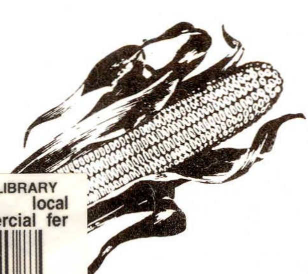
Bulletin 516-S

The Use of Commercial Fertilizers With Dryland Crops in Colorado



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Preface

This bulletin gives the results of commercial fertilizer experiments on wheat, corn, and sorghum under dryland conditions in Colorado.

These studies were conducted during the period of 1952 to 1958. Emphasis was placed on the yield and quality of crops.

This project was supported in part by funds from the Phillips Petroleum Company and acknowledgment is made to them as well as to the Colorado Extension agents and specialists, Experiment Station personnel, farmer cooperators, and others of the fertilizer industry for their assistance.

Contents

The Use of Commercial Fertilizers With Dryland Crops In Colorado

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Introduction

The use of commercial fertilizers is recognized as an important part of a sound program for maximum crop production in many sections of the United States. This use has been largely confined to the more humid and irrigated areas. However, after 7 years of study it is apparent that there is a place for nitrogen fertilizer in some of the cropping systems of the dryland regions of Colorado. While yield increases are not as spectacular in this region as in others, they are still significant.

There has been considerable doubt about the use of commercial fertilizer in areas of low annual precipitation. While the beneficial effects of fertilizer are not entirely predictable, the results presented here, obtained over a 7-year period, tend to clarify the situation to a large degree.

Conclusions are based on 47 experiments with winter wheat, corn, and sorghum which were conducted on various soil types and in several precipitation zones. A number of experiments were abandoned due to crop failure caused by wind, drought, and poor germination. During 1954, 1955, and 1956, the experiments were confined primarily to the northeastern section of the state where soil moisture was more favorable for crop production.

The multiple objectives of the research were to determine if additional fertilizer would increase crop yields under non-irrigated conditions and, if so, to determine the most effective rate

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and time of application of the fertilizer and the effectiveness of different carriers of commercial nitrogen. It was desired also to evaluate the effectiveness of fertilizers on crops grown on different soil types and to determine the soil moisture conditions most likely to result in yield increase.

Since 1953, rain gauges have been used at all experimental sites in order to obtain a record of the precipitation. Soil moisture contents were determined periodically throughout the growing season at the experimental sites. The results applying to soil moisture and wheat yields have been summarized in a separate publication (1).[2]

In the tables of this report, N and NN have been used to designate the rates of nitrogen. Unless otherwise designated, N=25 or 30 pounds nitrogen per acre and NN=50 or 60 pounds nitrogen per acre. Higher rates of nitrogen were used in several of the experiments, but since there were no increases in yield at these rates of application, they are not reported here. Potassium fertilizers were also used at some locations, but since no yield increases were obtained, the data have been omitted.

The terms "sandy land" and "hard land" are used extensively in eastern Colorado. In this report sandy land refers to loamy sand and sandy loam soils, while hard land refers to all soil types heavier than sandy loam.

The locations of the experiments, the soil type, and the crop variety can be found in table A-1 in the appendix.

Results of Experiments With Wheat

Rates of nitrogen (tables 1-3)

Ten experiments in which two rates of nitrogen were applied are reported in tables 1, 2, and 3. There was a significant response to nitrogen in four of the tests, but only in one experiment (D-30-53) (table 3) was there an additional increase beyond the first rate of nitrogen fertilizer. Generally, the wheat with the heavier rate of nitrogen has not out-yieled tha twith the lower rate by more than 2 bushels. This small increase is not sufficient to cover the cost of the extra fertilizer. The most economical rate of nitrogen for this area is about 30 pounds of nitrogen per acre.

Response to nitrogen in relation to soil type

Yield responses to applications of nitrogen were confined largely to sandy soils. Yield responses on hard land were obtained at only two locations. It appears that the interaction of soil moisture and cropping system is the predominant factor involved in

[2] Number in parentheses refers to corresponding number in Bibliography on page 17

Table 1.—Rates of nitrogen fertilizers applied to wheat

Field No.		CK	N	NN
D-42-54	Grain bu./acre	2.2	4.6**	3.7**
	% protein	13.9	14.6**	17.2**
	Test wt. lbs./bu.	57.7	57.3	55.0**
D-32-53	Grain bu./acre	12.4	12.1	11.6
	Straw tons/acre	0.99	1.09	1.07
	% protein	14.1	15.8	17.6**
	Test wt. lbs./bu.	58.0	57.3	57.3
D-31-53[1]	Grain bu./acre	13.1	21.7**	
	Straw tons/acre	0.80	1.47**	
	% protein	8.7	10.6**	
	Test wt. lbs./bu.	60.0	60.0	
D-48-54	Grain bu./acre	9.8	11.5	13.3**
	Straw tons/acre	0.62	0.72*	0.77**
	% protein	12.1	15.1**	16.5**
	Test wt. lbs./bu.	62.6	62.6	61.8

[1] Anhydrous ammonia at 40 lb. N/acre.
* Yield increases significant at 5% level.
**Yield increases significant at 1% level.

CK=No fertilizer
N =20 - 25 lb. N
NN=40 - 50 lb. N

Table 2.—Rates and carriers of nitrogen with wheat on light textured soils

Field no.		CK	AS[1]	AS[2]	AN[1]	AN[2]	U[1]	U[2]
D-30-53	Grain bu./acre	12.6	14.6	16.4**	18.1**	20.4**	15.5*	21.0**
	% protein (grain)	9.6	10.0	11.6**	10.6*	12.4**	10.5*	12.3**
	Test weight	59.5	59.5	58.8	59.8	58.0*	59.0	58.0*
D-47-54	Grain bu./acre	10.9	12.2	11.5	13.3	13.0		
	% protein (grain)	13.6	13.8	14.6	14.1	15.4**		
	Test weight	62.5	61.8	62.5	62.3	61.3		
D-44-54	Grain bu./acre	26.3	24.9	27.7	27.9	25.9		
	% protein (grain)	13.0	15.0**	14.7**	14.4	15.6**		
	Test weight	59.8	59.0	58.5**	59.3	57.5**		
D-75-56	Grain bu./acre	3.3			3.1	3.1	3.2	2.5
	% protein (grain)	18.4			18.8	18.8	18.4	17.6
	Test weight	53.5			53.0	54.0	54.5	54.0

CK =No treatment
AS[1] =25 lb. N/A ammonium sulfate
AS[2] =50 lb. N/A ammonium sulfate
AN[1]=25 lb. N/A ammonium nitrate
AN[2]=50 lb. N/A ammonium nitrate
U[1] =25 lb. N/A urea
U[2] =50 lb. N/A urea
*Yield increases significant at 5% level.
**Yield increases significant at 1% level.

Table 3.—Rates and carriers of nitrogen with wheat on heavy textured soils

Field no.		CK	AN[1]	AN[2]	AS[1]	AS[2]	DAP[1]	DAP[2]
D-64-55	Grain bu./acre	5.7	5.7	6.1	6.5	5.9	5.7	5.9
	% protein	19.7	20.4	20.5	20.4	20.7	20.4	20.0
	Bu. weight	57.9	57.6	57.5	56.4	56.5	57.1	56.6
D-65-55	Grain bu./acre	7.6	9.0	7.2	8.5	6.8	7.6	8.6
	% protein	14.8	16.5*	18.3**	16.1	17.8**	16.2	16.5*
	Bu. weight	58.7	58.0	55.6	57.4	57.5	57.7	56.6

CK = No treatment
AN[1] = Ammonium nitrate 20 lb. N/A
AN[2] = Ammonium nitrate 40 lb. N/A
AS[1] = Ammonium sulfate 20 lb. N/A
AS[2] = Ammonium sulfate 40 lb. N/A
DAP[1] = Diammonium phosphate 20 lb. N/A
DAP[2] = Diammonium phosphate 40 lb. N/A
U[1] = Urea 20 lb. N/A
U[2] = Urea 40 lb. N/A

*Yield increases significant at 5% level.
**Yield increases significant at 1% level.

yield response on heavier textured soils. Responses have occurred where there was adequate soil moisture but no fallow period for a buildup of nitrates, or where large amounts of residues were returned to the soil resulting in the tieup of available soil nitrogen. With loamy sand and sandy loam soils, organic matter content of the soil is a critical factor in determining the need for supplemental nitrogen. The organic matter content of these soils is generally 1 percent or less. On some of these soils, small but significant increases in yield were obtained from nitrogen applications when moisture conditions were too poor to produce economical yields. These increases are evidence of the inadequacy of the native soil nitrogen.

As a rule, there were very small differences due to the source of nitrogen applied to winter wheat at planting. When differences occurred, they were in favor of the nitrate form of nitrogen. The differences between carriers were associated with spring applications of nitrogen. At D-30-53 (table 2) yields of wheat from both rates of ammonium nitrate were greater than those for soils treated with corresponding rates of ammonium sulfate.

Anhydrous ammonia is equal to other carriers as a source of nitrogen for fall application. The mechanical damage to growing plants by the ripping action of the applicator restricts its use for spring applications.

Fall applications of nitrogen can be made prior to planting, at planting time at the side and below the seed, or as broadcast applications after emergence. Nitrogen fertilizers should not be placed in contact with the seed. To be effective, spring applications of nitrogen should be applied prior to the jointing stage of growth. Since the stage of growth varies with the season, April 10 has been found to be about the average latest date at which fertilizer can be applied with reasonable assurance of a response in crop yield.

There has been some concern in dryland areas about the detrimental effect of commercial fertilizers on growing crops. In this study there has been no evidence of serious damage to crops on sandy soils from the use of nitrogen fertilizer. This has been true regardless of the nitrogen carrier used or the time of application.

Fertilizer combinations

Phosphate applied broadcast and disked in prior to seeding has not been beneficial, either alone or in combination with nitrogen (table 4). The yield of wheat where phosphorus was applied remained about the same as that of the untreated wheat. Potassium was used at a few locations early in the study but was discontinued when it became apparent that it was the least important of the major elements as a limiting factor in crop production.

Straw yield and protein content of grain

Straw yields were increased by the use of nitrogen fertilizers at most of the locations. The importance of increased straw yields lies in a program of proper residue management. Vegetative cover is the best control for wind erosion and adequate residues are necessary to provide cover on cultivated soil.

Increased protein content of

Table 4.—Effect of nitrogen and phosphorus on yield and protein content of wheat

Field no.		CK	N	NP	P
D-1-52	Bushels/acre	12.5	11.3	11.8	11.9
	% protein	14.8	15.8	15.4	14.7
D-2-52	Bushels/acre	19.4	20.2	19.1	21.4
	% protein	9.6	11.4	11.6	11.1
	Test weight	59.7	59.0	59.0	60.3
D-3-52	Bushels/acre	28.3	32.5	29.4	30.2
	% protein	13.7	13.7	14.0	13.7
	Test weight	61.7	61.7	61.7	61.6
D-4-52	Bushels/acre	23.0	24.1	21.7	27.8
	% protein	18.3	18.9	18.6	17.2
	Test weight	53.0	52.9	52.5	55.3
D-5-52	Bushels/acre	20.8	25.6**	24.9*	21.8
	% protein	10.6	11.7	10.2	10.6
	Test weight	63.7	63.1	62.7	63.4
D-6-52	Bushels/acre	12.7	18.1**	18.0**	13.5
	% protein	10.3	12.7**	13.9**	10.4
	Test weight	61.5	60.5	61.0	61.5
D-7-52	Bushels/acre	22.2	26.4	27.4*	18.3
	% protein	8.6	11.9**	12.3**	8.6
	Test weight	61.4	61.5	61.1	61.3

*Yield increases significant at 5% level.
**Yield increases significant at 1% level.

grain has resulted from nitrogen application at several test locations. These increases are of benefit to the grower only when obtained under favorable moisture conditions. Under unfavorable moisture conditions, the protein content is high due to shriveling of the grain which results in a low quality, low weight wheat.

Results of Experiments With Corn

Rates, method of application, and carriers of nitrogen (tables 5,6,7)

Two tests were conducted in 1952 using three rates of nitrogen: 0, 20, and 40 pounds per acre. The heaviest rate was applied as a single application and as a split application. There were no significant differences in the yield at D-8-52. At the other location (D-10-52) yields were increased significantly by all nitrogen treatments. There were no statistical differences between the 20- and 40-pound rates of nitrogen or the different methods of application of the heavier rate. The protein content was increased only by the heavier rate of nitrogen.

Phosphorus application with the heavier rate of nitrogen failed to produce any additional increase in yield (table 5). At D-69-55 (table 6), the application of phosphorus with nitrogen did not increase yields, although the soil phosphorus was low as measured by the sodium bicarbonate test. Yield increases at this location were significant with nitrogen application of ammonium nitrate and urea.

Ammonium nitrate, ammonium sulfate and urea were compared at two rates of application in five tests (table 7). Responses in grain yield were obtained at two locations. D-34-53 there were no statistical differences in grain yield as measured by the L.S.D. between rates or carriers of nitrogen even though the lighter application of some nitrogen treatments did not produce a yield significantly greater than the check. The only difference in yield due to rates of nitrogen was between the two ra es of ammonium sulfate at D-36-53.

Results of nitrogen fertilizers with grain sorghum (table 8)

The results from five of the ten experiments conducted with grain sorghum are shown in table 8. Three sources of nitrogen were used at two different rates of application. Three of these tests were on sandy soils. Increased yields due to nitrogen fertilizers were obtained at one of these locations (D-37-53), while the yield from the heavier rate of urea was decreased at another (D-79-56). Protein content of the grain was increased at two locations. It is impossible to reach any conclusions concerning carriers of nitrogen since the high-

Table 5.—Rates and combinations of fertilizers with corn

Field no.		CK	N	NP-N	NN	NNP
D- 8-52	Bushels/acre	23.9	22.6	24.3	21.7	23.7
D-10-52	Bushels/acre	28.5	34.3*	37.3**	36.0**	33.7*
	% protein	7.3	7.6	9.0**	8.9**	8.3

*Significant at 5% level.
**Significant at 1% level.

NP-N=Split application of nitrogen at highest rate

Table 6.—Nitrogen-phosphorus applications to corn

Field no.		CK	AN	AS	U	AN-P	AS-P	U-P
D-69-55	Bushels/acre	23.3	35.3*	29.9	32.1*	20.9	23.5	20.7
	% protein	8.8	9.4	9.2	8.5	7.5	9.3	8.6

Table 7.—Rates and carriers of nitrogen with corn

Field no.		CK	AN^1	AN^2	AS^1	AS^2	U^1	U^2
D-34-53	Bushels/acre	15.6	22.0	23.6*	26.5**	22.7	23.3*	23.7*
	% protein	6.6	8.6**	8.8**	8.3**	8.6**	8.4**	8.5**
D-35-53	Bushels/acre	39.2	43.3	40.0	43.4	40.3	40.1	40.9
	% protein	7.8	8.4	8.8**	8.8**	9.0**	8.7**	8.5*
D-36-53	Bushels/acre	19.4	23.2	23.7*	20.0	24.3*	22.7	23.7*
	% protein	8.6	9.9**	10.0**	9.8**	10.6**	9.8**	10.2**
D-54-54	Bushels/acre	35.8	32.0	31.7	33.9	41.6	35.7	31.1
	% protein	10.5	10.7	10.9	10.6	10.8	10.6	10.8
D-80-56	Bushels/acre	20.4	20.1	16.9	22.6	21.4	20.6	23.0
	% protein	10.7	9.4	10.6	9.4	10.7	9.5	9.6

AN^1=Amonnium nitrate 25 lb. N/A
AN^2=Ammonium nitrate 50 lb. N/A
AS^1=Ammonium sulfate 25 lb. N/A
AS^2=Ammoonium sulfate 50 lb. N/A
U^1=Urea 25 lb. N/A
U^2=Urea 50 lb. N/A

*Yield increases significant at 5% level.
**Yield increases significant at 1% level.

est and lowest yield treatments, where fertilizers were applied, were generally with the same carrier.

At the two locations on loam soils, the only difference due to fertilizer was an increase in protein content of grain at D-67B-55 with the 40- pound rate of ammonium sulfate.

The other tests conducted with this crop included other variables such as varieties and seeding rate. Yields were increased by some nitrogen treatments at only two of these locations.

Table 8.—Rates and carriers of nitrogen with grain sorghum

Field no.		CK	AS¹	AS²	AN¹	AN²	U¹	U²
D-37-53†	Bushels/acre	30.2	44.5**	47.8**	40.2**	46.9**	43.0**	41.9**
	% protein	7.1	9.1**	10.2**	8.4**	10.0**	8.7**	9.5**
D-66-55†	Bushels/acre	12.8	12.6	9.3	12.1	10.2	10.7	13.3
	% protein	11.4	12.5*	13.7**	12.8*	13.3**	12.8*	12.1
D-79-56†	Bushels/acre	21.5	21.2	20.4	16.5	21.2	24.7	12.1*
	% protein	13.1	13.2	13.1	13.7	13.7	14.0	13.3
D-67A-55	Bushels/acre	21.9	23.5	25.0	19.5	27.6	20.8	22.7
	% protein	12.3	12.2	11.7	11.9	11.4	11.9	11.9
D-67B-55	Bushels/acre	18.7	25.0	14.5	18.9	16.6	22.7	15.3
	% protein	11.2	11.3	12.3*	11.9	11.7	11.2	12.1

† Sandy soils
*Yield increases significant at 5% level.
**Yield increases significant at 1% level.
CK = No fertilizer
AS¹ = Ammonium sulfate - 20 lb. N/A
AS² = Ammonium sulfate - 40 lb. - N/A
AN¹ = Ammonium nitrate - 20 lb. N/A
AN² = Ammonium nitrate - 40 lb. N/A
U¹ = Urea - 20 lb. N/A
U² = Urea - 40 lb. N/A

Discussion

Wheat experiments

Results of the fertilizer trials in Colorado are in general agreement with those reported from surrounding states (2) (3) (6) (8). ‡ However, some of these investigators, working under more favorable moisture conditions, have found rates of nitrogen up to 40 pounds nitrogen per acre to be the most economical. For the period during which these tests were conducted, it was found that about 30 pounds of nitrogen per acre was the optimum.

It is apparent from these studies that, as a rule, responses to nitrogen cannot be expected on heavy-textured soils. While there is an indication that some of the hard lands need additional nitrogen when moisture is adequate, the extent of these soils and the amounts of moisture necessary to obtain nitrogen responses have not been defined to the extent that recommendations can be made. Most of the responses to nitrogen were on sandy soils, and it is on these soils that the use of nitrogen fertilizer is feasible. Similar results have been reported from Kansas (3) and western Nebraska (6). ‡

Nitrogen fertilizer can be applied for winter wheat either in the fall or early spring. Spring applications of nitrogen should

‡ See footnote 2 on page 4

be made before April 10 to be most effective. There is an advantage to spring applications since fertilizer is not applied until the stand of wheat and soil moisture conditions can be evaluated at the beginning of spring growth. Applying nitrogen under favorable moisture conditions in the early spring does not guarantee increased yields will be obtained, since the amount of available soil moisture in the late spring appears to be the determining factor in the response of wheat to nitrogen (1). ‡ A disadvantage to spring application is that the heavy storms generally occur in March and early April in eastern Colorado. These storms may often prevent the application of fertilizer before April 10.

For fall application with wheat, all nitrogen carriers tested were about equally effective, but for spring applications, ammonium nitrate was slightly superior. Lowry et al. (6) ‡ found ammonium nitrate and urea to be more satisfactory than ammonium sulfate for spring applications, and in Utah, Peterson (8) ‡ found that when differences occurred between ammonium and nitrate forms of nitrogen, they were in favor of the nitrate.

Phosphorus applications broadcast and disked into the soil were not beneficial on wheat. This was particularly true where phosphorus was used alone. When applied with nitrogen, phosphorus increased the yield of wheat over the nitrogen check at one location only. Phosphorus alone resulted in decreased yields at the same location. Although a number of these tests were conducted during the drought of 1953-56, the yield was significantly reduced by the use of nitrogen only once. This reduction was with 25 pounds of nitrogen at Amherst in 1955. No other treatment reduced the yield and a significant increase was obtained at this location with the same rate of nitrogen plus phosphorus. Several experiments were abandoned due to extremely dry conditions, but in all cases the untreated plots were lost as well as the fertilized. Crop burning by the use of soil applied nitrogen was not evident during this study.

Protein content and test weight were used to indicate the quality of grain. These factors are controlled by the available soil moisture as well as the nitrogen content of the soil. Results of the work presented show the following general relationships. On sandy soils, if the moisture is adequate for a high crop yield and additional nitrogen is supplied, an increase in grain yield with an increase in percent protein can be expected without a decrease in bushel weight. On the heavier soils, an increase in grain yield is not likely; however, the bushel weight may be maintained at the desired level with an increase in protein content. If the soil moisture is not adequate in either land type, a

‡ See footnote 2 on page 4

response in grain yield is unlikely and the protein content will be high, due primarily to shriveling of the grain, which results in a low bushel weight. This effect has been described by Neidig and Snyder (7). ‡

Corn experiments

Production of row crops in the dryland areas of Colorado is confined primarily to sandier soils. This is especially true of corn. Corn production is well suited to some of the sandy regions of the northeastern part of the state. All experiments with corn as the test crop have been on these sandy soils.

Responses to nitrogen fertilizer were obtained on four of the eight corn experiments harvested, with an average increase of 6.8 bushels per acre. The protein content of grain was increased at four locations for an average increase of 1.5 percent.

Phosphate fertilizers applied at the side of the seed had no apparent effect on corn yield. As with wheat, about 30 pounds N/acre is the optimum rate to apply to corn grown on sandy lands. Nitrogen can be applied at seeding or sidedressed prior to the first cultivation.

There appears to be an interaction between variety and fertilizer nitrogen that affects the response by dryland corn. Yields were increased at three of the four locations where hybrid corn was grown, while the yield was increased at only one location with open-pollinated corn. At the location where yield of hybrid corn was not increased by fertilizer nitrogen, the organic matter content of 2 percent was exceptionally high and probably accounts for the failure to obtain responses to nitrogen treatments. The open-pollinated varieties used in this area vary greatly in the size and number of ears, which results in a less uniform population with which to measure differences due to fertilizer applications.

Sorghum experiments

Reduced wheat allotments have resulted in large acreages being left available for other crops, and for the most part this land has been used for grain and forage sorghum production. These soils are satisfactory for sorghum production under favorable climatic conditions. Climatic conditions during the planting and growing season may vary greatly from year to year or even within a given year. These variations tend to reduce the stability needed to make sorghum a completely satisfactory crop. In the northern half of eastern Colorado, the shorter growing season may prevent the crop from reaching maturity. To avoid the short season, sorghum is often planted too early, while the soil is cold. Early planting usually results in poor or spotted stands. These stand variations have probably resulted in yield differences that have been predominant over the

‡ See footnote 2 on page 4

effects of fertilizers. There is some evidence that surface planting may reduce stand variability, especially on the heavier soils.[3] With surface planting, the seed is placed in warm soil and germination is improved over planting in which the seed is placed in cool soil at the bottom of a lister furrow. The development of better adapted hybrids should improve sorghum production in this area.

Ten grain sorghum experiments on light-textured soils were harvested. Of these, responses to nitrogen were obtained at three locations. Responses to nitrogen were reported from southwestern Kansas where sorghum was grown on similar soils. (4).[‡]

Where responses in grain yield were obtained, precipitation was good during the growing season. At other locations, where the soil moisture was good at planting time with very little precipitation during the summer months, yields were low. This supports the correlation by Locke and Mathews (5)[‡] which shows a close relationship between July-August precipitation and the yield of milo.

Fertilizer applied to grain sorghum under favorable moisture conditions may result in increased yields, but more data are needed before general recommendations can be made for the use of fertilizers with this crop. It appears that with other conditions being favorable, 30 pounds of nitrogen per acre is beneficial with sorghum grown on sandy soils.

In considering the use of fertilizer on a crop of low cash value such as grain sorghum, the yield increase necessary to be economical must be considered. Roughly, 9 bushels per acre increase is required before any cash return is realized.

Nitrogen applied on forage sorghums grown on sandy loam or loamy sand soils gave responses on two of the three experiments harvested. Again, the data are limited, but it appears that when the available moisture is favorable, nitrogen fertilization may be profitable.

‡ See footnote 2 on page 4
3 Unpublished data, Central Great Plains Field Station, Akron, Colo.

Summary

Wheat yields were increased by applications of nitrogen fertilizers at 62 percent of the locations harvested on sandy soil. The average increase was 5.4 bushels per acre.

Nitrogen applications increased corn yields at 50 percent of the locations harvested on sandy land for an average increase of 6.8 bushels per acre. Protein content of grain was increased by an average of 1.5 percent.

Increases in grain sorghum yields due to nitrogen applications were obtained at only 30 percent of the locations harvested.

The following conclusions resulted from this study.

1. Responses to nitrogen by all dryland crops were confined primarily to sandy soils.
2. The most economical rate of application is about 30 pounds of nitrogen per acre for all crops.
3. With wheat there is no difference between carriers of nitrogen except for spring application. Ammonium nitrate is slightly superior for application during this period.
4. Increased yields due to fall or spring applications of nitrogen on wheat are about equal when the spring application is made prior to April 10.
5. Phosphorus and potassium applications broadcast and disked in prior to planting were not beneficial to dryland crops.
6. Protein content of grain can be increased by nitrogen application, but in dry years adding nitrogen may result in high protein, low weight wheat.
7. Nitrogen can be applied by broadcasting prior to seeding, side or top dressing after emergence, or at seeding. Nitrogen applied at seeding should not be placed in contact with the seed.

Appendix

Table A1.—Fertilizer experiment locations[1]

Field no.	Cooperator	Location	Previous crop	County agent	Soil type	Variety	Date fertilized
				Wheat			
D- 1-52	H. Klusman	Flagler	Wheat	D. Chadwick	Clay loam	Wichita	April 25
D- 2-52	Geisen Bros.	Agate	Fallow	W. Mason	Loam	Wichita	May 2
D- 3-52	G. Brown	Springfield	Fallow	C. Fithian	Silty clay loam	Wichita	May 3
D- 4-52	G. Walker	Loveland	Fallow	D. McMillen	Clay loam	Tenmarq	May 7
D- 5-52	W. Atkins	Haxtun	Corn	C. Block	Loamy sand	Turkey Red	May 9
D- 6-52	W. Wilcoxen	Idalia	Wheat	D. Colson	Sandy loam	Wichita	May 10
D- 7-52	J. Abbott	Windsor	Fallow	G. James	Sandy loam	Cheyenne	May 14
D-21-53	R. Buol	Burlington	Fallow	D. Chadwick	Loam	Comanche	Sept. 5 - Mar. 19
D-23-53	O. Marks	Sterling	Fallow	V. Carter	Loam	Tenmarq	Sept. 9 - Mar. 17
D-24-53	L. Skold	Paoli	Fallow	C. McMillen	Loamy sand	Wichita	Sept. 10 - Mar. 18
D-25-53	Timm Bros.	Amherst	Fallow	T. Hadden	Loam	Comanche	Sept. 11
D-30-53	H. Bonnell	Windsor	Fallow	G. James	Sandy loam	Wichita	April 21
D-31-53	R. Huette	Kersey	Fallow	G. James	Loamy sand	Unknown	Sept. 3
D-32-53	L. Kinnie	Julesburg	Wheat	C. McMillen	Clay loam	Unknown	May 4
D-24-54	L. Skold	Fairfield	Wheat	T. Hadden	Loamy sand	Cheyenne	Sept. 23
D-41-54	N. Frentress	Hayden	Wheat	M. Taylor	Loam	Saunders	Sept. 15
D-42-54	Timm Bros.	Amherst	Wheat	C. Hoffman T. Hadden	Loam	Comanche	Sept. 9
D-43-54	C. Lehl	Greeley	Fallow	G. James	Loamy sand	Kanred	Fall & spring
D-44-54	L. Acott	Gleming	Fallow	V. Carter	Sandy loam	Comanche	Sept. 1
D-46-54	J. Gurst	Joes	Fallow	W. Chandler	Sandy loam	Red Chief	Sept. 25 - Mar. 30
D-47-54	R. Westoff	Fort Morgan	Fallow	G. Hamilton	Sandy loam	Wichita	Mar. 23
D-48-54	L. Skold	Fairfield	Wheat	C. Hoffman	Sand	Comanche	May 6
D-41-55	N. Frentress	Hayden	Wheat & Fallow	M. Taylor	Loam	Saunders	Sept. 15
D-42-55	Timm Bros.	Amherst	Wheat & Fallow	C. Hoffman T. Hadden	Loam	Comanche	Aug. 24
D-64-55	G. Wyman	Milliken	Stubble Mulch	G. James C. Nelson	Loam	Kanred	April 2
D-65-55	F. Skipton	Elizabeth	Stubble Mulch	W. Mason	Sand clay loam	Wichita	April 5
D-41-56	N. Frentress	Hayden	Continuous Wheat Wheat after Fallow	M. Taylor	Loam	Saunders	May 3, 1956
D-42-56	Timm Bros.	Amherst	Continuous Wheat Wheat after Fallow	T. Hadden C. Hoffman	Loam	Comanche	Sept. 10, 1955

[1]Experiments listed are those for which harvest data are available.

Table A1.—(Continued)

Field no.	Cooperator	Location	Previous crop	County agent	Soil type	Variety	Date fertilized
				Corn			
D- 8-52	L. Brownell	Fleming	Wheat	S. Hoar	Loamy sand	Unknown	May 24
D-10-52	C. Bucklen	Karval	Corn	R. Hamill	Loamy sand	Colo. 152	May 26
D-34-53	M. Collins	Eckley	Corn	W. Chandler	Loamy sand	DeKalb	June 3
D-35-53	J. Rhoades	Fairfield	Corn	T. Hadden	Loamy sand	Corn Husker	June 4
D-36-53	E. Orcutt	Simla	Corn	W. Mason	Sandy loam	Open-pollinated	June 11
D-54-54	H. Colglazier	Holyoke	Corn	T. Hadden	Sandy loam	Open-pollinated	June 4
D-69-55	R. Edwards	Haxtun	Wheat	T. Hadden	Sandy loam	Steckley Hybrid	June 7
D-80-56	L. Acott	Fleming	Sorghum	V. Carter	Sandy loam	Open-pollinated	June 28
				Sorghum			
D-37-53	L. Blooding	Eads	Sorghum	B. Whitmore	Loamy sand	Martin	June 22
D-39-53	B. Neill	Springfield	Sorghum	C. Fithian	Sandy loam	Ellis Sorgo	June 23
D-53-54	E. Gasser	Akron	Wheat	C. Evans	Sandy loam	Fremont	June 9
D-66-55	H. Kravig	Karval	Sorghum	R. Hamill	Sandy clay loam	Coes	June 17
D-67A-55	A. Brandt	Ovid	Fallow	C. Hoffman	Loam	Norghum	July 8
D-67B-55	A. Brandt	Ovid	Wheat	C. Hoffman	Loam	Norghum	July 8
D-71-55	L. Wallace	Springfield	Sorghum	C. Fithian	Sandy loam	Five different varieties	June 8
D-77-56-57	H. Kravig	Karval	Sorghum	R. Hamill	Sandy loam	Reliance	June 16
D-78-56	S. Salyards	Dailey	Corn	V. Carter	Sandy loam	Reliance	June 28
D-79-56	L. Hart	Munn	Barley	S. Boyes	Sandy loam	Reliance	June 28
D-84-57	E. Collette	Kirk	Sorghum	J. Spiers D. Chadwick	Sandy loam	Reliance	June 17

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