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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

Outstate Fertilizer Testing Program

EFFECT OF COMMERCIAL FERTILIZERS

on the

Yield and Quality of Dryland Wheat, Corn and Sorghum in Colorado in 1955

K. G. Brengle, Robert S. Whitney, B. W. Greb and R. H. Tucker

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INTRODUCTION

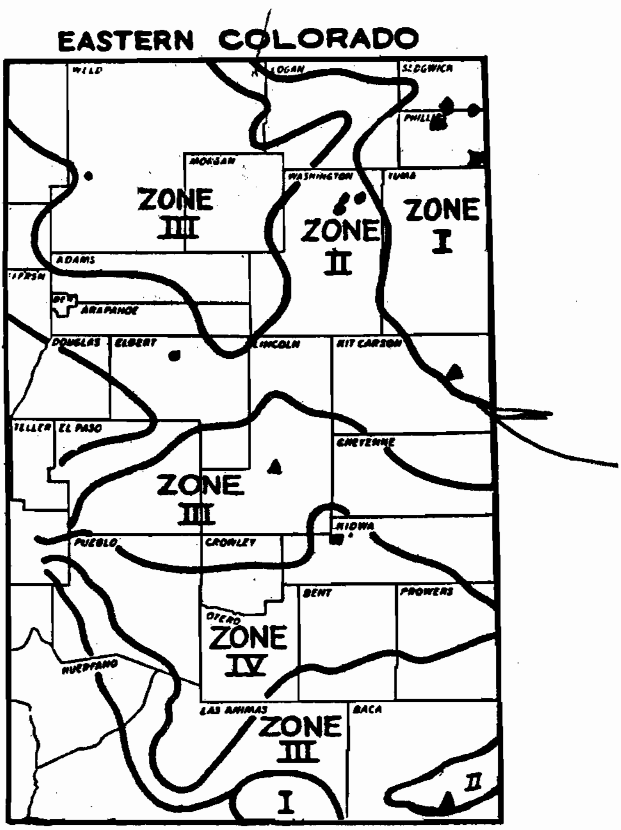
OUTSTATE FERTILIZER TESTING PROGRAM

An outstate testing program using commercial fertilizer on dryland crops was started in the spring of 1952. This program is supported in part by funds from Phillips Chemical Company.

The primary objective of these experiments is to determine the effect of nitrogen fertilizers--alone and in combination with other nutrient elements--on the yield and quality of winter wheat, corn, and sorghum on non-irrigated land in relation to variations in soil and climate.

This paper is a progress report of the commercial fertilizer experiments on wheat, corn, and sorghum conducted by the Agronomy Section (Soils) of the Colorado Agricultural Experiment Station during 1955.

Acknowledgment is made to the Colorado Extension Agents and Specialist, Experiment Station Personnel, farmer cooperators, and the fertilizer industry for assistance in conducting these experiments.



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

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

Fig. 1. Climatic Zones and Location of 1955 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 ON NON-IRRIGATED CROPS IN COLORADO IN 1955

THE STUDY

Fourteen commercial fertilizer field experiments were conducted in 1955 in various parts of the state. Six tests involved various fertilizer treatments on winter wheat, one test was on spring wheat, two were on corn, and five on sorghum. General information concerning each experiment is summarized in Table 1. Because of hail, grain yields were lost on three winter wheat experiments, and grain yields were low on two others where moisture was the limiting factor. Available soil moisture was also low on the spring wheat experiment. One corn and one sorghum experiment were lost due to drought.

Objectives

Objectives of these experiments varied from one location to another, but all studies included two or more of the following objectives:

1. To study the effect of rate of application of nitrogen on crop yields.
2. To determine the effect on yield of time of fertilizer application.
3. To study the influence of various nitrogen carriers on crop response.
4. To determine the effect of nitrogen and phosphorus combinations as well as nitrogen alone on crop yield.
5. To determine the effect of nitrogen on yield of crops grown in various soil types and at variable moisture contents.
6. To study the effect of fertilizer under different cropping systems on crop production.

Climatic Conditions

Precipitation (Table 2) in the fall of 1954 was considerably higher than in the previous year. However, the dry soil condition prior to the rains, the below-normal winter precipitation, and strong winds in early spring reduced the effectiveness of the moisture.

In most areas where experiments were conducted, above normal rains in May and June resulted in tillering of the winter wheat, but very few tillers produced mature heads by harvest. In general, the crop year of 1955 was not favorable for the production of winter wheat in most dryland areas of Colorado. Wheat in most sections suffered from drought or hail, but the northeastern corner of the state had good soil moisture and high yields were produced.

Heavy spring rains delayed the planting of corn and sorghum about two weeks, but in most areas it resulted in enough stored soil moisture to produce a fair or good crop. The precipitation during the summer was below normal and of little benefit to the growing crops.

Table 1. Fertilizer Experiment Location, 1955.

Field No.	Cooperator	Location	Management	County Agent	Land Type	Crop Variety	Date Fertilized
D-41-55	N. Frentress	Hayden	Continuous Wheat Wheat after Fallow	M. Taylor	Hard-land	Saunders	Sept. 15, 1954
D-42-55	Timm Bros.	Amherst	Continuous Wheat Wheat after Fallow	T. Hadden C. Hoffman	Hard-land	Comanche	Aug. 24, 1954
D-61-55[1]	E. Koonce	Otis	Wheat after Fallow	C. Evans	Hard-land	Wichita	Sept. 8, 1954
D-62-55[1]	F. Frenzel	Otis	Wheat after Fallow	C. Evans	Sandy-land	Wichita	Sept. 9, 1954
D-63-55[1]	C. Koonce	Otis	Wheat after Fallow	C. Evans	Sandy-land	Wichita	Sept. 9, 1954
D-64-55	G. Wyman	Milliken	Stubble Mulch	C. Nelson	Hard-land	Kanred	April 2, 1955
D-65-55	F. Skipton	Elizabeth	Stubble Mulch	W. Mason	Semi-Hard-land	Wichita	April 5, 1955
D-66-55	H. Kravig	Karval	Sorghum after Sorghum	R. Hamill	Semi-Hard-land	Coes	June 17, 1955
D-67A-55 D-67B-55	A. Brandt	Ovid	Sorghum after Fallow Sorghum after Wheat	C. Hoffman	Hard-land	Norghum	July 1, 1955
D-68-55[2]	M. Buol	Burlington	Sorghum after Wheat	D. Chadwick	Hard-land	Reliance	June 18, 1955
D-71-55	L. Wallace	Springfield	Sorghum after Sorghum	C. Fithian	Sandy-land	Five different varieties	June 8, 1955
D-69-55	R. Edwards	Haxtun	Corn after Wheat	T. Hadden	Sandy-land	Steckley Hybrid	June 7, 1955
D-70-55[2]	J. Jacobs	Eads	Corn after Corn	B. Whitmore	Sandy-land	DeKalb 410	June 16, 1955

1 Grain yields lost due to hail.
2 Crop lost by drought.

Table 2. Precipitation Received on Experimental Sites During the 1954-55 Season

Field No.	Location	1954 July	1954 Aug.	1954 Sept.	1954 Oct.	1954 Nov.	1954 Dec.	1955 Jan.	1955 Feb.	1955 Mar.	Apr.	May	June	Total	Normal* Ave.
D-41-55	Hayden	1.17	2.01	2.58	1.95	1.23	0.90	1.28	1.71	0.45	0.77	1.00	1.05	16.10	16.14
D-42-55	Amherst	3.15	1.52	2.61	0.75	0.15	0.20	0.15	0.25	0.30	1.50	4.80	3.97	19.35	17.61
D-61-55[1]	Otis					0.02	0.05	T	T	0.03	0.41	3.28	3.56	7.35	10.19
D-62-55[1]	Otis														
D-63-55[1]	Otis														
D-64-55	Milliken										0.04	3.45	2.08	5.57	5.52
D-65-55	Elizabeth										0.24	1.32	2.03	3.59	5.65

Corn and Sorghum		June	July	Aug.	Sept.	Total	Normal Average Same Period
D-66-55	Karval	1.30	1.55	4.62	1.20	8.67	7.35
D-67A & B 55	Ovid		1.74	0.93		2.67	4.60
D-68-55[2]	Burlington	0.25	0.02	0.77		1.04	8.03
D-69-55	Haxtun	3.60	1.38	1.67	0.90	7.55	9.29
D-70-55[2]	Eads	No record					
D-71-55	Springfield	1.06	0.10	0.14		1.30	6.25

* Colorado Agricultural Handbook 1952
1 Grain yields lost due to hail.
2 Crop lost by drought.

WHEAT EXPERIMENTS

Continuous Cropping vs. Wheat After Fallow

Two long term experiments were initiated in 1954 at Hayden and Amherst to study the effect of fertilizers on wheat grown after fallow and wheat grown under a continuous cropping system[1/]. The objective of these tests is to determine if a continuous cropping program involving the use of fertilizers on wheat can compete with the accepted wheat after fallow system. The site at Hayden is in a winter precipitation belt where spring wheat is grown. Amherst is in the summer rainfall belt with winter wheat being used in the experiment. This is the first year in which a comparison of the two cropping systems has been obtained.

D-41-55. N. Frentress Farm, Hayden, Colorado.

Table 3 shows the results of the fertilizer treatments on both the continuous wheat and wheat after fallow. No straw yields were taken because of the presence of Russian thistle. The thistle was particularly bad on the continuously cropped plots (up to 30% of the harvested seed was thistle). The grain yields were very low on the continuous wheat plots, and because of the competition with weeds, the yields were lower than normally would be expected.

There were no increases in yields due to any fertilizer treatment under either cropping system. Fifty pounds of nitrogen per acre under the wheat fallow practice, and 25 pounds of nitrogen per acre plus phosphorus under the continuous cropping system produced a significant decrease in yield. There were no differences in bushel weight due to fertilizer treatments, but there were significant or highly significant increases in percent protein on the continuous plots with all treatments except phosphorus alone.

1/ Started in 1954 by B. W. Greb, formerly Assistant Agronomist (Soils), Colo. Agr. Exp. Sta., presently Soil Scientist, U.S.D.A., U.S. Akron Field Station, Akron, Colorado.

Table 3. D-41-55 Routt County, Continuous Wheat vs. Wheat after Fallow, Loam Soil

Treatment	Grain Bu./Acre	Bu. Wt.	% Protein in Grain
Continuous Wheat			
CK	3.45	55.8	14.3
N	2.03	56.2	15.5**
NP	1.14*	55.5	15.1*
NN	2.97	54.5	16.0**
NNP	2.16	55.7	16.0**
P	3.06	56.2	14.4
Wheat after Fallow			
CK	13.63	57.2	15.0
N	11.88	57.2	15.2
NP	13.45	57.0	15.4
NN	9.58**	57.3	14.9
NNP	12.81	56.8	15.7
P	12.91	57.2	14.6
LSD at 5% Level	2.05	NS	.77
LSD at 1% Level	2.97		1.13

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

CK = No treatment
N = 25 lbs. N/A
NP = 25 lbs. N/A + 100 lbs. P_2O_5/A
NN = 50 lbs. N/A
NNP = 50 lbs. N/A + 100 lbs. P_2O_5/A
P = 100 lbs. P_2O_5/A
Ammonium nitrate used as the source of nitrogen.
Treble superphosphate used as the source of P_2O_5.

Table 4. D-41-55 Comparison of Yields with Different Cropping Systems

	Grain Yield		Bushel Weight		% Protein in Grain	
	Continuous Cropping	Wheat after Fallow	Continuous Cropping	Wheat after Fallow	Continuous Cropping	Wheat after Fallow
CK	3.45	13.63*	55.8	57.2	14.3	15.0
N	2.03	11.88	56.2	57.2	15.5	15.2
NP	1.14	13.45*	55.5	57.0	15.1	15.4
NN	2.97	9.58	54.5	56.3	16.0	14.9
NNP	2.16	12.81*	55.7	56.8	16.0	15.7
P	3.06	12.91	56.2	57.2	14.4	14.6
LSD 5% Level	9.96		NS		NS	

* Significant at 5% level.

Irrespective of fertilizer treatment, greater yields of grain were obtained after fallow than after wheat (Table 4). The no treatment, the 25 pounds of nitrogen plus phosphorus, and the 50 pounds of nitrogen plus phosphorus per acre under the wheat fallow system produced a significant increase in grain yield over the same plots under continuous wheat. The cropping system had no influence on bushel weight or percent nitrogen in the grain.

D-42-55. Timm Bros. Farm, Amherst, Colorado.

The results of fertilizer treatments under both cropping systems are shown in Table 5. Under the continuous cropping system, there was a significant increase in yield of grain with the 50 pounds of nitrogen plus phosphorus and a highly significant increase with the 25 pounds of nitrogen plus phosphorus treatments with the latter treatment having the highest yield. The phosphorus plot resulted in a highly significant decrease in yield of grain under continuous cropping. Only the 25 pounds of nitrogen plus phosphorus treatment resulted in a highly significant increase in yields of grain on the fallowed wheat plots. The 25 pounds of nitrogen treatment resulted in highly significant decrease in grain yield.

There were no significant differences in straw yield or bushel weight under either cropping system due to fertilizer treatments. The treatment with 25 pounds of nitrogen plus phosphorus under continuous cropping and both rates of nitrogen, without phosphorus, under the wheat fallow system produced significant increases in percent protein, while the 50 pounds of nitrogen and 50 pounds of nitrogen plus phosphorus treatments on the continuous plots and the 50 pounds of nitrogen plus phosphorus treatment on the wheat-fallow plots produced highly significant increases in percent protein.

There was a significant difference in grain yield due to the cropping systems except on the plots receiving 25 pounds of nitrogen per acre (Table 6).

There were no differences in straw yield, bushel weight or percent protein due to the different cropping systems.

Due to the height that the plots were cut, approximately one-third of the straw was left standing; therefore the yields reported are lower than the amount actually produced.

Table 5. D-42-55 Sedgwick-Phillips Counties, Continuous Wheat vs Wheat after Fallow, Loam Soil

Treatment	Grain Bu/A	Straw Tons/A	% Protein in Grain	Bu. Wt.
Continuous Cropping				
CK	15.33	0.34	13.0	59.7
N	20.30**	0.43	15.1	58.7
NP	25.67**	0.41	15.3*	57.6
NN	18.40	0.36	17.1**	56.8
NNP	19.20*	0.41	16.4**	57.6
P	10.20**	0.25	13.7	58.8
Wheat after Fallow				
CK	34.20	0.53	12.7	60.6
N	29.50**	0.52	15.6*	59.7
NP	40.33**	0.49	14.0	62.8
NN	34.06	0.52	15.6*	61.1
NNP	33.53	0.52	16.0**	60.2
P	31.17	0.47	13.0	61.7
LSD 5% Level	3.20	NS	2.2	NS
LSD 1% Level	4.66		3.3	

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

CK = No treatment
N = 25 lbs. N/A
NP = 25 lbs. N/A + 100 lbs. P_2O_5/A
NN = 50 lbs. N/A
NNP = 50 lbs. N/A + 100 lbs. P_2O_5/A
P = 100 lbs. P_2O_5/A

Ammonium nitrate used as the source of nitrogen.
Treble superphosphate used as the source of P_2O_5.

Table 6. D-42-55 Comparison of Yields with Different Cropping Systems

	Grain Yield		Straw Yield		Bushel Weight		% Protein in Grain	
	Continuous Cropping	Wheat after Fallow	Continuous Cropping	Wheat after Fallow	Continuous Cropping	Wheat after Fallow	Continuous Cropping	Wheat after Fallow
CK	15.33	34.20*	0.34	0.53	59.7	60.6	13.0	12.7
N	20.30	29.50	0.43	0.52	58.7	59.7	15.1	15.6
NP	25.67	40.33*	0.41	0.49	57.6	62.8	15.3	14.0
NN	18.40	34.06*	0.36	0.52	56.8	61.1	17.1	15.6
NNP	19.20	33.53*	0.41	0.52	57.6	60.2	16.4	16.0
P	10.20	31.17*	0.25	0.47	58.8	61.7	13.7	13.0
LSD 5% Level	14.00		NS		NS		NS	

* Significant at 5% level

CK = No treatment
N = 25 lbs. N/A
NP = 25 lbs. N/A + 100 lbs. P_2O_5/A

NN = 50 lbs. N/A
NNP = 50 lbs. N/A + 100 lbs. P_2O_5/A
P = 100 lbs. P_2O_5/A

Source of Nitrogen and Time of Application

E. Koonce Farm D-61-55, F. Frenzel Farm D-62-55, C. Koonce Farm D-63-55

These experiments were conducted near Otis, Colorado, using ammonium nitrate and anhydrous ammonia as the sources of nitrogen which were applied at the rate of 40 lbs. N per acre. The anhydrous ammonia was applied in the fall and the ammonium nitrate was used in both fall and early spring applications. Superphosphate was applied to half the plots in the fall at the rate of 50 lbs. P_2O_5 per acre on D-61-55 and at the rate of 30 lbs. P_2O_5 per acre on D-62-55 and D-63-55. Grain yields are not reported because hail just before harvest reduced yields at these locations by 75 to 95 percent.

D-61-55. E. Koonce Farm, Otis, Colorado.

This experiment was on hard lands with the soil moisture at the time of the fall application of fertilizers being good at a depth of three feet. At the time of fertilizer application in the spring, the soil was wet only in the second and third foot depths. There were no differences in straw yields or bushel weight due to fertilizer treatments. The fall applications of ammonium nitrate, ammonium nitrate plus phosphorus, and anhydrous ammonia plus phosphorus produced significant increases in percent protein. The spring applications of ammonium nitrate with and without phosphorus resulted in highly significant increases in percent protein. There were no differences between the two nitrogen carriers or between the fall and spring applications. Phosphorus had no effect on the yield of straw or bushel weight of grain. The lack of sufficient soil moisture was evident throughout most of the spring. Good rains in May and June resulted in considerable tillering, but many of the heads did not fill out. The results of this experiment are shown in Table 7.

Table 7. D-61-55 Washington County, Wheat after Fallow, Loam Soil

Treatment	Straw Tons/A	% Protein in Grain	Bushel Weight
CK	.64	14.2	59.4
N_1	.64	15.8*	58.6
N_2	.66	16.9**	56.9
Anhy	.68	15.5	59.1
N_1P	.67	16.0*	57.0
N_2P	.62	16.5**	57.6
Anhy + P	.67	16.0*	59.0
P	.63	14.4	59.7
LSD 5% Level	NS	1.5	NS
LSD 1% Level		2.0	

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

CK = No treatment
N_1 = Ammonium nitrate 40 lbs. N/A, fall application
N_2 = Ammonium nitrate 40 lbs. N/A, spring application
Anhy = Anhydrous ammonia 40 lbs. N/A, fall application
N_1P = Ammonium nitrate 40 lbs. N/A (fall application), 50 lbs. P_2O_5/A
N_2P = Ammonium nitrate 40 lbs. N/A (spring application), 50 lbs. P_2O_5/A
Anhy + P = Anhydrous ammonia 40 lbs. N/A (fall application), 50 lbs. P_2O_5/A
P = 50 lbs. P_2O_5/A. All P_2O_5 applied in fall.

D-62-55. F. Frenzel Farm, Otis, Colorado.

This experiment was conducted on a sandy loam soil, and the soil moisture was good to a depth of 5 feet at the time of both the fall and the spring application of nitrogen. Table 8 shows the results of this experiment. There were no differences in straw yield or bushel weight due to rate, source, or time of application of nitrogen. Phosphorus caused no variation in yield when added to the nitrogen treatments. A highly significant increase in protein content was obtained by all nitrogen treatments. It is likely, from past experiments and the appearance of these plots in the spring, that a response in grain yield to nitrogen fertilizer would have been obtained had the plots not been damaged by hail.

Table 8. D-62-55 Washington County, Wheat after Fallow, Sandy Loam Soil

Treatment	Straw Tons/Acre	% Protein in Grain	Bushel Weight
CK	.51	13.0	60.0
N_1	.66	16.3**	59.5
N_2	.61	16.5**	59.7
Anhy	.68	14.7**	59.1
N_1P	.70	15.2**	59.6
N_2P	.74	15.7**	59.7
Anhy P	.61	14.4**	59.1
P	.53	12.5	59.5
LSD 5% Level	NS	1.2	NS
LSD 1% Level		1.7	

** Significant at 1% level
CK = No treatment
N_1 = Ammonium nitrate 40 lbs. N/A (fall application)
N_2 = Ammonium nitrate 40 lbs. N/A (spring application)
Anhy = Anhydrous ammonia 40 lbs. N/A (fall application)
N_1P = Ammonium nitrate 40 lbs. N/A (fall application), 30 lbs. P_2O_5/A
N_2P = Ammonium nitrate 40 lbs. N/A (spring application), 30 lbs. P_2O_5/A
Anhy P = Anhydrous ammonia 40 lbs. N/A (fall application), 30 lbs. P_2O_5/A
P = 30 lbs. P_2O_5/A. All P_2O_5 applied in fall.

D-63-55. C. Koonce Farm, Otis, Colorado.

This experiment was on a heavier sandy loam than D-62-55, and the underlying layers were considerably finer in texture. The soil moisture was good to a depth of 60 inches in both fall and spring. The data from this experiment is shown in Table 9. Significant increases in straw yields were obtained with all nitrogen treatments. A highly significant increase in percent protein was realized by all nitrogen treatments except the anhydrous ammonia application. The fall application of ammonium nitrate and the anhydrous ammonia + phosphorus treatments reduced the bushel weight by a highly significant amount and the anhydrous ammonia and the fall applied ammonium nitrate + phosphorus reduced it significantly. However, in all cases, the bushel weight was over 60 pounds per bushel; therefore the effects of these treatments appear to be unimportant.

The evidence of responses to nitrogen treatments was not as pronounced in this field as at the D-62-55 location during the spring. However, there were indications that had the complete grain crop been harvested responses to nitrogen would have been obtained.

Table 9. D-63-55 Washington County, Wheat after Fallow, Sandy Loam Soil

Treatment	Straw Tons/Acre	% Protein in Grain	Bushel Weight
CK	0.89	12.7	61.7
N_1	1.10**	15.6**	60.6**
N_2	1.17**	15.7**	61.3
Anhy	1.07*	14.0	61.0*
N_1P	1.11**	14.9**	60.9*
N_2P	1.11**	15.3**	61.1
Anhy P	1.12**	14.8**	60.5**
P	0.88	12.0	61.5
LSD 5% Level	0.15	1.4	0.73
LSD 1% Level	0.21	1.9	0.99

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

CK = No treatment
N_1 = Ammonium nitrate 40 lbs. N/A (fall application)
N_2 = Ammonium nitrate 40 lbs. N/A (spring application)
Anhy = Anhydrous ammonia 40 lbs. N/A (fall application)
N_1P = Ammonium nitrate 40 lbs. N/A (fall application), 30 lbs. P_2O_5/A
N_2P = Ammonium nitrate 40 lbs. N/A (spring application), 30 lbs. P_2O_5/A
Anhy P = Anhydrous ammonia 40 lbs. N/A (fall application), 30 lbs. P_2O_5/A
P = 30 lbs. P_2O_5/A. All P_2O_5 applied in fall.

Nitrogen Applications on Wheat Grown on Stubble Mulched Land

G. Wyman Farm, Milliken, Colorado, and F. Skipton Farm, Elizabeth, Colorado.

These two locations were fertilized in the spring of 1955 using three different carriers of nitrogen, diammonium phosphate, ammonium nitrate, and ammonium sulfate at 20, 40, and 80 lbs. N/Acre. It appeared likely that additions of nitrogen would be beneficial under a stubble mulch practice where large amounts of material with a wide carbon to nitrogen ratio were being returned to the soil. Low available soil moisture at both sites resulted in very low yields.

D-64-55. G. Wyman Farm, Milliken, Colorado.

Table 10 shows the data from this experiment. The grain yield was very low with no differences due to fertilizer treatments. Also, no differences in straw yield and bushel weight were obtained by fertilizer treatments. The 80 lb. N/A applications of ammonium nitrate and ammonium sulfate resulted in significant increases in percent protein. This experiment was on a loam soil. Between 12 to 60 inches in depth, the available soil moisture was very low.

Table 10. D-64-55 Weld County, Wheat after Stubble Mulch, Loam Soil

Treatment	Grain Bu/A	Straw Tons/A	% Protein in Grain	Bushel Weight
CK	5.7	.48	19.7	57.1
DAP 20	5.7	.49	20.4	56.6
DAP 40	5.9	.48	20.0	58.0
DAP 80	6.3	.50	20.3	57.6
AN 20	5.7	.46	20.4	57.5
AN 40	6.1	.49	20.5	55.5
AN 80	5.3	.50	21.5*	56.4
AS 20	6.5	.47	20.4	56.5
AS 40	5.9	.49	20.7	54.1
AS 80	4.6	.51	22.1*	57.9
LSD 5% Level	NS	NS	1.3	NS

* Significant at 5% level
CK = No treatment
DAP 20 = Diammonium phosphate 20 lbs. N/A
DAP 40 = Diammonium phosphate 40 lbs. N/A
DAP 80 = Diammonium phosphate 80 lbs. N/A
AN 20 = Ammonium nitrate 20 lbs. N/A
AN 40 = Ammonium nitrate 40 lbs. N/A
AN 80 = Ammonium nitrate 80 lbs. N/A
AS 20 = Ammonium sulfate 20 lbs. N/A
AS 40 = Ammonium sulfate 40 lbs. N/A
AS 80 = Ammonium sulfate 80 lbs. N/A

D-65-55. F. Skipton Farm, Elizabeth, Colorado.

This experiment was on a sandy clay loam soil. The soil moisture was very low to a depth of 60 inches. The yields are shown in Table 11. No differences due to fertilizer treatments were obtained in grain and straw yields or bushel weight. There were highly significant increases in protein content from the plots treated with diammonium phosphate, ammonium nitrate, and ammonium sulfate at 80 pounds of nitrogen per acre and ammonium nitrate and ammonium sulfate at 40 pounds of nitrogen per acre. Significant increases were obtained from the diammonium phosphate treatment at 40 pounds of nitrogen per acre and the ammonium nitrate treatment at 20 pounds of nitrogen per acre.

Table 11. D-65-55 Elbert County, Wheat after Stubble Mulch, Sandy Clay Loam Soil

Treatment	Grain Bu/A	Straw Tons/A	% Protein in Grain	Bushel Weight
CK	7.6	0.51	14.8	58.7
DAP 20	7.6	0.56	16.2	57.7
DAP 40	8.6	0.64	16.5*	56.6
DAP 80	8.3	0.63	17.6**	56.0
AN 20	9.0	0.63	16.5*	58.0
AN 40	7.2	0.61	18.3**	55.6
AN 80	6.1	0.56	19.0**	55.7
AS 20	8.5	0.61	16.1	57.4
AS 40	6.8	0.52	17.8**	57.5
AS 80	6.4	0.55	18.5**	57.6
LSD 5% Level	NS	NS	1.7	NS
LSD 1% Level			2.4	

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

CK = No treatment
DAP 20 = Diammonium phosphate 20 lbs. N/A
DAP 40 = Diammonium phosphate 40 lbs. N/A
DAP 80 = Diammonium phosphate 80 lbs. N/A
AN 20 = Ammonium nitrate 20 lbs. N/A
AN 40 = Ammonium nitrate 40 lbs. N/A
AN 80 = Ammonium nitrate 80 lbs. N/A
AS 20 = Ammonium sulfate 20 lbs. N/A
AS 40 = Ammonium sulfate 40 lbs. N/A
AS 80 = Ammonium sulfate 80 lbs. N/A

Summary of Wheat Experiments.

The two fertilizer experiments on continuously cropped wheat and wheat after fallow were harvested. The continuously cropped plots at Hayden suffered from drought and competition from weeds. At this site, there was no increase in grain yield or bushel weight due to fertilizer treatments. Protein content was increased by a significant or highly significant amount on the continuously cropped plots only. The check, the 25 pounds of nitrogen plus phosphorus and the 50 pounds of nitrogen plus phosphorus treatments on the wheat after fallow plots were significantly higher than the same treatments on continuous wheat. At Amherst, increases in grain yield and protein content were obtained by nitrogen application on both the continuously cropped and the wheat after fallow plots. All nitrogen treatments except the 25 pound rate per acre in the case of the wheat-fallow plots produced significantly higher yields than the same treatments on the continuous wheat plots.

Three experiments involving sources of nitrogen and time of application were conducted in the Otis area. Hail just before harvest reduced the grain yields to a point that they could not be measured. Two of the experiments resulted in increases in percent protein by some nitrogen treatments, while the third location showed differences due to nitrogen in the straw yield, protein content, and bushel weight of grain. There were indications that responses in grain yield to nitrogen fertilizer would have been obtained at two of these sites had the complete crop been harvested. There were no differences due to the source or the time of application of nitrogen.

Two experiments were conducted with sources and rates of nitrogen on wheat after stubble mulch. One location was near Milliken and one near Elizabeth. Soil moisture was very deficient at both sites and this resulted in low yields. At Milliken, only the heaviest rates of N with ammonium nitrate and ammonium sulfate produced a significant increase in protein content, while at Elizabeth all treatments except 20 pounds of nitrogen per acre from diammonium phosphate and ammonium sulfate produced significant or highly significant increases in percent protein. There were no differences in yield due to source of nitrogen.

CORN AND SORGHUM EXPERIMENTS

Two corn and five sorghum experiments were conducted in eastern Colorado during the 1955 season. A corn test at Eads was lost due to drought and hail, and a sorghum test at Burlington was lost because of drought.

Three sorghum experiments involved the use of urea, ammonium nitrate, ammonium sulfate, and diammonium phosphate at the rate of 20 and 40 pounds of nitrogen per acre. At Karval, Coes was planted on land which was cropped to sorghum in the preceding year. Two experiments were conducted on the Brandt farm near Ovid. The cropping systems included sorghum after fallow and sorghum after wheat. Since it was necessary to put these tests in specific areas according to cropping practice, there is no valid comparison between the stubble and fallowed land.

At Springfield, urea was applied at 20 and 40 pounds of nitrogen per acre to five sorghum varieties. The varieties had been planted in non-randomized strips and no valid comparison could be made between them.

The only corn experiment harvested was near Haxtun. The soil contained only 18 pounds of available phosphorus (P_2O_5) per acre so phosphorus was added to the treatments in various combinations with nitrogen.

<u>D-66-55</u>. <u>H. Kravig Farm, Karval, Colorado.</u>

The results of this experiment are shown in Table 12. The test was conducted on sandy clay loam soil, and the stored moisture was good to a depth of three feet. The experimental plan included four carriers of nitrogen-urea, ammonium nitrate, ammonium sulfate, and diammonium phosphate at 20 and 40 pounds of nitrogen per acre. The variety used in this experiment was Coes, so both grain and forage yields were taken. At the time of harvest, considerable grain was still immature. There were no differences in grain yield, green forage, or oven-dry forage due to nitrogen fertilizers. There was a tendency for the higher rate of nitrogen to produce the highest yields, although there were no significant differences between the rates or the carriers of nitrogen. In the forage, protein content was increased by a significant or highly significant amount by all treatments except 20 pounds of nitrogen per acre from urea and diammonium phosphate. Significant or highly significant increases in protein content of grain were obtained from all treatments except 40 pounds of nitrogen per acre in the form of urea.

Table 12. D-66-55 Lincoln County, Continuous Sorghum, Sandy Clay Loam

Treatment	Grain Bu/A	Green Forage Tons/A	Oven-dry Forage Tons/A	Protein Dry Forage %	Protein Grain %
CK	12.80	2.99	0.93	2.7	11.4
Urea 20	10.74	2.45	0.78	4.0	12.8*
Urea 40	13.30	2.92	1.07	5.1**	12.1
AN 20	12.14	2.43	0.74	4.4*	12.8*
AN 40	10.21	3.04	0.83	5.1**	13.3**
AS 20	12.58	2.46	0.68	5.7**	12.5*
AS 40	9.31	2.63	0.88	6.0**	13.7**
DAP 20	13.81	2.59	0.78	4.2	12.5*
DAP 40	13.85	3.18	0.81	5.0**	12.9**
LSD 5% Level	NS	NS	NS	1.7	1.1
LSD 1% Level				2.3	1.5

CK = No treatment
Urea 20 = Urea at 20 lbs. N/A
Urea 40 = Urea at 40 lbs. N/A
AN 20 = Ammonium nitrate at 20 lbs. N/A
AN 40 = Ammonium nitrate at 40 lbs. N/A
AS 20 = Ammonium sulfate at 20 lbs. N/A
AS 40 = Ammonium sulfate at 40 lbs. N/A
DAP 20 = Diammonium phosphate at 20 lbs. N/A
DAP 40 = Diammonium phosphate at 40 lbs. N/A

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

D-67A-55, D-67B-55. A. Brandt Farm, Ovid, Colorado.

These experiments involved the same fertilizer treatments that were used in D-66-55, but the soil had a loam textural grade and Norghum sorghum was planted. D-67A-55 had sorghum after fallow and D-67B-55 had sorghum following wheat. The results of D-67A-55 are shown in Table 13, and the results of D-67B-55 are shown in Table 14. There were no significant increases or decreases in yield of grain or bushel weight due to nitrogen fertilizer on either experiment. At the time the plots were fertilized, the soil moisture on D-67A-55 was good to a depth of 3 feet and on D-67B-55 it was good to a depth of only 2 feet. The available soil moisture probably accounts for the trends of the treatments. On the sorghum after fallow plots, the heaviest rate of nitrogen from all carriers except diammonium phosphate tended to produce the highest grain yield, while in the case of sorghum after wheat the lighter application of nitrogen from all sources except diammonium phosphate tended to produce the highest grain yield. In this experiment, as in most of the dryland tests where phosphorus has been used, the results are erratic. Considerable more study is needed to explain phosphate activity in soils under the dry farming conditions of Colorado.

Only ammonium sulfate and diammonium phosphate applied at the rate of 40 pounds of nitrogen per acre increased the percent protein significantly on D-67B-55. No significant differences in protein content were produced on D-67A-55.

Table 13. D-67A-55 Sedgwick County, Sorghum after Fallow, Loam Soil

Treatment	Grain Bu/A	Bushel Weight	% Protein in Grain
CK	21.90	52.6	12.3
U 20	20.67	53.1	11.9
U 40	22.65	54.0	11.9
AS 20	23.50	53.3	12.2
AS 40	24.97	53.9	11.7
AN 20	19.53	52.9	11.9
AN 40	27.63	54.0	11.4
DAP 20	23.50	52.9	12.2
DAP 40	16.47	54.0	12.6
LSD	NS	NS	NS

Table 14. D-67B-55 Sedgwick County, Sorghum after Wheat, Loam Soil

Treatment	Grain Bu/A	Bushel Weight	% Protein in Grain
CK	18.71	56.2	11.2
U 20	22.71	56.1	11.2
U 40	15.35	56.3	12.1
AS 20	24.97	56.2	11.3
AS 40	14.46	56.2	12.3*
AN 20	18.91	56.2	11.9
AN 40	16.57	55.5	11.7
DAP 20	18.71	55.9	11.7
DAP 40	21.03	55.7	12.3*
LSD 5% Level	NS	NS	1.0

* Significant at 5% level

CK = No treatment
U 20 = Urea 20 lbs. N/A
U 40 = Urea 40 lbs. N/A
AS 20 = Ammonium sulfate 20 lbs. N/A
AS 40 = Ammonium sulfate 40 lbs. N/A
AN 20 = Ammonium nitrate 20 lbs. N/A
AN 40 = Ammonium nitrate 40 lbs. N/A
DAP 20 = Diammonium phosphate 20 lbs. N/A
DAP 40 = Diammonium phosphate 40 lbs. N/A

D-69-55. R. Edwards Farm, Haxtun, Colorado.

This test was conducted on a sandy loam soil using Steckly hybrid corn. The soil moisture at fertilization was good to a depth of 3 feet and fair in the 4th foot. Since this location had only 18 lbs. of available phosphorus (P_2O_5) per acre, as determined by the sodium bicarbonate extraction, phoshorus was applied. However, as the data in Table 15 shows all treatments with phosphorus yielded about the same as the no treatment plot and ammonia nitrate and urea alone produced significant increases in yield of grain. Ammonium sulfate did not increase the yield significantly. However, there was an increase of about 6.6 bushels per acre. There were no significant differences in protein content due to fertilizer treatment.

Table 15. D-69-55 Phillips County, Corn after Wheat, Sandy Loam Soil

Treatment	Grain Bu/A	% Protein in Grain
AN + P	20.91	7.5
AS + P	23.48	9.3
U + P	20.67	8.6
DAP	23.52	8.7
CK	23.29	8.8
AN	35.28*	9.4
AS	29.93	9.2
U	32.08*	8.5
P	22.05	8.4
LSD 5% Level	8.55	NS

* Significant at 5% level

AN + P = Ammonium nitrate + phosphorus
AS + P = Ammonium sulfate + phosphorus
U + P = Urea + phosphorus
DAP = Diammonium phosphate
CK = No treatment
AN = Ammonium nitrate
AS = Ammonium sulfate
U = Urea
P = Treble superphosphate

All nitrogen applied at 30 lbs. N/A
Phosphate applied at 75.7 lbs. P_2O_5/A

D-71-55. L. Wallace Farm, Springfield, Colorado.

This test included 20 and 40 pounds of nitrogen per acre in the form of urea, and five different sorghum varieties were planted. The experiment was not designed to get a valid test of the differences between sorghum varieties so the results are confined to the behavior due to fertilizer treatments. Table 16 shows these results. There were no significant differences in grain yield or bushel weight due to application of nitrogen. The soil moisture was good to a depth of 60 inches at the time the plots were fertilized. The protein content was increased significantly by the 20 pounds of nitrogen on Midland, the 40 pounds of nitrogen on Martin, and by both 20 and 40 pounds of nitrogen on 7078, only the 40 pound nitrogen application on Midland produced a highly significant increase over the check.

Table 16. D-71-55 Baca County, Continuous Sorghum, Sandy Loam

Variety	Treatment	Grain Bu/A	Bushel Weight	% Protein in Grain
Martin	CK	28.59	59.7	8.8
	20	27.80	59.8	10.0
	40	29.29	60.0	11.3*
Midland	CK	24.23	59.5	8.1
	20	29.80	60.3	10.3*
	40	23.36	59.2	11.8**
Westland	C	23.40	58.7	10.3
	20	25.71	59.5	11.0
	40	32.99	59.7	11.1
7078	CK	29.69	57.8	8.4
	20	23.90	58.5	10.3*
	40	32.40	58.3	10.8*
Combine Kafir 60	CK	32.05	59.5	9.2
	20	22.77	58.7	9.2
	40	33.53	59.0	9.5
LSD 5% Level		NS	NS	1.9
LSD 1% Level				2.6

CK = No treatment
20 = Urea 20 lbs. N/A
40 = Urea 40 lbs. N/A

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

Summary of Corn and Sorghum Experiments.

Four sorghum and one corn experiment were harvested in 1955. There was a significant increase in yield of corn due to 30 lb. N per acre from ammonium nitrate and urea. Phosphorus applications had no effect on the grain yield and no significant differences were obtained in protein content due to fertilizer applications.

No significant differences in grain yield at any of the sorghum sites were obtained by additions of fertilizers. Protein content of either grain or forage was increased by nitrogen treatments on all sorghum experiments except D-67A-55.

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 17 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 17. Soil Properties and Soil Moisture Levels

Field Number	Depth Inches	Soil Texture	pH	Lime %	Organic Matter %	Total Nitrogen %	Available P_2O_5 Lbs/A	Soil Moisture at Time of Fertilization: Continuous	Soil Moisture at Time of Fertilization: Fallowed	Moisture Equivalent % H_2O
D-41-55	0-12	Loam	6.9	3.1	1.54	.066	140.0	9.4	15.1	19.00
	12-24	Silty Clay Loam	7.0	4.3	1.19	.065		14.5	16.7	23.33
	24-36	Silt Loam	7.4	4.8	1.03	.066		12.8	13.4	21.04
	36-48	Silt Loam	7.8	6.2	.83	.046		13.5	15.2	22.13
	48-60	Silt Loam	8.0	8.1	.64	.031		15.5	15.1	21.55
D-42-55	0-12	Loam	7.0	0.1	1.61	.094	90.0	21.0	15.5	20.00
	12-24	Loam	7.3	0.2	1.05	.069		17.0	17.2	21.00
	24-36	Loam	7.8	2.0	.82	.060		10.3	13.3	21.00
	36-48	Loam	8.1	5.7	.47	.031		7.3	11.6	19.00
	48-60	Sandy Loam	8.1	4.8	.30	.021		7.3	8.0	14.00
								Fall Application	Spring Application	
D-61-55[1]	0-12	Loam	6.8	0.1	1.29	.086	93.5	13.7	8.6	15.35
	12-24	Sandy Loam	6.8	0.1	0.71	.042		13.1	18.9	14.17
	24-36	Sandy Clay Loam	7.1	0.5	0.57	.038		15.1	19.2	14.87
	36-48	Loam	7.9	10.2	0.44	.034		8.3	9.2	21.89
	48-60	Sandy Loam	8.1	8.0	0.25	T		6.7	2.2	12.66
D-62-55[1]	0-12	Sandy Loam	6.4	0.0	0.82	.055	40.5	12.4	5.6	7.64
	12-24	Sandy Loam	6.7	0.0	0.59	.032		8.7	8.5	9.16
	24-36	Sandy Loam	7.3	0.2	0.41	.035		8.3	10.1	9.01
	36-48	Sandy Loam	7.6	0.5	0.49	.035		11.2	9.5	15.31
	48-60	Loamy Sand	8.0	0.9	0.31	.035		10.3	7.4	8.34
D-63-55[1]	0-12	Sandy Loam	6.1	0.1	0.82	.044	68.0	12.1	9.5	9.75
	12-24	Sandy Loam	6.3	0.0	0.60	.042		13.4	9.2	13.67
	24-36	Sandy Clay Loam	6.7	0.3	0.56	.045		14.5	11.7	15.85
	36-48	Sandy Clay Loam	6.9	0.1	0.59	.041		17.0	14.2	18.84
	48-60	Sandy Loam	7.9	1.7	0.29	.022		8.8	12.3	9.38
D-64-55	0-12	Loam	6.4	1.2	1.17	.066	125.0		17.61	17.86
	12-24	Clay Loam	7.2	9.3	1.03	.078			11.51	23.77
	24-36	Loam	7.7	10.4	0.40	.024			8.24	17.46
	36-48	Loam	8.1	8.6	0.23	.018			8.73	21.07
	48-60	Silt Loam	8.2	8.8	0.20	.018			10.18	18.72

Table 17. Soil Properties and Soil Moisture Levels (Cont'd)

Field Number	Depth Inches	Soil Texture	pH	Lime %	Organic Matter %	Total Nitrogen %	Available P_2O_5 lbs/A	Soil Moisture at Time of Fertilization % H_2O	Moisture Equivalent % H_2O
D-65-55	0-12	Sandy Clay Loam	5.5	0.9	1.43	.061	77.0	8.29	14.57
	12-24	Sandy Clay Loam	5.9	1.1	0.59	.039		10.13	17.89
	24-36	Sandy Loam	6.5	0.9	0.30	.019		6.77	10.61
	36-48	Sandy Loam	6.9	0.8	0.16	.013		6.34	9.52
	48-60	Sandy Clay Loam	7.0	1.3	0.16	.013		7.60	15.59
D-66-55	0-12	Sandy Clay Loam	6.4	1.4	1.05	.069	49.5	16.36	16.74
	12-24	Loam	7.7	5.2	1.10	.061		11.38	18.93
	24-36	Loam	8.2	5.9	0.43	.029		11.00	20.02
	36-48	Loam	8.4	5.4	0.34	.014		8.09	16.91
	48-60	Sandy Clay Loam	8.6	8.6	0.28	.014		8.07	12.42
D-67A-55	0-12	Loam	6.3	0.7	1.65	.102	132.0	23.09	25.45
	12-24	Silt Loam	7.5	1.3	1.34	.072		20.64	22.85
	24-36	Silt Loam	7.0	1.1	1.56	.091		22.09	26.56
	36-48	Silt Loam	7.8	1.5	0.39	.038		12.24	22.60
	48-60	Loamy Sand	8.2	0.8	0.05	.010		4.36	6.53
D-67B-55	0-12	Loam	6.6	0.8	1.28	.095	110.0	23.86	21.73
	12-24	Loam	7.2	1.1	0.87	.067		21.08	23.19
	24-36	Loam	7.0	1.1	1.08	.077		12.53	23.40
	36-48	Silt Loam	8.1	3.0	0.48	.041		10.13	22.58
	48-60	Sandy Loam	8.5	3.5	0.12	.011		4.91	10.09
D-68-55[2]	0-12	Silt Loam	6.6	0.5	1.35	.082	99.0	21.08	21.03
	12-24	Silt Loam	7.9	5.3	0.93	.077		13.01	21.23
	24-36	Silt Loam	8.2	5.9	0.76	.054		11.63	23.64
	36-48	Silt Loam	8.2	5.3	0.33	.030		10.70	21.07
	48-60	Silt Loam	8.3	5.4	0.27	.024		10.05	19.13
D-69-55	0-12	Sandy Loam	7.4	1.4	0.78	.043	18.0	15.67	13.62
	12-24	Clay Loam	8.1	3.9	1.38	.070		24.41	28.18
	24-36	Silt Loam	8.7	11.8	0.68	.037		21.55	24.26
	36-48	Loam	8.7	6.7	0.41	.018		13.29	17.00
	48-60	Sandy Loam	8.4	1.8	0.15	.008		4.65	11.79

Table 17. Soil Properties and Soil Moisture Levels (Cont'd)

Field Number	Depth Inches	Soil Texture	pH	Lime %	Organic Matter %	Total Nitrogen %	Available P_2O_5 Lbs/A	Soil Moisture at Time of Fertilization % H_2O	Moisture Equivalent % H_2O
D-70-55[2]	0-12	Loam	6.3	0.5	1.27	.050	53.0	16.32	17.74
	12-24	Loam	7.0	0.7	0.83	.048		10.59	19.50
	24-36	Loam	7.8	2.8	0.67	.040		11.55	20.93
	36-48	Loam	8.0	2.0	0.50	.035		12.29	19.89
	48-60	Loam	8.1	4.1	0.24	.030		16.01	22.22
D-71-55	0-12	Sandy Loam	8.0	5.1	1.32	.068	27.5	16.22	18.67
	12-24	Sandy Loam	8.2	10.3	0.31	.030		18.34	13.87
	24-36	Sandy Clay Loam	8.1	7.7	0.05	.024		16.51	21.29
	36-48	Sandy Loam	8.3	8.0	0.07	.015		16.41	15.69
	48-60	Sandy Loam	8.5	6.6	T	.008		11.64	11.37

1 Grain Yield lost due to hail.
2 Experiments lost due to drought.

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