Colorado Agricultural and Mechanical College

Outstate Fertilizer Testing Program

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COMMERCIAL FERTILIZER EXPERIMENTS

With

Non-Irrigated Wheat, Corn and Sorghum in Eastern Colorado

In

1954

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OUTSTATE FERTILIZER TESTING PROGRAM

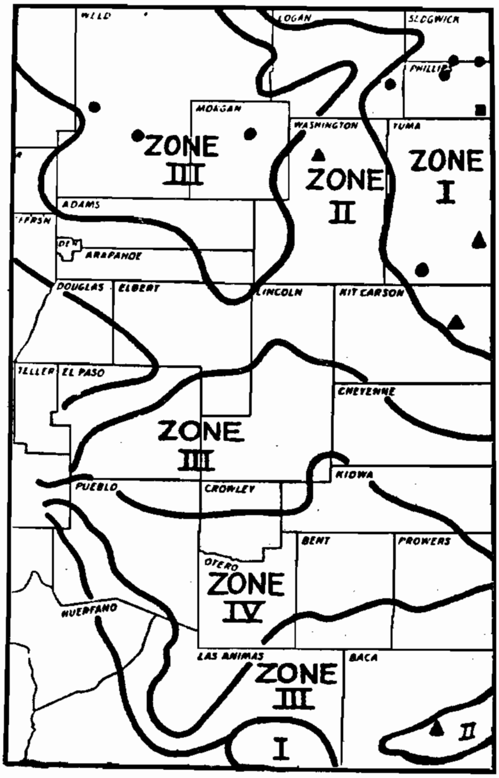
In the spring of 1952, a program was initiated for soil fertility research on non-irrigated croplands in Colorado. This program was made possible by a Grant-in-Aid from the Phillips Chemical Company which was supplemented by state and federal funds.

The long-range objective of the experimentation is to determine the effect of nitrogen fertilizers alone and in combination with phosphorus and potassium on the yield and quality of winter wheat, corn and sorghum on non-irrigated land in relation to variations in soil and climate.

This circular is a progress report of commercial fertilizer experiments on wheat, corn, and sorghum conducted by the Agronomy Section (Soils) of the Colorado Agricultural Experiment Station during the 1954 season.

Acknowledgement is made to the Colorado Extension Agents and Specialists, Experiment Station personnel, farmer cooperators, and fertilizer industry for assistance in conducting these tests.

EASTERN COLORADO



Zone	Annual Effective Rainfall*	Crop
I	17-19 inches	● Wheat
II	15-17 "	■ Corn
III	13-15 "	▲ Sorghum
IV	<13 "	

*Based on records of precipitation, temperature, evaporation, mature soil characteristics, altitude and crop yields.

Fig. 1. Climatic Zones and Location of 1954 Experiments

Map reproduced from "Land Types in Eastern Colorado" by L. A. Brown, D. S. Romine, R. T. Burdick, and A. Kezer. Colo. Agr. Exp. Sta. Bul. 486, June 1, 1944.

COMMERCIAL FERTILIZER EXPERIMENTS IN NON-IRRIGATED CROPS IN COLORADO IN 1954

Fourteen commercial fertilizer experiments were conducted in Colorado during the 1954 season on non-irrigated land. These experiments included nine tests on wheat, four on sorghum, and one on corn. Various land types representative of these crops were selected for study and all experiments were conducted on private farms. Two of the wheat and three of the sorghum experiments were abandoned as the result of poor germination and drought which caused crop failure.

The majority of the tests were conducted in the northeastern section of the state (see Fig. 1) because of unusually adverse soil moisture conditions in other areas. One wheat test was located in Routt County and one sorghum experiment was located in Baca County.

The specific objectives of the experiments varied with the type of crop and location, but two or more of the following objectives were applicable to each study.

1. To determine if lack of available nitrogen ~~is a~~ limiting ~~factor in~~ crop production ~~under non-irrigated conditions~~.
2. To determine the most effective rate and time of application of nitrogen, ~~on non-irrigated crops under~~ the soil and climatic conditions of Colorado.
3. To evaluate the effectiveness of different commercial carriers of nitrogen on non-irrigated crops.

4. To determine the soil nutrient and soil moisture factors likely to result in yield increases when treated with nitrogen fertilizer under non-irrigated conditions.

Two long-term wheat experiments were initiated in September, 1953, at Hayden and Amherst, Colorado (see Table 1). A statement of the objectives and the plot design of these experiments are presented later.

Climatic Conditions

The autumn of 1953 was generally warm and dry until early November. In northeastern Colorado, moderate snows were received only in portions of Logan, Sedgwick, Phillips, and Washington counties. Most of the rest of eastern Colorado experienced an open,dry winter. One moderately heavy snow was recorded in the east central and southeastern counties. The beneficial effect of the storm was diminished by warm weather in January, 1954, and by successive wind storms during the period of February to June. The absence of moisture and higher than average temperatures and wind velocity during April, May, and June resulted in a considerable seasonal moisture deficiency throughout eastern Colorado. The precipitation received at Hayden was below normal for the 1954 crop season.

Farm rain gages were installed at most of the experimental locations and the precipitation was recorded from near planting time to harvest. The rainfall data for the individual locations are given in Table 2. These recordings are subject to some error, particularly in measuring moisture from snow fall.

TABLE 1. Fertilizer Experiment Locations, 1954

Field No.	Cooperator	Location	Management	County Agent	Land Type	Crop Variety	Date Fertilized
D-24-54	L. Skold	Fairfield	Wheat after Wheat	T. Haddan	Sandy	Cheyenne	Sept. 23
D-41-54*	N. Frentress	Hayden	Wheat after Wheat	M. Taylor	Hard-land	Saunders	Sept. 15
D-42-54	Timm Bros.	Amherst	Wheat after Wheat	C. Hoffman & T. Haddan	Semi-hardland	Comanche	Sept. 9
D-43-54	C. Lehl	Greeley	Wheat after Fallow	G. James	Sandy	Kanred	Fall & Spring
D-44-54	L. Acott	Fleming	Wheat after Fallow	V. Carter	Semi-hardland	Comanche	Sept. 1
D-45-54*	R. Huette	Kersey	Wheat after Fallow	G. James	Sandy	Wichita	Sept. 3
D-46-54	J. Gurst	Joes	Wheat after Fallow	W. Chandler	Sandy	Red Chief	Sept. 25 & Mar. 30
D-47-54	R. Westoff	Fort Morgan	Wheat after Fallow	G. Hamilton	Mod. Sandy	Wichita	Mar. 23
D-48-54	L. Skold	Fairfield	Wheat after Wheat	C. Hoffman	Sandy	Comanche	May 6
D-50-54*	B. Neill	Springfield	Sorghum after Sorghum	C. Fithian	Mod. Sandy	Several Varieties	May 21
D-51-54*	Baxter & Konkel	Armel	Sorghum after Wheat	W. Chandler	Hard-land	Martin	June 11
D-52-54*	O. Farnsworth	Burlington	Sorghum after Sorghum	D. Chadwick	Hard-land	Fremont	June 10
D-53-54	E. Gasser	Akron	Sorghum after Wheat	C. Evans	Semi-hardland	Fremont	June 9
D-54-54	H. Colglazier	Holyoke	Corn after Corn	T. Haddan	Semi-hardland	Open Pollinated	June 4

* Crop lost by poor germination and drought.

Table 2. Precipitation Received on Experimental Locations During the 1953-1954 Seasons

Wheat Experiments		Inches of Rainfall													Normal** Average
Field No.	Location	1953 July	1953 Aug.	1953 Sept.	1953 Oct.	1953 Nov.	1953 Dec.	1954 Jan.	1954 Feb.	1954 Mar.	1954 April	1954 May	1954 June	Total	Same Period
D-24-54	Fairfield	2.5	2.4	0.2	1.4	0.9	0.5	0.1	0.0	0.8	0.4	2.0	0.3	11.5	17.2
D-41-54*	Hayden			0.0	0.6	1.2	0.9	1.0	0.4	2.5	0.7	0.8	1.0	9.1	13.4
D-42-54	Amherst	1.3	3.4	0.1	2.3	1.6	0.6	0.2	0.0	1.2	0.4	2.6	0.4	14.1	17.2
D-43-54	Greeley			0.0	0.1	0.6	0.3	0.2	0.0	0.7	0.2	0.9	1.4	4.4	9.7
D-44-54	Fleming			0.3	1.0	1.9	0.2	0.0	0.0	0.9	0.5	1.3	1.2	7.3	13.0
D-45-54*	Kersey	No Recording													
D-46-54	Joes			0.0	0.5	0.7	0.9	0.3	0.0	1.3	0.1	1.6	0.0	5.4	12.0
D-47-54	Fort Morgan									0.3	0.2	0.7	0.0	1.2	6.5
D-48-54	Fairfield	2.5	2.4	0.2	1.4	0.9	0.5	0.1	0.0	0.8	0.4	2.0	0.3	11.5	17.2

Sorghum and Corn Experiments		1954 June	1954 July	1954 Aug.	1954 Sept.	Total	Normal Average** Same Period
D-50-54*	Springfield	No recording					
D-51-54*	Armel	No recording					
D-52-54*	Burlington	0.4	0.9	0.3	0.2	1.8	9.4
D-53-54	Akron	0.5	3.5	1.9	1.4	7.3	7.8
D-54-54	Holyoke	1.9	1.6	2.4	1.2	6.9	9.3

* Crop lost by poor germination and drought.
** Colorado Agricultural Handbook, 1952 Average of two nearest recording communities.

METHODS AND MATERIALS

GENERAL

Nitrogen was the only fertilizer element studied in 1954. Nitrogen is combined chemically in the various commercial carriers as ammonium salts (NH_4^+), ammonia gas (NH_3), nitrate (NO_3^-), and as an amino group (NH_2^-) in organic compounds. The types of fertilizer materials used and their analysis are listed below:

Ammonium sulfate	21% N
Ammonium Nitrate	33.5% N
Urea	45% N
Anhydrous ammonia	82% N

Ammonium sulfate and ammonium nitrate were broadcasted on established wheat stands and these materials plus urea were banded at one side of germinating corn and sorghum seed near the bottom of the lister furrows. Anhydrous ammonia was applied at a depth of 5-6 inches.

CONTINUOUS WHEAT

A. Skold Farm (D-24-54) (D-48-54) Sedgwick - Phillips County

Experiment D-24-54 was a continuation of an experiment started in 1953.[1] The objective was to determine the residual effect of fertilizer on wheat the second year after application. Plots originally fertilized in 1953 with 25 and 50 pounds of nitrogen alone were split and an additional 25 pounds of nitrogen were applied to half of each plot for the 1954 experiment. The other half of each plot was not fertilized.

1/ B. W. Greb, Robert S. Whitney, and R. H. Tucker, 1954. Commercial fertilizer experiments with non-irrigated wheat in eastern Colorado in 1953. Colo. Agr. Exp. Sta. Gen. Series Paper No. 564.

The treatment symbols and treatments are listed below:

No.	Treatment Symbol	Treatment-Pounds per Acre
1	check	no fertilizer
2	P	30 pounds P_2O_5
3	NP	25 pounds N, 30 pounds P_2O_5
4	NNP	50 pounds N, 30 pounds P_2O_5
5	NNPK	50 pounds N, 30 pounds P_2O_5, 30 pounds K_2O
6	N	25 pounds N
7	NN	50 pounds N
8	N + 25 pounds N 1954	25 pounds N + 25 pounds N 1954
9	NN + 25 pounds N 1954	50 pounds N + 25 pounds N 1954

Ammonium nitrate was used as a source of nitrogen.

Experiment D-48-54 was on sandy-land in which the 1953 hailed-out wheat crop had been stubbled back. Ammonium nitrate fertilizer was applied at the rates of 0, 30, 60, and 90 pounds of nitrogen per acre. The plots (25 feet x 8 feet) were laid out in randomized blocks and the treatments were replicated five times. Five, eight-foot rows were harvested from each plot for yield of grain, straw, protein, and bushel weight determinations.

The results of the Skold Farm experiments are shown in Tables 3 and 4 respectively.

B. Frentress Farm (D-41-54) and Timm Bros. Farm (D-42-54) Long-Term Experiments

The primary objective is to determine if wheat grown continuously with supplemental nitrogen fertilizer can compete economically with the established practice of alternating wheat and fallow (with and without nitrogen) in areas where (1) spring and summer moisture is predominate and (2) where fall and winter moisture predominates. The place of phosphate fertilizer in the two systems of management also will be determined. The first comparison between continuous and fallowed wheat will be obtained in 1955. Preliminary soil analyses and yield of wheat from the continuous cropping test are reported in this paper.

The plots sizes (400 feet to 450 feet long and 20 feet to 24 feet wide) permits use of full-scale farm machinery for all operations of tillage, planting, harvesting, and fertilization. The tillage treatments initiated on stubble were laid out so that an annual comparison of continuous versus fallowed wheat can be obtained after the first year. A total of three replications were included. For the 1954 crop on continuous wheat, nitrogen at the rate of 0, 40, and 80 pounds N was applied at Amherst (D-42-54) and 0, 30, and 60 pounds at the Hayden (D-41-54) location. Winter wheat was planted at Amherst and spring wheat was planted at Hayden.

Poor and sporadic germination of wheat at Hayden resulted in crop failure. The yields at Amherst (D-42-54) are reported in Table 5.

SUMMER FALLOWED WHEAT

A. Source and Rates of Nitrogen Application: Acott Farm (D-44-54), Huette Farm (D-45-54) and Westoff Farm (D-47-54)

Experiments D-44-54 and D-45-54 consisted of fall application of various nitrogen carriers at different rates. One test was conducted on a medium textured soil (Acott Farm) and the other on a light textured soil (Huette Farm). A total of seven treatments were replicated four times in randomized blocks. The individual plots were 50 feet x 6 2/3 feet in size. Poor germination and wind erosion resulted in a crop failure on the Huette location. The treatment symbols and treatments are listed below:

No.	Treatment Symbol	Treatment-Pounds per Acre
1	Check	No fertilizer
2	A. S. 25	Ammonium sulfate 25 pounds N
3	A. S. 50	Ammonium sulfate 50 pounds N
4	A. N. 25	Ammonium nitrate 25 pounds N
5	A. N. 50	Ammonium nitrate 50 pounds N
6	Anhy. 25	Anhydrous ammonia 25 pounds N
7	Anhy. 50	Anhydrous ammonia 50 pounds N

The wheat experiment on the Westoff Farm (D-47-54) was started in March on moderately sandy soil. Seven fertilizer treatments, replicated four times, were applied on plots 25 feet long and 8 feet wide. The treatment symbols and treatments are listed below:

No.	Treatment Symbol	Treatment-Pounds per Acre
1	Check	No fertilizer
2	A. S. 25	Ammonium sulfate 25 pounds N
3	A. S. 50	Ammonium sulfate 50 pounds N
4	A. S. 100	Ammonium sulfate 100 pounds N
5	A. N. 25	Ammonium nitrate 25 pounds N
6	A. N. 50	Ammonium nitrate 50 pounds N
7	A. N. 100	Ammonium nitrate 100 pounds N

Results of experiments D-44-54 and D-47-54 are shown in Tables 6 and 7.

B. Source and Time of Nitrogen Application: Lehl Farm (D-43-54)

This experiment involved the application of 40 pounds of nitrogen per acre in the form of ammonium sulfate and ammonium nitrate at five different dates of application. Fertilizer was applied September 23, April 1, April 20, May 10, and June 1. A total of eleven fertilizer treatments were replicated four times on plots 20 feet long and 6 feet wide. Results of this experiment are shown on Table 8.

C. Rates and Time of Nitrogen Application: Gurst Farm (D-46-54)

Nitrogen in the form of ammonium nitrate at the rate of 0, 20, 40, and 60 pounds per acre was applied in the fall of 1953 and in the early spring of 1954. A total of seven fertilizer plots were replicated four times on plots 30 feet long and 6 feet wide. Results of this experiment are shown on Table 9.

CORN AND SORGHUM

One experiment D-50-54 located in Baca county, involved rates of nitrogen applied at 0 and 33 pounds per acre. Five grain sorghum varieties were included in the test. Fertilizer was applied to plots

4 rows wide and 1400 feet long. A severe drouth eliminated any chance for yield determinations.

Four experiments, three on sorghum and one on corn, (D-51-54, D-52-54, D-53-54, and D-54-54) involving sources and rates of nitrogen fertilizer, were started in June. Experiments D-51-54 and D-52-54 suffered from severe drouth and no yields could be obtained. The individual plots for both corn and sorghum were eighty feet long and four rows wide (40-inch rows). A total of eighty feet of the center two crop rows were selected for harvest of corn, while 50 feet of sorghum row was harvested.

The forage sorghum experiment in Washington county was harvested in the following manner: the stalks were cut from each plot and green weights obtained; six stalks selected at random from each plot were chopped into small pieces and retained in an air-tight container for moisture and protein analysis.

The experimental results on sorghum and corn are given in Tables 10 and 11.

EXPERIMENTAL RESULTS - WHEAT

Skold Farm (D-24-54) (D-48-54) Sedgwick - Phillips Counties. Continuous Wheat, Loamy Sand Soil.

Experiment D-24-54 was conducted on continuous wheat on loamy sand soil which had responded favorably to fertilization in an experiment conducted in 1953. The seed bed was relatively dry at planting time, and the soil was moist to a depth of 24 inches. Some of the wheat germinated in mid-September, the rest a month later. At no time between planting and harvest was the soil moist below 30 inches. Since there was no significance in the yields produced by the fall and spring application of nitrogen in 1953 the yields of grains, straw, and protein in the grain from similar treatments were averaged together and the means analyzed for statistical significance. An example is shown below:

1953 Application $\dfrac{N_{fall} + N_{spring}}{2}$ or $\dfrac{NN_{fall}P + NN_{spring}P}{2}$

Table 3. Yield of Wheat, Skold Farm (D-24-54) Sedgwick-Phillips Counties, Continuous Wheat, Loamy Sand Soil

Treatment Symbol	Bushels per Acre	Tons Straw per Acre	Bushel Wt.	Percent Protein
Check	6.8	0.53	58.8	13.0
P	8.5**	0.56	58.8	13.4
NP	7.3	0.62**	57.8	13.9
NNP	6.3	0.62**	56.0**	15.1**
NNPK	6.5	0.63**	56.3**	14.2
N	5.8	0.52	57.8	15.0**
NN	6.6	0.63**	56.3**	14.9**
N + 25 pounds N 1954	5.7	0.63**	55.8**	17.4**
NN + 25 pounds N 1954	4.9**	0.66**	55.0**	17.3**
5% L.S.D.	1.2	0.09	1.5	1.3

P = 30 pounds P_2O_5 }
K = 30 pounds K_2O } Fertilizer applied in 1953
N = 25 pounds N }
NN = 50 pounds N

Protein analysis based on 14% moisture in grain
* - Significant at 5% level
** - Significant at 1% level

The wheat suffered for lack of available moisture during the month of June. As a consequence considerable shrinkage of grain occurred and earlier indications of response to nitrogen were largely cancelled out.

The only significant increase in yield over the no-treatment plots was obtained from the 1953 phosphate treatment. A significant depression in yield resulted from the higher rate of residual nitrogen when 25 pounds of additional nitrogen were added in 1954. There was no significant increase or decrease in yield from the other fertilizer treatments.

A small but significant increase in straw was produced by the higher rates of residual nitrogen alone or in combination with phosphorus and by the additional nitrogen applied in 1954.

A significant depression in bushel weight of grain was produced by the higher rate of residual nitrogen and by the additional nitrogen applied in 1954.

Significant increases in protein were obtained largely by the higher rates of residual nitrogen and particularly by the additional nitrogen applied.

The ammonium nitrate for experiment D-48-54 was applied May 6 on nitrogen deficient wheat growing on sandy soil. The land had been stubbled-back to wheat after the 1953 crop hailed out. Examination of the soil profile revealed a fairly adequate supply of available moisture (60 inches) June 1st. Thereafter, no effective precipitation was received.

Table 4. Yield of Wheat, Arnold Farm (D-48-54) Sedgwick-Phillips Counties, Continuous Wheat, Sandy Soil

Treatment	Bushels Per Acre	Tons Straw Per Acre	Bushel Wt.	Percent Protein
Check	9.8	0.62	62.6	12.1
30 pounds N/acre	11.5	0.72*	62.6	15.1**
60 pounds N/acre	13.3**	0.77**	61.8	16.5**
90 pounds N/acre	12.8**	0.76**	61.2**	17.9**
5% L. S. D.	2.3	0.09	1.1	0.8

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

Protein analysis based on 14% moisture in grain

Owing to the late date of fertilization, it was not expected that a maximum effect on yield would occur since the tillering stage was already past. The higher rates of application did produce new tillers but they did not ripen in time for harvest.

A significant increase in yield was obtained from 60 and 90 pounds of nitrogen per acre. However, the application of 90 pounds of nitrogen produced slightly less wheat than did the 60-pound application. A small but significant increase in straw was produced by nitrogen at all rates of application.

A highly significant increase in protein was produced by all rates of nitrogen applied. Higher protein wheat was obtained by progressively increasing application of ammonium nitrate.

Only the 90 pound rate of N suppressed the bushel weight of grain significantly below the no-treatment plots.

Timm Bros. Farm (D-42-54), Sedgwick-Phillips Counties, Continuous Wheat, Medium Textured Soil.

This long-term experiment was initiated on heavy stubble in August, 1953. Six blocks of plots were sown back to wheat and three blocks were prepared for the 1954 summer fallow period. The amount of straw remaining from the 1953 harvest was estimated to be 7000 pounds per acre which made the drilling of wheat in September a difficult operation. The seed bed was dry and germination was not obtained until late October. The soil was moist to a depth of 16 inches and the moisture never exceeded that depth from planting until harvest. Extreme nitrogen deficiency was in evidence on the non-fertilized plots as early as February. Spot checks on soil nitrate nitrogen were made periodically during the spring on fertilized and unfertilized plots. The results below are the means of four analyses made for each treatment of each sampling date.

Initial Fall Treatment	Mar. 29 ppm NO_3-N	May 6 ppm NO_3-N	June 3 ppm NO_3-N
No Fertilizer	2	2	2
40 pounds N/acre	11	4	2
80 pounds N/acre	19	14	4

An acute shortage of available moisture and high temperature seriously reduced the potential yield of grain and caused grain shrinkage during the month of June.

Table 5. Yield of Wheat, Timm Bros. Farm (D-42-54) Sedgwick-Phillips Counties, Continuously Cropped, Medium Textured Soil

Treatment	Bushels per Acre	Bushel Wt.	Percent Protein
Check	2.2	57.7	13.9
40 pounds N/acre	4.6**	57.3	14.6**
80 pounds N/acre	3.7**	55.0**	17.2**
5% L. S. D.	0.7	1.1	0.5

Ammonium nitrate application
*   Significant at 5% level
**   Significant at 1% level

Protein analysis based on 14% moisture in grain

While no exact measurement of straw yield was obtained, the yield of straw was estimated to be 0.3 ton per acre on the non-fertilized plots and about 0.8 ton on the fertilized.

Despite an acute moisture deficiency, the fertilized plots produced a significantly higher yield of grain although not enough for an economic return. The application of 80 pounds of nitrogen reduced the yield of grain and bushel weight of grain significantly below the 40-pound rate of application.

The addition of nitrogen produced a significant increase in the protein percentage of the grain.

Acott Farm (D-44-54), Logan County, Summer Fallowed Wheat, Medium Textured Soil.

This experiment was placed on heavier and more fertile soil than was indicated by the surrounding sandy lands in the area. Stored soil moisture at the time of fertilization in September was excellent and extended to a depth of more than five feet in the profile. The precipitation received from planting until harvest was below normal.

A good yield of wheat was obtained from all plots (Table 6) and no significant increase or decrease in yield was produced by any of the nitrogen treatments, even though a slight nitrogen deficiency in the spring was indicated by light green leaves.

Table 6. Yield of Wheat, Acott Farm (D-44-54) Logan County, Summer Fallowed, Medium Textured Soil

Treatment	Bushels per Acre	Tons straw per Acre	Bushel Wt.	Percent Protein
Check	26.3	1.96	59.8	13.0
Ammonium sulfate 25 pounds N	24.9	2.28**	59.0	15.0**
Ammonium sulfate 50 pounds N	27.7	2.25*	58.5**	14.7**
Ammonium nitrate 25 pounds N	27.9	2.35**	59.3	14.4
Ammonium nitrate 50 pounds N	25.9	2.35**	57.5**	15.6**
Anhydrous ammonia 25 pounds N	27.1	2.22*	59.5	14.1
Anhydrous ammonia 50 pounds N	25.2	2.51**	56.8**	16.1**
5% L. S. D.	N.S.	0.25	0.9	1.2

Pounds/acre - fertilization
N. S. - Not significant
* - Significant at 5% level
** - Significant at 1% level

Protein analysis based on 14% moisture in the grain

All fertilizer treatments produced a significant increase in straw when compared with the no fertilizer plots.

The bushel weight of grain was significantly reduced by the application of 50 pounds of nitrogen per acre, but not by the 25-pound rate.

The application of nitrogen produced a significant increase in the protein content of grain. A significantly higher average protein content of grain was obtained from the higher rate of ammonium nitrate and anhydrous ammonia than from the lower rate of the same materials.

Westoff Farm (D-47-54), Morgan County, Summer Fallowed Wheat, Moderately Sandy Soil.

Available soil moisture at the time of fertilization (Mar. 23) was relatively low except in the 36 to 60-inch depth of the profile. The precipitation received between fertilization and harvest was well below normal. The effectiveness of fertilization was relatively low primarily because of insufficient precipitation.

Table 7. Yield of Wheat, Westoff Farm (D-47-54)
Morgan County, Summer Fallowed,
Moderately Sandy Soil.

Treatment	Bushels per Acre	Tons Straw per Acre	Bushel Wt.	Percent Protein
Check	10.9	0.62	62.5	13.6
Ammonium sulfate 25 pounds N	12.2	0.69	61.8	13.8
Ammonium sulfate 50 pounds N	11.5	0.70	62.5	14.6
Ammonium nitrate 100 pounds N	12.9	0.74	61.5	14.7
Ammonium nitrate 25 pounds N	13.3	0.72	62.3	14.1
Ammonium nitrate 50 pounds N	13.0	0.71	61.3	15.4**
Ammonium nitrate 100 pounds N	13.7	0.83	61.5	16.0**
5% L. S. D.	N.S.	N.S.	N.S.	1.3

pounds/acre fertilization
N.S. - Not significant
* - Significant at 5% level
** - Significant at 1% level

Protein analysis based on 14% moisture in the grain

No significant increase of grain or straw was obtained by nitrogen application although a fairly good trend was evident in those plots receiving ammonium nitrate.

A significant increase in protein of the grain was produced with the 50 and 100 pounds per acre application of nitrogen in the form of ammonium nitrate.

Lehl Farm (D-43-54), Weld County, Summer Fallowed Wheat, Loamy Sand Soil.

Available soil moisture, either stored initially at the time of planting or received as precipitation between planting and harvest was critically low at all times. Despite the very low yields obtained on the experimental plots, some important observations were made.

Table 8. Yield of Wheat, Lehl Farm (D-43-54), Summer Fallowed, Loamy Sand Soil

Treatment	Bushels per Acre	Tons Straw per Acre	Percent Protein
Check	2.9	0.23	13.0
Ammonium nitrate - Sept. 15	4.3**	0.39**	16.6**
Ammonium nitrate - April 1	4.0*	0.32*	17.7**
Ammonium nitrate - April 20	4.4**	0.35**	17.1**
Ammonium nitrate - May 10	3.0	0.24	18.1**
Ammonium nitrate - June 1	2.8	0.24	13.6
Ammonium sulfate - Sept. 15	4.0*	0.32**	15.3**
Ammonium sulfate - April 1	3.2	0.25	14.9**
Ammonium sulfate - April 20	3.1	0.27	13.9
Ammonium sulfate - May 10	2.8	0.24	13.1
Ammonium sulfate - June 1	2.6	0.23	13.6
5% L. S. D.	1.0	0.07	1.1

All applications at the rate of 40 pounds N/acre

* - Significant at 5% level

** - Significant at 1% level

Protein analysis based on 14% moisture in the grain

The fall application of ammonium sulfate and the fall and first two spring applications of ammonium nitrate produced small but significant increases in yield of grain and straw.

The yields of grain and straw, and the protein content of grain were significantly higher on the average for all rates of ammonium nitrate application than the average of the ammonium sulfate treatments.

Less grain and straw were produced when the nitrogen was applied after April 30th. No significant difference in yield between the fall and early spring (April 1) application occurred.

Ammonium nitrate was more effective in increasing the protein content of grain on later dates of spring application than was ammonium sulfate. In fact ammonium nitrate tended to give higher per cent protein up to May 10 application.

Gurst Farm (D-46-54), Yuma County, Summer Fallowed Wheat, Sandy Loam Soil.

The initial quantity of available soil moisture at the time of fertilization (September 25) was moderately good, the soil being moist at depths in excess of 5 feet. However, only very limited amounts of precipitation were received from October until harvest in July. Available soil moisture was almost exhausted in the first 60 inches of soil in the profile by June 11.

Table 9. Yield of Wheat, Gurst Farm (D-46-54), Yuma County, Summer Fallowed Sandy Loam Soil

Treatment	Bushels per Acre	Tons Straw per Acre	Bushel Wt.	Percent Protein
Check	13.1	1.40	58.8	12.4
20 pounds N Sept. 25	12.7	1.50	56.0**	14.0**
40 pounds N Sept. 25	13.5	1.59	55.5**	16.0**
60 pounds N Sept. 25	12.8	1.53	54.8**	17.3**
20 pounds N March 30	14.0	1.53	57.8	14.4**
40 pounds N March 30	13.9	1.39	57.0	15.4**
60 pounds N March 30	13.9	1.47	58.3	16.3**
5% L. S. D.	N.S.	N.S.	2.1	1.2

Ammonium nitrate used
N. S. - Not significant
* - Significant at 5% level
** - Significant at 1% level

Protein analysis based on 14% moisture in the grain

There was no significant increase or decrease in yield of grain or straw due to nitrogen fertilization.

The fall application of nitrogen caused a significant depression in bushel weight of grain.

All fertilized plots produced a significant increase in the protein content of grain, and this increase progressed significantly with higher rates of nitrogen application.

DISCUSSION AND SUMMARY -- WHEAT EXPERIMENTS

An acute shortage of available stored and precipitation moisture, affected yields and fertilizer responses at all but two of the seven wheat experiments harvested. Application of nitrogen produced a significant increase in yield of grain at three locations and a significant increase in yield of straw at five of the locations. However, the yield responses for both grain and straw to nitrogen were below those recorded in 1952 and 1953.

Protein responses to nitrogen fertilization were obtained in all seven experiments. The higher application of nitrogen produced a higher protein wheat. Similar results were obtained in the 1953 trials.

During the 1953 and 1954 seasons, nitrogen has tended to reduce the bushel weight of grain. This effect was more pronounced at the higher rate of application. The overall reduction varies from 1 - 4 pounds per bushel.

The various commercial carriers of nitrogen tested have proved to be about equally effective in increasing the yield of wheat when top dressed with the exception of ammonium sulfate applied in the spring. Experiments conducted in 1953 and 1954 have indicated that top-dressed ammonium sulfate may be inferior to the other carriers for spring applications. This appears to be a natural result of the time lag required for the conversion of ammonia to nitrates by nitrifying organisms during the cooler temperatures of the spring months, and for the leaching of nitrate into the root zone. Because the ammonium ion is held by clay and humus colloids near the surface of the soil, much of the nitrogen is not available to the growing wheat until nitrates are formed and washed down to the root zone by additional rainfall. Further experimentation on the fall application of ammonium sulfate will be necessary to determine its effectiveness when compared with other nitrogen carriers.

Evidence and observations on the best time of application of most nitrogen fertilizer on wheat indicates that either early spring or fall applications can be made. Applications made after May 1 produce additional tillers which generally do not ripen in time for harvest, and the maximum yield is not obtained. An earlier application also allows a greater period of time for precipitation to move the nitrogen down into the root zone.

There is no evidence that non-irrigated crops in Colorado receive sufficient moisture to leach fertilizer nitrogen beyond the root zone of the crops grown. Roots of wheat have been observed to extend 66 inches deep as early as March 20, on sandy loam soils. Observations made to date indicate that available soil moisture as deep as five feet is exhausted by harvest time unless very favorable precipitation is received.

The value of having a reasonable supply of stored sub-soil moisture at planting time cannot be over-emphasized. It has been observed on non-irrigated wheat that normal or near normal precipitation between planting and harvesting will not consistently produce good yields unless reserve sub-soil moisture is available. A minimum of 36 inches of moist soil on hard-lands and 48 inches of moist soil on lighter textured soil is considered a fairly adequate quantity. An example of the effects of sub-soil moisture can be shown in yields of grain in experiments conducted at the Acott (D-44-54) and the Gurst farms (D-46-54) when compared with yields on the Timm Bros. farm (D-42-54). At all three of these locations, the amount of rainfall received from September to July was below normal. The amount received at Timm Bros., however, was still 2 inches more than at the Acott experiment and 4 inches more than at the Gurst experiment. The final check plot yields were 2.2, 26.3, and 13.1 bushels per acre on the Timm Bros., Acott, and Gurst experiments respectively. Stored sub-soil moisture carried the wheat to moderately good yields at the latter two locations despite limited supplemental rainfall. Other outstanding examples of this are evident in the 1953 experiments.

Experiments conducted in 1953 and 1954 indicate that addition of dry forms of commercial nitrogen will not "burn" the wheat or reduce the yield below non-fertilized wheat where nitrogen is deficient regardless of moisture conditions even at higher rates than usually recommended

(30 to 40 pounds of N per acre).

Theoretical and practical considerations are involved in both fall and early spring application of fertilizer which may apply to specific situations. Early spring application has a decided advantage in that a later appraisal of stored sub-soil moisture and of the stand of wheat is possible. A favorable amount of stored soil moisture in March would markedly reduce the economic hazards of fertilization. It is also true that some seedings may be lost due to poor fall germination or to wind erosion during fall and winter months when the average precipitation is low and wind velocities are high.

Fall applications have some advantages over spring applications. Fertilizers are generally more obtainable in the fall, and working schedules for some farmers may be more favorable in the fall than in the spring. Some consideration must be given to the possibility that fall application may produce better rooting, tillering, and coverage of the soil by wheat plants, thus reducing wind erosion hazards.

EXPERIMENTAL RESULTS - SORGHUM AND CORN

Gasser Farm (D-53-54), Washington County. Forage Sorghum on Medium Textured Soil.

This experiment was located on the rolling sandy land area northwest of Akron on level land at the base of a 3 - 5% slope. This particular site had received depositions of soil from the surrounding terrain as revealed by auger samples and laboratory analysis. The texture of the surface soil was fine sandy loam, while the lower depths ranged from loam to silt loam (see table 12).

The organic matter content of the soil in the small area of the experiment was abnormally high in the 36-48 inch and 48-60 inch depth of the profile. This indicates burial of older top soil.

The soil was moist to a depth in excess of 5 feet at the time of fertilization. Normal precipitation was received between planting and harvest.

Table 10. Yield of Forage Sorghum, Gasser Farm (D-53-54) Medium Textured Soil

Treatment		Tons Green Forage per Acre	Tons Oven-Dry Forage Per Acre	Protein in Dry Forage %	Protein Pounds per Acre
Check		4.7	1.57	8.5	269
Ammonium sulfate	25 pounds N	5.9**	1.96**	9.0	350**
Ammonium sulfate	50 pounds N	6.2**	2.08**	9.1	378**
Ammonium nitrate	25 pounds N	5.7**	1.90**	9.8**	358**
Ammonium nitrate	50 pounds N	5.8**	1.91**	9.8**	368**
Urea	25 pounds N	5.9**	1.94**	8.8	341**
Urea	50 pounds N	6.0**	1.99**	8.8	347**
5% L.S.D.		0.8	0.28	0.8	53

* - Significant at 5% level
** - Significant at 1% level

All nitrogen treatments produced significantly more forage than the no-fertilizer plots.

Each of the three commercial sources of nitrogen (ammonium sulfate, ammonium nitrate, and urea) produced similar increases in yield.

There was no apparent advantage in the use of 50 pounds of nitrogen per acre when compared with the yields produced by the 25-pound rate of application.

Increases in percentage of protein in the forage as the result of nitrogen application were small for ammonium sulfate and urea but were significantly increased by ammonium nitrate.

The protein yield per acre from an average of all nitrogen carriers was 364, 350, and 269 pounds of protein per acre from 50 pounds of nitrogen, 25 pounds of nitrogen, and no fertilizer, respectively. All fertilizer treatments produced significantly more total protein per acre than the no fertilizer treatment.

The moisture content of the green forage averaged 64-68% for all treatments.

Colglazier Farm (D-54-54), Phillips County. Corn Grown on Medium Textured Soil.

This experiment was conducted on medium textured soil where the initial soil moisture level was good at the time of fertilization to a depth in excess of 5 feet. The rainfall received between planting and harvest was slightly below normal.

Table 11. Yield of Corn, Colglazier Farm (D-54-54). Phillips County, Medium Textured Soil.

Treatment		Bushels per Acre	Tons Stover per Acre	Percent Protein, Grain
Check		35.8	0.92	10.5
Ammonium sulfate	25 pounds N	33.9	0.79	10.7
Ammonium sulfate	50 pounds N	41.6	1.15	10.9
Ammonium nitrate	25 pounds N	32.0	0.99	10.6
Ammonium nitrate	50 pounds N	31.7	0.91	10.8
Urea	25 pounds N	35.7	1.17	10.6
Urea	50 pounds N	31.1	0.95	10.8
5% L. S. D.		N.S.	N.S.	N.S.

N.S. - Not significant

Grain yield and protein analysis based on 15.5% moisture in grain

There was no significant increase or decrease in the yield of grain or stover by the use of nitrogen fertilizer on corn at this location.

No significant increase in the protein content of grain was produced by nitrogen fertilization.

Examination of the plots in August and early September revealed no indication of nitrogen deficiency.

DISCUSSION AND SUMMARY - CORN AND SORGHUM EXPERIMENTS

Since 1952, a total of six fertilizer experiments on corn have been harvested. Corn yields were significantly increased at three of the six locations. In cases where responses have been recorded, the use of 25 to 30 pounds of nitrogen per acre appears to be the optimum rate of application. Protein increases of 1-2% were recorded in all cases except the experiment reported in this paper.

On experiments where phosphorus or phosphorus plus potassium have been applied with nitrogen on corn, an early season stimulating effect on stalk growth has been observed. This effect generally produces a greater yield of stalks and crop residues, but no additional yield of grain or protein above that produced by nitrogen alone [redacted].

There are some indications that where soil and climatic conditions for nitrification are quite favorable in May and June, the production of nitrates from soil organic matter may be nearly sufficient for the corn population per acre normally planted for non-irrigated conditions.

Fertilizer experiments conducted in 1953 and 1954 have indicated that 25 to 30 pounds of nitrogen per acre are sufficient for sorghums grown on sandy-lands. An increase in protein content of the forage or grain is usually obtained by nitrogen fertilization. Several reports from agricultural agencies and individual farmers have revealed favorable yield responses of grain sorghum to nitrogen fertilization on sandy-lands in various locations of eastern Colorado.

Average performances of three commercial sources of nitrogen (ammonium sulfate, ammonium nitrate, and urea) have produced similar degrees of response in terms of yield, residues, and protein on both corn and sorghum.

The question of whether or not to use nitrogen fertilizers on non-irrigated crops growing on nitrogen deficient soils depends mainly on the supply of moisture. In cases where corn and sorghum are grown continuously, the use of fertilizers may be determined largely by seasonal April, May and early June precipitation. If the soil is moist to a depth of over 40 inches at planting time, a preplant application or a later side dressing of nitrogen may be effective.

SOIL PROPERTIES

The surface soils on which the experimental tests were conducted are approximately neutral, but the sub-soils are more alkaline owing to a higher lime content. The hard-lands are characterized by a higher clay and silt content, moisture equivalent, and lime accumulation which is closer to the surface than in the lighter textured soils. The moisture equivalent shown in Table 12 is a rough measure of the maximum water holding capacity of field soils which have adequate drainage.

Moderately sandy and sandy soils possess a greater infiltration and percolation rate for moisture than the heavier textured soils, but they have a lower moisture holding capacity. Some lighter soils in Eastern Colorado show an accumulation of clay below a depth of 30 inches which acts as a reservoir for holding larger quantities of water. Better utilization of light rainfall occurs in the lighter soils than in hard-lands.

The organic matter content of non-irrigated soils in Eastern Colorado is relatively low. Organic matter accumulates in the surface soil and nitrate nitrogen is largely derived from the nitrogen in it. The lighter textured soils contain 30-50% less organic matter in the surface 12 inches of soil than the hard-lands. Thus, a deficiency of available nitrogen is more likely to occur in sandier land. Nitrogen deficiencies are particularly noticeable on lighter textured soils during the spring months when the wheat foliage often has a yellowish-green cast.

Continuous cropping tends to deplete the supply of available nitrogen. Whenever crop residues are returned to the soil and another crop is planted shortly afterward, competition for available nitrogen between bacteria and the growing crop ~~occurs.~~ In any new decay process, the nitrogen required for increased bacterial activity is high and a shortage of available nitrogen for immediate plant use may occur. The practice of fallowing allows a sufficiently long period for decomposition to take place, and a more favorable supply of nitrogen as well as moisture is available for plant use.

Table 12. Soil Properties and Soil Moisture Levels

Field Number	Depth Inches	Soil Texture	pH	Lime %	Organic Matter %	Total Nitrogen %	Avail. P_2O_5** lbs./acre	Moisture in Soil at Time of Fertilization % H_2O	Moisture Equivalent % H_2O
Skold:	0-12	Loamy sand	7.4	0.1	1.00	.034	60	13.0	10
D-24-54	12-24	Loamy sand	7.5	0.2	.68	.024		10.3	11
	24-36	Loamy sand	7.7	0.3	.34	Trace		5.1	7
	36-48	Loamy sand	7.8	1.1	.25	Trace		4.1	7
	48-60	Loamy sand	7.9	1.6	.16	Trace		4.3	7
Frentress D-41-54*	0-12	Loam	6.9	0.2	1.95	.098	140	15.0	19
Timm	0-12	Loam	7.0	0.1	1.61	.091	90	15.7	20
D-42-54	12-24	Loam	7.3	0.2	1.05	.068		12.6	21
	24-36	Loam	7.8	2.0	.82	0.62		11.4	21
	36-48	Loam	8.1	5.7	.47	Trace		11.7	19
	48-60	Sandy loam	8.1	4.8	.30	Trace		10.1	14
Lehl	0-12	Loamy sand	6.9	0.0	.77	.041	75	10.0	8
D-43-54	12-24	Loamy sand	7.0	0.3	.51	.032		8.6	9
	24-36	Loamy sand	8.0	2.8	.23	Trace		6.7	8
	36-48	Loamy sand	8.1	3.8	.17	Trace		7.0	7
	48-60	Loamy sand	8.2	2.1	.08	Trace		5.2	6
Acott:	0-12	Sandy loam	6.4	0.0	2.12	.116	175	15.5	18
D-44-54	12-24	Sandy loam	7.4	0.8	1.20	.060		16.6	19
	24-36	Loam	7.5	0.9	1.08	.070		17.3	23
	36-48	Loam	8.2	10.8	.38	Trace		19.5	21
	48-60	Loamy sand	8.4	3.2	.18	Trace		11.0	10
Gurst:	0-12	Sandy loam	6.9	0.1	1.18	.067	80	13.5	12
D-46-54	12-24	Sandy loam	7.1	0.2	.85	.057		10.7	15
	24-36	Sandy loam	8.1	5.9	.45	Trace		10.0	13
	36-48	Loamy sand	8.0	3.8	.33	Trace		6.0	9
	48-60	Loam	8.0	10.0	.20	Trace		13.3	19

* No yields obtained.

** Determined by sodium bicarbonate extraction.

Table 12. (Cont'd.) <u>Soil Properties and Soil Moisture Levels</u>

Field Number	Depth Inches	Soil Texture	pH	Lime %	Organic Matter %	Total Nitrogen %	Avail. P_2O_5** lbs./acre	Moisture in Soil at Time of Fertilization % H_2O	Moisture Equivalent % H_2O
Westoff D-47-54	0-12	Sandy loam	6.8	0.0	1.12	.068	80	10.5	11
	12-24	Sandy loam	8.2	4.9	1.56	.058		11.5	18
	24-36	Sandy loam	8.3	3.1	.62	.037		13.1	20
	36-48	Loam	8.2	2.7	.84	.050		15.2	24
	48-60	Silt loam	8.3	4.9	.45	Trace		13.0	27
Skold D-48-54	0-12	Sand	6.7	0.2	.82	.037	15	10.2	6
	12-24	Loamy sand	6.9	0.1	.80	.046		8.1	8
	24-36	Sandy loam	6.9	0.2	.92	.054		15.1	18
	36-48	Loam	7.1	0.1	.43	Trace		14.5	19
	48-60	Sandy loam	8.1	5.8	.31	Trace		13.0	16
Baxter & Konkel D-51-54*	0-12	Loam	7.0	1.0	1.68	.124	80	20.2	22
	12-24	Silt loam	7.9	2.8	.97	.071		18.5	24
	24-36	Silt loam	8.3	6.7	.75	.056		13.5	26
	36-48	Silt loam	8.3	7.1	.42	Trace		11.5	22
	48-60	Silt loam	8.5	7.2	.29	Trace		12.2	19
Farnsworth D-52-54*	0-12	Silt loam	7.9	4.7	1.40	.095	25	16.0	25
	12-24	Silt loam	8.0	10.5	1.07	.088		18.5	26
	24-36	Silt loam	8.3	10.6	.48	Trace		15.8	24
	36-48	Silt loam	8.3	8.1	.35	Trace		14.0	21
	48-60	Silt loam	8.3	8.0	.23	Trace		10.9	20
Gasser D-53-54	0-12	Sandy loam	6.4	0.7	1.90	.104	140	19.7	21
	12-24	Loam	6.5	0.9	1.37	.086		15.6	23
	24-36	Loam	6.9	1.0	.87	.060		17.4	24
	36-48	Loam	7.2	1.6	1.34	.076		13.0	27
	48-60	Silt loam	7.6	2.2	1.67	.082		14.8	31
Colglazier D-54-54	0-12	Sandy loam	6.4	1.0	2.04	.105	165	18.4	20
	12-24	Loam	6.9	1.6	1.20	.054		16.7	21
	24-36	Loam	7.8	13.9	1.37	.074		22.0	30
	36-48	Silt loam	8.1	12.9	.75	.038		24.6	30
	48-60	Silt loam	8.3	12.9	.25	Trace		21.6	28

* No yields obtained.

** Determined by sodium bicarbonate extraction.

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