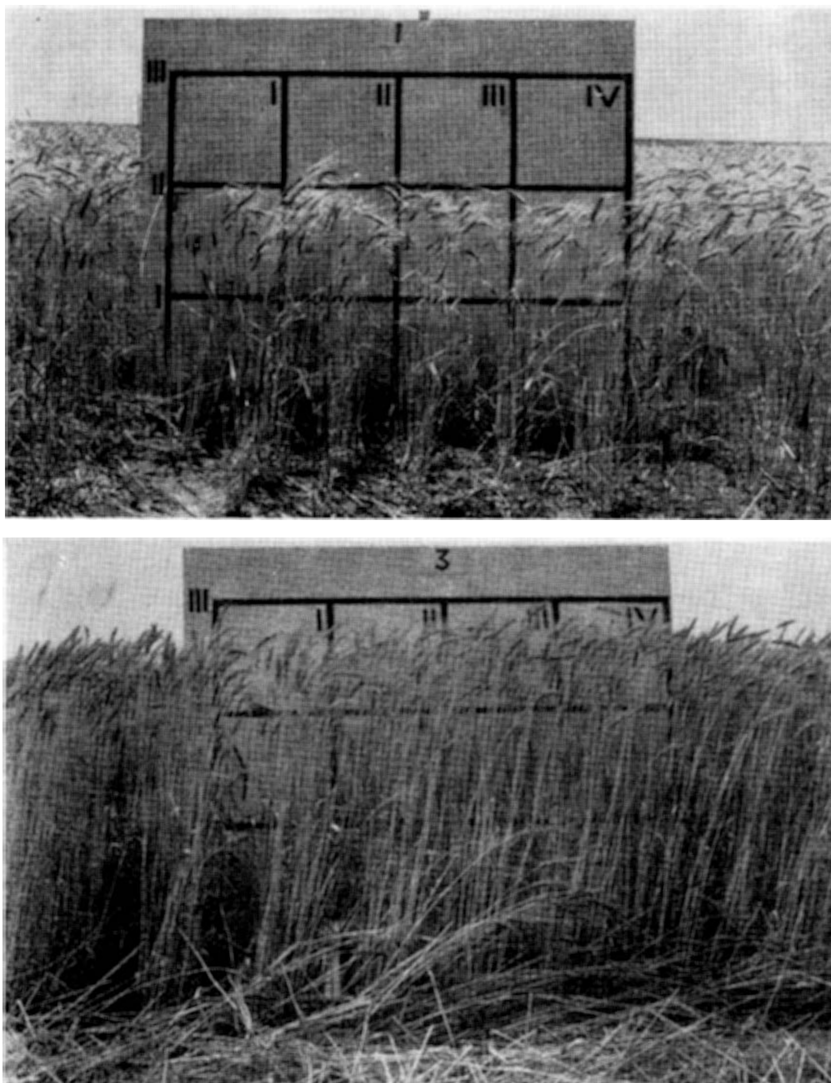

Figure 5.—Effect of nitrogen fertilizer on yield of wheat, Enterprise Soil, (1—check, 5-year average—22.9 bushels per acre; 3—40-0-0, 5-year average yield—29.2 bushels per acre).

Enterprise Soil. Phosphorus fertilizer did not affect yields on Enterprise soil. (Compare treatments 40-0, 40-4.4, 40-8.7, 40-17.5, and 40-34.7, (Figure 3).

Grain protein decreased with each increment of applied phosphorus (See the 40-0, 40-4.4, 40-8.7, 40-17.5, and 40-34.7 treatments, Figure 6).

Increasing phosphorus rates with uniform nitrogen (40 pounds per acre) increased the phosphorus content of the grain (Figure 8). However, the differences were slight and only the extremes were significant. High nitrogen rates applied with uniform phosphorus (17.5 pounds per acre) reduced phosphorus in the grain slightly, but significantly.

When first year residual effects were measured in 1963, there were no significant differences due to previously applied phosphorus.

Placement of Phosphorus Fertilizer

Broadcast and row application of phosphorus fertilizer were compared at rates of 8.7, 17.5, and 34.9 pounds per acre on Pratt soil (Figure 7). The two placements were equal in their effect on wheat yields. Without significant response to phosphorus, appreciable differences would not be expected to result from the two placements studied.

Effect of Tillage Treatments

Average yield and grain protein data for subble-mulch and one-way tillage are shown in Figures 3 and 6, respectively. There was little yield

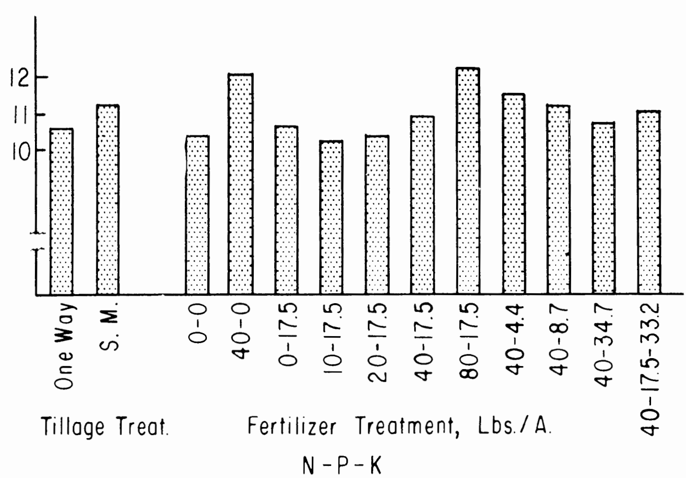

Figure 6.—Effect of one-way and stubble mulch and fertilizer treatments on grain protein content, Enterprise Soil, Experiment V, Woodward, Oklahoma, 1957-1962.

difference due to tillage treatments. Average yields for the five-year period for all fertilizer treatments on the two tillage methods were 27.3 and 26.7 bushels per acre for the stubble mulch and one-way respectively. Unfertilized check plots on the two tillage methods made identical average yields—22.9 bushels per acre. Stubble-mulch tillage yields were significantly higher than one-way tillage in 1958, but were significantly lower than one-way tillage in 1960. Differential winter killing in the fall of 1959 reduced yields on stubble-mulch as compared with the one-way tillage in 1960. When a severe freeze occurred in November 1959, plants were smaller and the soil was less compact on stubble-mulch than on one-way plots. Consequently, stands were reduced much more on stubble-mulched plots.

There was no tillage-fertilizer treatment interaction. Tillage treatments did not affect response to fertilizer treatments.

Grain protein (Figure 6) averaged slightly higher (0.7 percent) on stubble-mulch tillage than on one-way tillage. Protein on all treatments of stubble mulch averaged higher, but only 3 of the 12 differences were significant.

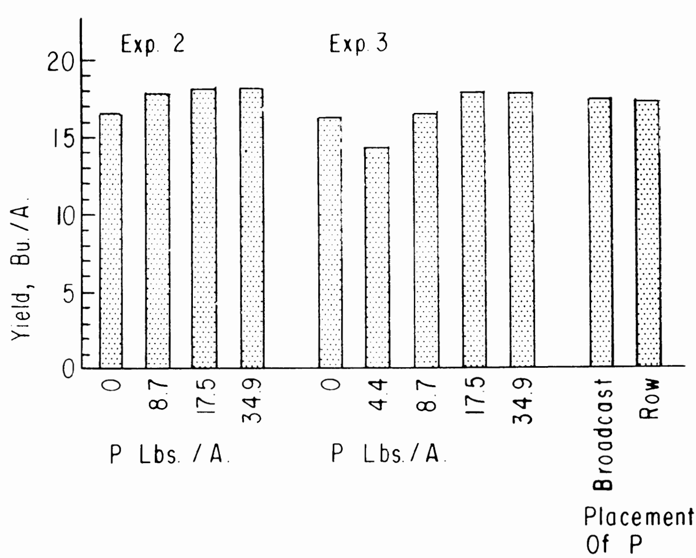

Figure 7.—Effect of rates and placements of phosphorus on wheat yields, phosphorus combined with 40 pounds of nitrogen per acre, Pratt Soil, Experiment II, 1950-1956, Experiment III, 1951-1956, Woodward, Oklahoma.

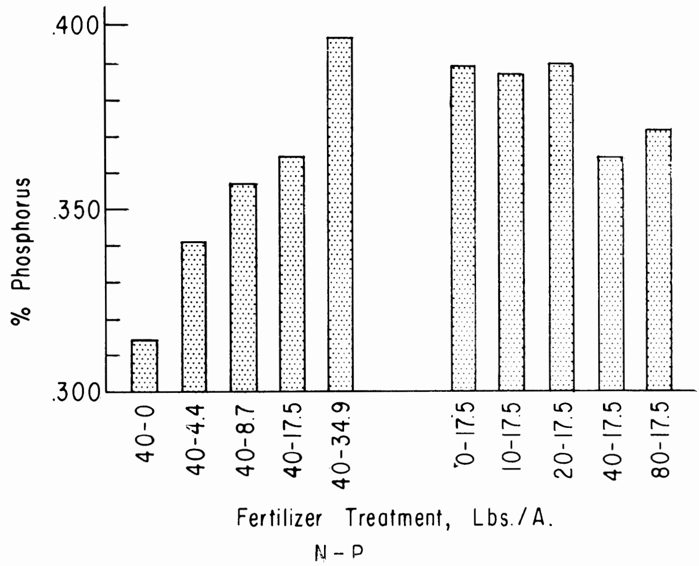

Figure 8.—Effect on the phosphorus content of the grain from applications of: (left) uniform nitrogen with variable phosphorus (right) variable nitrogen with uniform phosphorus, Enterprise Soil, Experiment IV, Woodward, Oklahoma, 1958-1962.

Discussion

The results obtained on the individual soils should not be interpreted to fit only those specific soils. Instead, the two series of experiments should be interpreted together, giving an estimate of possible fertilizer response on both soils over a period of time with both favorable climatic conditions.

The greatest yield responses to fertilizer occurred in seasons with favorable precipitation, favorable distribution of precipitation, and above average yields. The Pratt soil experiments were conducted during a period of below average and extremely variable precipitation, response to nitrogen was obtained in the 1958-1963 experiments but not in average and rather consistent precipitation. (Consequently, precipitation limited wheat yields on Pratt, while soil fertility limited those on Enterprise. Actually, Enterprise is inherently more fertile than Pratt and under similar climatic conditions, greater fertilizer response would be expected on Pratt.

Results indicate that both soils will respond to nitrogen fertilization on seasons or series of seasons when climatic conditions are favorable for high yields, but neither soil will respond to nitrogen when yields are low as a result of climatic limitations. The extreme variability in climatic conditions in the area makes prediction of fertilizer response quite difficult.

Locke and Matthews (1) investigated the relation of wheat yields to climatic factors at Woodward. They were able to describe conditions under which favorable yields were obtained, but correlations between soil moisture at seeding and yield, and total and monthly precipitation and yield, were too low for these parameters to be used to predict yield levels.

Though no positive method exists for predicting nitrogen fertilizer response, growers can consider all of the facts at hand in deciding whether or not to apply it. Crop stand and condition, soil moisture, and previous crop yields are important in determining possible response to nitrogen fertilizer. Nitrogen application can be delayed until spring when stand conditions, soil moisture, and the possibility of raising a good crop are easier to assess than at planting time. When yields of previous crops have been high, soil nitrogen levels are probably lower than they would be after a period when yield levels have been limited by drought.

If nitrogen fertilizer is applied and response does not occur because of drought conditions, at least part of it will be carried over for use by succeeding crops. In this series of experiments, residual response to fertilizer was found both in a good wheat year (1957) after a drought period, and in a poor wheat year (1963) after a series of good wheat years.

The lack of significant yield response to phosphorus in experiments on both Pratt and Enterprise soils indicates that phosphorus is not limiting on these soils. However, the trend toward increased yields with phosphorus fertilizer on Pratt soil (1.5 bushels per acre) and the significant increase from residual phosphorus fertilizer on that soil in 1957 indicates a possible incipient phosphorus deficiency.

Results indicate that the tillage method did not affect yields or fertilizer response. This is an interesting finding in that, on some soils and in some locations, yields have been lower under stubble-mulch than under "clean" tillage.

Summary

Five experiments involving fertilization of wheat were conducted at the Southern Great Plains Field Station. Three of these were on Pratt soil, 1950-1957, and two were on Enterprise soil, 1958-1963.

Precipitation was below average and extremely variable from 1950-1957 and above average and relatively consistent from 1958-1963. Yield response to nitrogen was obtained in the 1958-1963 experiments but not in the 1950-1957 studies. Though the experiments were conducted on two different soils, presence or absence of response to nitrogen is attributed to climatic rather than soil differences.

No significant yield response was obtained from phosphorus fertilizer on either soil, but yield trends indicated a possible incipient phosphorus deficiency on Pratt soil.

Phosphorus fertilizer placement (with the seed at planting or broadcast prior to planting) did not affect wheat yield.

There was a response to residual fertilizer in all experiments.

In a comparison of stubble-mulch and one-way tillage, the method of tillage did not affect average wheat yields or fertilizer response.

Literature Cited

(1) Locke, L. F. and Matthews, O. R. Relation of cultural practices to winter wheat production, Southern Great Plains Field Station, Woodward, Oklahoma, U.S. Dept. Agr. Cir. 917, 54 pp., illus., June 1953.

Appendix

Table 1.—Effect of rate and time of application of nitrogen and phosphorus on wheat yields. Average of 3 replications, Pratt Soil, (Experiment I), Woodward, Oklahoma, 1950-1957.

Fertilizer Treatment													
Lb/A N (Fall)	40	10	0	20	0	10	0	10	0	20	0	0	
Lb/A N (Mid-Feb.)	0	10	40	0	0	30	20	0	0	0	20	10	
(Lb/A P	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	0	0	0	17.5	
	BUSHELS PER ACRE												
Year													Avg.
1950	22.3	16.3	19.3	17.5	18.9	21.2	19.1	16.0	17.8	14.9	15.6	14.7	17.8
1951	23.6	21.9	19.4	20.2	17.4	19.6	18.6	15.8	18.8	18.6	17.9	18.4	19.0
1952	36.1	33.6	32.5	30.9	30.4	33.7	31.1	31.1	30.4	31.0	29.0	28.7	31.5
1953	12.0	13.6	13.4	11.4	10.9	9.8	15.7	12.9	9.7	10.6	13.1	11.7	12.1
1954	14.7	16.3	15.2	16.4	17.1	15.1	12.0	17.0	13.4	14.7	10.9	10.0	14.4
1955	10.8	12.9	11.7	10.7	11.8	9.1	11.3	12.9	9.9	9.4	12.3	10.0	11.1
1956	11.8	11.8	11.1	11.7	12.1	9.3	10.0	12.0	10.4	9.2	8.6	11.9	10.5
Average	18.8	17.8	17.5	17.0	16.9	16.8	16.8	16.8	15.8	15.5	15.3	15.0	16.7
	a[1]	ab	abc	abcd	abcd	bcd	bcd	bcd	cde	de	de	e	
1957[2]	28.6	29.9	29.2	29.2	26.8	25.3	32.2	29.0	23.7	24.1	25.8	25.0	27.4
	abcd	ab	abc	abc	cde	de	a	abc	e	e	cde	e	

[1] Means followed by the same letter are not significantly different at the .05 level.
[2] No fertilizer applied on 1957 crop.

Table 2.—Effect of rate of application of phosphorus on wheat yields, Average of 5 replications (Experiment II), Pratt, Soil, Woodward, Oklahoma, 1950-1957.

	Fertilizer Treatment (Lbs. P/A)[1]				
	17.5	34 9	8.7	0	
	BUSHELS PER ACRE				
Year					Avg.
1950	21.0	20.2	21.7	22.4	21.3
1951	16.2	19.5	18.3	15.9	17.5
1952	37.1	37.1	35.7	34.7	36.2
1953	9.9	9.7	10.4	8.1	9.5
1954	16.8	15.5	15.5	14.4	13.6
1955	11.8	12.0	10.5	11.0	11.3
1956	14.4	13.2	12.6	10.0	12.6
Average	18.2	18.2	17.8	16.6	17.4
1957[3]	30.2	28.5	27.4	23.5	27.4
	a[2]	a	ab	b	

[1] 40 lbs. of N/A applied with each treatment.
[2] Means followed by the same letter are not significantly different at the .05 level.
[3] No fertilizer applied on 1957 crop.

Table 3.—Effect of rate and placement of phosphorus fertilizer on wheat yields, average 4 replications, Pratt Soil (Experiment III), Woodward, Oklahoma, 1951-1957.

	Fertilizer Treatment (Lbs P/A)[1]								
Broadcast	0	17.5	0	34.9	8.7	0	0	0	
With Seed	34.9	0	17.5	0	0	0	8.7	4.4	
	BUSHELS PER ACRE								
Year									Avg.
1951	18.0	17.3	17.9	17.5	17.5	18.9	16.8	13.1	17.1
1952	36.9	36.3	34.7	35.3	33.1	31.8	31.5	28.5	33.5
1953	18.1	15.4	17.2	15.8	14.4	13.2	14.9	12.6	15.2
1954	13.7	14.6	14.0	13.0	13.8	13.8	12.7	13.4	13.6
1955	12.8	13.2	12.2	14.5	13.8	11.3	12.2	12.5	12.8
1956	7.8	9.9	9.2	7.4	8.1	8.1	7.9	7.7	8.3
Average	17.9	17.8	17.5	17.3	16.8	16.2	16.0	14.6	16.8
	a	a	a	a	a	ab	ab	b	
1957[2]	29.8	31.0	28.6	29.4	29.4	24.4	28.1	25.3	28.3
	a[3]	a	ab	a	a	c	ab	bc	

The average yields of 8.7, 17.5, and 34.9 pounds per acre phosphorus treatments were: Broadcast—17.3 bushels per acre; applied in row—17.1 bushels per acre.
[1] 40 lbs. N/A applied with treatment.
[2] No fertilizer applied on 1957 crop.
[3] Means followed by the same letter are not significantly different at the .05 level.

Table 4.—Effect of tillage methods and fertilizer treatments on wheat yields, average 3 replications, Enterprise Soil, (Experiment IV), Woodward, Oklahoma, 1958-1962.

Fertilizer Treamtent:													
N	0	0	40	40	40	10	20	80	40	40	40	40	
P	0	17.5	0	17.5	34.9	17.5	17.5	17.5	4.4	8.7	17.5	43.7[1]	
K	0	0	0	0	0	0	0	0	0	0	33.2	0	
	BUSHELS PER ACRE												
Year	**One-Way**												**Avg.**
1958	26.5	27.1	30.5	23.8	33.1	30.0	25.5	33.8	31.3	24.9	32.1	26.8	28.8
1959	29.6	33.3	37.7	29.1	31.0	26.2	25.3	33.8	25.1	26.3	30.8	28.4	29.7
1960	12.2	15.3	23.4	18.7	22.5	18.6	14.7	28.3	21.7	22.9	24.5	21.6	20.4
1961	27.4	33.4	31.3	29.1	38.1	26.7	27.0	40.3	28.0	32.6	33.0	33.0	31.7
1962	19.1	19.1	22.9	23.2	29.7	21.0	17.5	26.5	22.5	24.6	26.2	24.5	23.1
Average	22.9	25.6	29.2	24.8	30.9	24.5	22.0	32.5	25.8	26.3	29.3	26.9	26.7
	jk[2]	ghij	abcde	hijk	ab	hijk	k	a	fghij	efghi	abcde	efghi	
	Stubble Mulch												
1958	27.3	28.5	30.3	31.2	33.5	26.1	29.3	37.1	31.3	32.7	30.3	31.5	30.7
1959	34.3	28.9	35.8	41.0	29.6	31.1	21.8	38.2	39.8	32.9	36.1	33.8	33.6
1960	6.5	9.4	10.5	13.8	15.7	10.7	13.9	18.0	12.7	15.6	20.7	16.1	13.6
1961	26.8	34.2	36.0	34.0	33.0	29.5	33.3	37.1	36.3	37.0	38.1	37.3	34.4
1962	19.7	22.4	24.7	23.0	25.7	21.8	23.3	21.5	26.4	27.1	29.0	26.2	24.2
Average	22.9	24.7	27.5	28.6	27.4	23.8	24.3	30.4	29.3	29.1	30.8	29.0	27.3
	jk[2]	hijk	cdefgh	bcdefg	defgh	ijk	hijk	abcd	abcde	bcde	abc	bcdef	
	One-Way and Stubble Mulch												
Five-year average	22.9	25.1	28.3	26.7	29.1	24.2	23.2	31.4	27.5	27.7	30.1	27.9	27.1
	e[2]	cde	abc	bcd	ab	de	e	a	bcd	bcd	ab	abc	
	1963 Residual Fertilizer Yields												
One-Way	12.8	12.1	16.1	15.3	16.3	12.2	11.3	18.1	14.4	16.1	15.2	14.9	14.6
Stubble Mulch	14.0	14.6	17.3	16.4	15.1	14.8	15.1	16.8	16.7	17.0	19.1	17.7	16.2
Average	13.4	13.4	16.7	15.9	15.7	13.5	13.2	17.4	15.5	16.6	17.1	16.3	15.4
	c[2]	c	ab	ab	ab	c	c	a	b	ab	ab	ab	

[1] 43.7 pounds P applied once in 5 years.
[2] Means followed by the same letter are not significantly different at the .05 level.

Table 5.—Effect of tillage methods and fertilizer treatments on percent protein in wheat, average 3 replications, Enterprise Soil, (Experiment IV), Woodward, Oklahoma, 1958-1962.

Fertilizer Treamtent:													
N	0	0	40	40	40	10	20	80	40	40	40	40	
P	0	17.5	0	17.5	34.9	17.5	17.5	17.5	4.4	8.7	17.5	43.7[1]	
K	0	0	0	0	0	0	0	0	0	0	33.2	0	
	PERCENT PROTEIN												
Year	**One-Way**												**Avg.**
1958	9.7	10.7	10.4	9.0	9.6	9.1	9.8	10.0	10.3	10.4	9.7	9.6	9.9
1959	8.9	9.4	10.0	9.1	9.6	8.9	8.7	10.3	9.8	9.4	9.3	8.8	9.4
1960	11.3	11.7	12.1	11.9	11.3	11.7	11.3	12.2	11.6	11.6	11.8	12.0	11.7
1961	9.2	8.9	10.5	9.1	9.4	8.7	8.8	10.9	9.5	9.1	9.7	9.4	9.5
1962	10.8	11.2	15.7	13.3	12.6	11.0	10.8	14.8	13.5	13.4	13.2	13.7	12.8
Average	10.0	10.4	11.8	10.5	10.5	9.9	9.9	11.6	10.9	10.8	10.8	10.7	10.6
	gh[2]	fgh	bs	fgh	fgh	h	h	bcd	def	ef	ef	efg	
	Stubble Mulch												
1958	9.8	9.6	10.7	10.0	9.3	9.5	9.4	11.5	10.4	10.2	10.4	10.2	10.1
1959	9.6	9.5	10.4	9.7	9.6	9.7	9.5	10.8	10.2	9.8	9.7	9.8	9.9
1960	12.7	12.6	12.6	12.4	12.3	12.4	12.7	13.1	13.2	13.1	12.3	12.7	12.7
1961	9.6	9.8	11.0	10.0	9.8	9.6	10.0	10.9	10.4	9.9	9.7	10.1	10.1
1962	12.0	12.5	15.9	13.7	12.6	11.7	12.3	16.5	14.5	13.9	13.4	14.4	13.6
Average	10.7	10.8	12.1	11.1	10.7	10.6	10.8	12.6	11.8	11.4	11.1	11.4	11.3
	efg[2]	ef	ab	cdef	efg	fgh	ef	a	bc	bcde	cdef	bcde	
	One-Way Stubble Mulch												
Five-Year Average	10.4	10.6	12.0	10.8	10.6	10.2	10.3	12.1	11.4	11.1	10.9	11.1	11.0
	def[2]	cdef	a	cde	cdef	f	ef	a	b	bc	bcd	bc	

[1] 43.7 pounds P applied once in 5 years.
[2] Means followed by the same letter are not significantly different at the 0.5 level.

Table 6.—Effect of tillage methods and fertilizer treatments on percent phosphorus in wheat, average 3 replications, Enterprise Soil, (Experiment IV), Woodward, Oklahoma, 1958-1962.

Fertilizer Treamtent:													
N	0	0	40	40	40	10	20	80	40	40	40	40	
P	0	17.5	0	17.5	34.9	17.5	17.5	17.5	4.4	8.7	17.5	43.7[1]	
K	0	0	0	0	0	0	0	0	0	0	33.2	0	
	PERCENT PHOSPHORUS												
Year	One-Way												Avg.
1958	.237	.303	.265	.334	.302	.287	.355	.303	.326	.244	.314	.314	.299
1959	.325	.320	.237	.313	.334	.316	.336	.315	.274	.295	.309	.297	.306
1960	.512	.470	.437	.464	.492	.505	.477	.477	.457	.457	.445	.472	.472
1961	.340	.380	.270	.330	.370	.400	.360	.330	.300	.340	.350	.340	.345
1962	.393	.383	.287	.373	.427	.413	.403	.397	.300	.350	.337	.353	.367
Average	.362 bcdef[2]	.372 abcdef	.301 g	.363 bcdef	.384 abc	.384 abc	.386 abc	.365 abcdef	.332 efg	.338 defg	.351 cdef	.356 cdef	.358
	Stubble Mulch												
1958	.302	.320	.264	.299	.351	.293	.330	.316	.288	.294	.330	.307	.308
1959	.265	.315	.288	.300	.325	.328	.333	.292	.255	.324	.311	.313	.304
1960	.513	.524	.500	.500	.529	.490	.506	.508	.497	.504	.501	.498	.506
1961	.340	.440	.310	.360	.410	.420	.390	.370	.350	.380	.380	.360	.374
1962	.360	.430	.280	.367	.427	.420	.410	.410	.363	.377	.380	.357	.382
Average	.356 cdef[2]	.405 ab	.328 fg	.364 abcdef	.409 a	.390 abc	.394 abc	.379 abcd	.350 cdef	.375 abcde	.380 abcd	.367 abcdef	.375
	One-Way And Stubble Mulch												
Five-Year Average	.359 bcd[2]	.389 ab	.314 e	.364 bcd	.397 a	.387 abc	.390 ab	.372 abc	.341 de	.357 cd	.366 abcd	.361 bcd	.366

[1] 43.7 pounds P applied once in 5 years.
[2] Means followed by the same letter are not significantly different at the 0.5 level.

Table 7.—Effect of time of application of nitrogen on wheat yields, average 4 replications, Enterprise Soil, (Experiment V), Woodward, Oklahoma, 1957-1962.

Time of Application			At Planting	Feb.	Mar.	Apr.	
					Lbs/A		
N	0	0	40	40	40	40	
P	0	17.5	17.5	17.5	17.5	17.5	
	BUSHELS PER ACRE						
Year							Avg.
1957	10.0	16.9	13.5	16.3	13.6	15.7	14.3
1958	23.5	21.4	33.6	28.1	28.1	30.7	27.6
1959	34.4	33.9	36.1	38.1	37.7	34.7	35.8
1960	11.2	10.5	19.1	21.1	15.0	16.2	15.5
1961	23.4	24.9	36.1	36.2	39.4	33.6	32.3
1962	17.8	17.6	26.0	28.4	26.5	26.8	23.8
Average	20.1	20.9	27.4	28.0	26.7	26.3	24.9
	c[2]	bc	a	a	ab	ab	
1963 Residual fert. yields	13.5	12.6	16.0	16.6	17.2	17.9	15.6
	c[2]	c	b	ab	ab	a	

[1] All P applied with the seed.
[2] Means followed by the same letter are not significantly different at the .05 level.

Table 8.—Effect of time of application of nitrogen on protein content of Grain, average 4 replications, Enterprise Soil, (Experiment V), Woodward, Oklahoma, 1957-1962.

Time of Application			At Planting	Feb.	Mar.	Apr.	
					Lbs/A		
N	0	0	40	40	40	40	
P	0	17.5	17.5	17.5	17.5	17.5	
	PERCENT						
Year							Avg.
1957	8.2	8.1	7.8	8.9	8.7	8.4	8.3
1958	9.7	9.7	9.9	10.4	11.1	10.6	10.2
1959	9.0	9.0	9.4	9.8	9.7	10.6	9.6
1960	11.9	11.9	11.6	12.0	12.1	12.4	12.0
1961	9.8	9.9	9.6	10.6	10.9	13.0	10.6
1962	11.9	12.2	13.8	14.2	14.1	15.0	13.4
Average	10.1	10.1	10.4	11.0	11.1	11.7	10.7
	e[2]	e	d	c	b	a	

[1] All P applied with the seed.
[2] Means followed by the same letter are not significantly different at the .05 level.

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