Colorado Agricultural and Mechanical College

Outstate Fertilizer Testing Program

February 1953 • General Series Paper No. 526

Commercial Fertilizer Experiments with Non-Irrigated Crops in Eastern Colorado in 1952

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Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the Colorado Agricultural and Mechanical College Extension Service, J. E. Morrison, Director, and United States Department of Agriculture Cooperating.

FORT COLLINS, COLO. MARCH 1953

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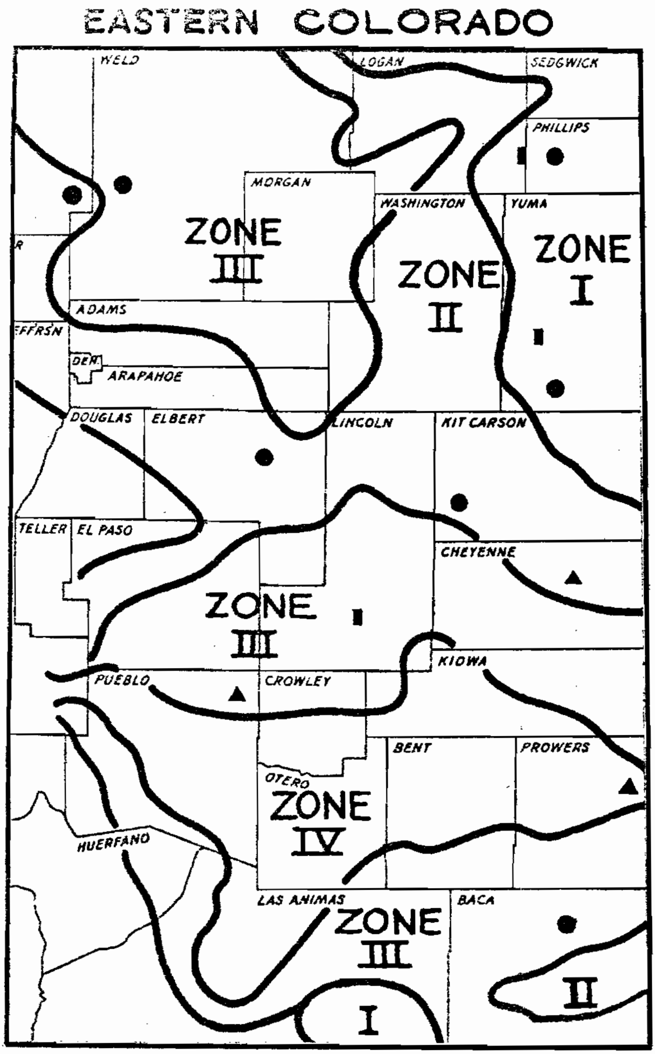
OUTSTATE FERTILIZER TESTING PROGRAM

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 66 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 winter wheat, corn, and sorghum conducted by the Agronomy Section (Soils) of the Colorado Agricultural Experiment Station.

Acknowledgement is made to the Colorado extension agents and specialists, experiment station personnel, and farmer cooperators for their assistance in conducting these tests.



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 1952 Experiments

COMMERCIAL FERTILIZER EXPERIMENTS WITH NON-IRRIGATED CROPS IN EASTERN COLORADO IN 1952

Fertilizer experiments on non-irrigated crops in eastern Colorado were initiated in the spring of 1952. Seven winter wheat, three corn, and three sorghum tests were conducted on typical non-irrigated croplands in the area (see Fig. 1). It was considered desirable to include as many of the major climatic zones and land types as possible because of previous inconclusive response data. The location of the experimental sites and associated information are given in Table 1.

Hard-land, moderately sandy, and sandy-land types were included in the 1952 studies. The normal farming practices are to crop the light textured soils continuously and to alternately fallow and crop the hard-lands. Nevertheless, in some areas, continuous cropping of hard-lands in periods of favorable moisture is practiced.

The climatic conditions which prevailed during the growing season in eastern Colorado during 1952 were typified by a relatively moist, cool spring followed after June 5 by occasional hot winds (95-108° F.) which prevailed over most of the non-irrigated region for periods in excess of ten days. The

Table 1. Fertilizer Test Locations in 1952

Winter Wheat

Field No.	Cooperator	Location	Management	County Agent	Land Fertilized	Land Type	Variety
D-1-52	H. Klusman	Flagler	Wheat after Wheat	D. Chadwick	April 25	Hard-land	Wichita
D-2-52	Geisen Bros.	Agate	Wheat after Fallow	W. Mason	May 2	" "	Wichita
D-3-52	Gerald Brown	Springfield	Wheat after Fallow	C. Fithian	May 3	" "	Wichita
D-4-52	George Walker	Loveland	Wheat after Fallow	D. McMillen	May 7	" "	Tenmarq
D-5-52	Wilbur Atkins	Haxtun	Wheat after Corn	C. Block	May 9	Sandy	Turkey Red
D-6-52	W. F. Wilcoxen	Idalia	Wheat after Wheat	D. Colson W. Chandler	May 10	Moderately Sandy	Wichita
D-7-52	Jack Abbott	Windsor	Wheat after Fallow	G. James	May 14	Moderately Sandy	Cheyenne

Corn

D-8-52	L. W. Brownell	Fleming	Corn after Wheat	S. Hoar	May 24	Sandy	Unknown
D-9-52	M. Wingfield	Mildred	Corn after Corn	D. Colson W. Chandler	May 22	"	Unknown
D-10-52	Carl Bucklen	Karval	Corn after Corn	R. Hamill	May 26	"	Colo.152

Sorghum

D-11-52	H. A. Beiber	Cheyenne Wells	Sorghum after Wheat	M. Taylor	June 10	Hard-land	Coes
D-12-52	Leo Pollart	Holly	Sorghum after Wheat	Vernon Carter	June 11	" "	Martin
D-13-52	Ray Hodges	Boone	Sorghum after Corn	M. V. Haines	May 23	Sandy	Coes

northern half of the non-irrigated region generally received more moisture during the months of April and May than did the southern half. The extended drought period resulted in the abandonment of one corn test (D-9-52) and all three sorghum experiments. A hail storm considerably reduced the winter wheat yields at one location.

Soil samples were collected at each location and various soil studies were made. The results are listed by field number and are shown in Table 4.

METHODS AND MATERIALS

The fertilizer elements used for experimentation are expressed as follows: nitrogen (N), phosphorus (P_2O_5), potassium (K_2O). The types of fertilizer materials used and their analyses are listed below:

Ammonium nitrate	33.5% N
Urea	45% N
Triple superphosphate	43% P_2O_5
Muriate of potash	60% K_2O

Solutions of urea at saturated and half saturated strengths were used as foliar sprays on six of the winter wheat trials. A small amount of detergent was added to the solutions to act as a spreader.

Winter Wheat

With the exception of the Klusman farm, all wheat tests included eight fertilizer treatments. The plots were laid out in randomized blocks and replicated four times. The Klusman location received five treatments and five replications (latin square design). The experimental plots were eighteen feet long and five rows wide (10-inch rows). At harvest, three eight-foot rows or a total of twenty-four feet was harvested from each plot for yield determination. A grain sample was selected from each plot for protein analysis.

The cultural operations were performed by the farmer co-operators. The dry fertilizers were side dressed with a hand drill. The urea solutions were sprayed onto the foliage with a hand sprayer. A portable tank of carbon dioxide was used to supply pressure for the hand sprayer. All fertilizer rates and yield calculations were made on an acre basis.

Wheat experiments D-2-52 through D-7-52 all received the eight fertilizer treatments listed below:

No.	Treatment Symbol	Treatment - Pounds Per Acre
1	Check	No fertilizer
2	N	30 lbs. N
3	P	30 lbs. P_2O_5
4	NP	30 lbs. N, 30 lbs. P_2O_5
5	NPK	30 lbs. N, 30 lbs. P_2O_5,10 lbs. K_2O
6	Urea dry	30 lbs. N.
7	Urea 1/2 sat.	30 lbs. N.
8	Urea sat.	30 lbs. N

At the Klusman location (D-1-52), the first five of the above treatments were followed except that the nitrogen was applied at the rate of 20 pounds N per acre.

Corn

The corn experiments D-8-52 and D-10-52 received identical fertilizer treatments. The main fertilizer application was made shortly after seed germination as a side dressing and later additional treatment with 20 pounds of nitrogen was made early in July on two of the plots. The plots were eighty feet long and four rows wide (40-inch rows). A total of eighty feet of corn in the center two rows was selected for harvest. The following fertilizer treatments were used in the corn experiments:

No.	Treatment Symbol	Treatment - Pounds Per Acre
1	Check	No fertilizer
2	N	20 lbs. N in May
3	NN	40 lbs. N in May
4	N-N	20 lbs. N in May, 20 lbs. N in July
5	NP-N	20 lbs. N, 40 lbs. P_2O_5 in May; 20 lbs. N in July
6	NNP	40 lbs. N, 40 lbs. P_2O_5 in May
7	NNPK	40 lbs. N, 40 lbs. P_2O_5, 12 lbs. K_2O in May
8	NNPKK	40 lbs. N, 40 lbs. P_2O_5, 48 lbs. K_2O in May

In tables presented later in this circular, the "treatment symbol" will be used to denote the fertilizer treatment for both wheat and corn.

EXPERIMENTAL RESULTS ON WINTER WHEAT

Klusman Farm (D-1-52), Kit Carson County

This experiment was conducted on hard-land soil in which the 1951 hailed-out wheat crop had been stubbled back. The soil moisture level at fertilization was considered good (see Table 4). The wheat was badly damaged on May 15 by hail and the second growth was harvested.

None of the fertilizer treatments produced an increase in yield of grain (see Table 2). A slightly higher protein conten was obtained on the nitrogen treated plots but the increase was not significant.

Geisen Bros. Farm (D-2-52), Elbert County
Brown Farm (D-3-52), Baca County
Walker Farm (D-4-52, Larimer County

These experiments were connected on fallowed hard-lands where the initial soil moisture levels at fertilization were good to excellent (see Table 4). Adequate additional quantitie of moisture were received on the Walker farm, while both the Geisen and Brown locations received little effective moisture after May 15. The heat wave appeared to have materially reduced the expected yield of grain on the Geisen farm, and it caused a low bushel weight and reduced yield on the Walker place.

There was no significant yield or protein response to fertilization at any of the three locations (see Table 2). Considering the adverse climatic conditions which existed, it is interesting to note that there was no significant decrease in yield due to fertilizer treatments. Leaf tip burning did occur on the plants sprayed with a saturated solution of urea. This appeared to cause a slight reduction in yield at all three locations but the differences were not significant. The phosphorus treatment at the Walker place showed a higher bushel weight and a 4.8 bushel increase in yield but these increases were not significant. This may have been caused by a maturity effect, that is, the phosphate caused the grain to ripen ahead of the heat wave. Grain shrinkage on the Walker farm was reflected in the higher protein content of the grain. The phosphated treatment showed the lowest protein percentage.

Atkins Farm (D-5-52), Phillips County
Wilcoxen Farm (D-6-52), Yuma County
Abbott Farm (D-7-52), Weld County

These experiments were conducted on lighter textured soils. Two of the locations were cropped the year before. In all three locations the soil moisture level throughout the experimental period was fairly adequate.

Significant increases of 4 to 6 bushels of grain per acre were obtained from the application of 30 lbs. of nitrogen at all three locations (see Table 2). No response was obtained from phosphorus alone. Application of phosphorus and potassium in addition to nitrogen produced no additional significant increase in yield. The protein content of wheat on the Wilcoxen and Abbott locations and the straw yield (data not shown) from the Atkins and Wilcoxen farms were significantly increased by nitrogen fertilizers.

Summary on Winter Wheat Experiments

Fertilizer experiments with spring application of nitrogen on winter wheat showed significant increases in yields at three of the seven locations tested.

In the six experiments in which ammonium nitrate and urea were used, the average yield for the ammonium nitrate treatment was 24.5 bushels as compared with 23.3, 23.6 and 21.6 bushels for urea dry, urea 1/2 saturated, and urea saturated, respectively.

Some burning of the foliage was caused by both of the urea spray treatments. This was more pronounced in the saturated form. The effect of burning by urea in the saturated form is probably reflected in the average yield shown above.

Urea spray treatments contributed no more to the protein content of grain than the side dressed forms of nitrogen. In two cases the urea spray produced a significantly higher protein content than the check plots but was significantly less than produced by the dry form of nitrogen.

In no case was a significant increase in yield obtained from the spring application of phosphorus alone. Phosphorus in combination with nitrogen and potassium did not produce a response above that obtained from nitrogen. Failure to obtain responses to phosphorus from spring application does not necessarily mean a sufficient supply of phosphorus occurred at all locations. It is possible that the late date of application, the shallow depth of application, and the lack of additional rainfall may have influenced the failure of phosphate response.

Table 2. Yield of Grain and Protein on Winter Wheat

Field No.		Check	N	P	NP	NPK	Urea dry	Urea 1/2 sat.	Urea sat.	5% L.S.D.
						Treatment				
D-1-52	Bushels/acre	12.5	11.3	11.9	11.8	12.5				N.S.
	% Protein	14.8	15.8	14.7	15.4	15.7				N.S.
D-2-52	Bushels/acre	19.4	20.2	21.4	19.1	19.9	20.3	19.9	16.9	N.S.
	% Protein	9.6	11.4	11.1	11.6	10.6	11.2	11.5	9.8	N.S.
D-3-52	Bushels/acre	28.3	32.5	30.2	29.4	27.4	30.8	31.3	27.0	N.S.
	% Protein	13.7	13.7	13.7	14.0	14.0	13.6	13.7	13.9	N.S.
D-4-52	Bushels/acre	23.0	24.1	27.8	21.7	21.0	23.5	23.6	22.2	N.S.
	% Protein	18.3	18.9	17.2	18.6	18.8	18.8	18.7	18.5	N.S.
D-5-52	Bushels/acre	20.8	25.6**	21.8	24.9*	26.3**	22.8	24.8	23.2	3.2 bus.
	% Protein	10.6	11.7	10.6	10.2	10.9	11.3	11.6	10.2	N.S.
D-6-52	Bushels/acre	12.7	18.1**	13.5	18.0**	18.8**	16.3*	15.4*	13.2	2.9 bus.
	% Protein	10.3	12.7**	10.4	13.9**	13.1**	12.8**	11.3*	11.3*	.74%
D-7-52	Bushels/acre	22.2	26.4	18.3	27.4*	26.5*	26.2	26.3	27.3*	4.3 bus.
	% Protein	8.65	11.9**	8.64	12.3**	12.4**	13.4**	10.5**	10.4**	.88%

Protein analysis based on 14% moisture in grain
N.S. - Not significant

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

The bushel weight of grain from the different experiments varied from 52 to 62 pounds, however, the bushel weight was not significantly affected by fertilization in any location. No significant decreases in yield were obtained by the use of fertilizer as compared with the check plots in any location. Responses to nitrogen were confined to the lighter textured soils.

EXPERIMENTAL RESULTS ON CORN

Brownell Farm (D-8-52), Logan County

This experiment was conducted on a very light textured soil. The initial soil moisture was adequate but after the middle of June the location was subjected to severe drought throughout the remainder of the summer. Some early response to nitrogen was indicated by the size of the stalks early in July. No increase in yield of grain was obtained from any fertilizer treatment at harvest(see Table 3). A significant increase in dry stover was obtained from 40 lbs. of nitrogen in combination with phosphorus. This was probably a carry-over from the earlier favorable growing season. No significant burning or decrease in yield was caused by the fertilization treatments.

Bucklen Farm (D-10-52), Lincoln County

This experiment was conducted on sandy soil which maintained a fairly adequate moisture level throughout most of the growing season.

One of the replications was materially affected by a small blow spot and the results therefore were based on three replications.

The yield of grain was significantly increased in all the fertilized plots in comparison with the no treatment plots. This increase appears to have been caused by nitrogen. A slight further increase in yield was obtained when nitrogen was applied in combination with phosphorus and potassium but this increase was not significantly better than when nitrogen was applied alone.

The 40 pound rate of nitrogen alone or with phosphorus and potassium significantly increased the yield of dry stover and per cent of protein in the grain as compared with the no treatment plots. The 20 pound rate of nitrogen gave no significant response in yield of stover or protein.

The grain yield increase ranged from 5 to 9 bushels per acre (see Table 3). Forty pounds of nitrogen applied in two increments at different times did not have any significant advantage over the other treatments.

Table 3. Yield of Grain, Dry Stover and Protein on Corn

	D-8-52		D-10-52		
Treatment Symbol	Bushel/Acre	Pounds dry Stover/acre	Bushel/acre	Pounds dry Stover/acre	% Protein
Check	23.9	720	28.5	560	7.3
N	22.6	755	34.3*	605	7.6
NN	21.7	770	36.0**	755*	9.0**
N-N	22.9	720	34.7*	720*	8.4*
NP-N	24.3	785	37.3**	735*	8.9**
NNP	23.7	1110**	33.7**	735*	8.3
NNPK	25.1	1060**	37.5**	850**	9.1**
NNPKK	22.6	1260**	37.1**	850**	8.5*
L.S.D. 5%	N.S.	166 lbs.	4.9 bus.	166 lbs.	1.1%
" 1%	N.S.	222 lbs.	6.7 bus.	222 lbs.	1.5%

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

N.S. - Not significant

* - Significant at 5% level

** - Significant at 1% level

SOIL PROPERTIES

The surface soils on which the experimental tests were conducted have a relatively neutral pH. An increased lime content of the subsoils results in a more alkaline reaction. The hard-lands are characterized by their higher clay content, higher moisture equivalents, and lime accumulations which are closer to the surface than in the lighter textured soils. A review of Table 4 shows that most of the hard-land experimental locations contained an adequate supply of moisture at the time the fertilizer was applied. The moisture equivalent is a rough measure of the maximum water holding capacity of field soils which have adequate drainage.

Moderately sandy and sandy soils possess more rapid infiltration and percolation rates for moisture but have a rather low moisture holding capacity as compared with heavier textured soils. Some lighter soils in eastern Colorado show accumulations of clay and lime below a depth of 30 inches which can act as a reservoir for holding larger quantities of water for plant use. These soils appear to make greater utilization of light rainfall than can the hard-land.

The organic matter content of non-irrigated soils in eastern Colorado is relatively low as compared to many agricultural soils in the United States. This material accumulates in the upper portion of the soil profile. Nitrate nitrogen is largely derived from the nitrogen in organic matter. The lighter textured soils contain about 40 per cent less organic matter in the surface 12 inches of soil than the hard-lands. Thus a possible deficiency of nitrogen for plant usage appears more likely to occur on sandier soils. Continuous cropping also tends to prevent nitrate nitrogen accumulations from taking place. Nitrogen deficiencies are particularly noticeable on lighter textured soils during the early spring months when the wheat foliage often has a yellowish-green cast. Wheat stubble-back on hard-lands may show a similar phenomena if competition for nitrogen by bacteria is too great. In any decay process the nitrogen requirement for increased bacterial activity is high and a shortage of available nitrogen for plant use may occur.

Future Experimentation

Eight fertilizer experiments on winter wheat were started in the fall of 1952. These experiments involve the sources of nitrogen, rates of nitrogen in combination with phosphorus and potassium, and time of application (fall versus spring). The nitrogen sources include anhydrous ammonia, ammonium nitrate and urea.

Plans are being drawn for additional fertility experimentation on corn and sorghum during the 1953 season.

Additional studies of soil properties will be continued on the soils collected from the various experimental locations. These studies will include wilting point and available nutrient determinations.

Table 4. Soil Properties and Soil Moisture Levels

Field Number	Depth Inches	Soil Texture	pH	Lime %	Org. Matter %	Nitrogen % Total	Moisture in Soil at Fertilization $\%H_2O$	Moisture Equiv. % H_2O
Klusman D-1-52	0-12	Clay Loam	7.0	0.7	1.75	.094	23.4	24.8
	12-24	" "	8.1	3.5	.81	.030	22.6	27.1
	24-36	" "	8.4	4.6	.52	.029	20.2	26.5
	36-48	" "	8.4	8.2	.37	.019	18.3	25.7
	48-60	" "	7.9	8.0	.35	.018	17.2	24.4
Geisen D-2-52	0-12	Loam	6.2	0.0	1.89	.095	24.0	22.3
	12-24	Clay Loam	7.9	5.7	.93	.059	21.8	25.0
	24-36	" "	8.1	8.6	.59	.039	17.3	26.2
	36-48	" "	8.2	6.5	.34	.021		25.4
	48-60	" "	8.1	5.6	.31	.019		26.0
Brown D-3-52	0-12	Silty Clay Loam	7.6	3.4	2.03	.105	18.5	26.2
	12-24	" " "	7.7	12.2	.82	.046	16.6	26.2
	24-36	" " "	8.2	10.4	.68	.035	18.8	27.0
	36-48	Clay Loam	8.4	9.2	.56	.030	19.4	28.4
	48-60	" "	8.3	5.3	.40	.025	19.1	28.9
Walker D-4-52	0-12	Clay Loam	6.7	1.1	1.25	.081	17.3	22.5
	12-24	" "	7.8	10.4	.92	.057	17.9	25.2
	24-36	" "	8.0	11.7	.62	.038	19.3	25.1
	36-48	" "	8.3	7.7	.51	.027	18.5	25.3
	48-60	" "	8.2	9.2	.32	.025	18.3	26.2
Atkins D-5-52	0-12	Loamy Sand	7.1	0.0	.82	.037	9.3	6.9
	12-24	" "	7.0	0.0	.93	.035	9.4	9.9
	24-36	" "	7.3	0.2	.83	.032	9.8	9.8
	36-48	Sandy Loam	8.0	7.8	.54	.030		18.1
	48-60	" "	8.1	5.7	.51	.016		16.4

Table 4 Continued. Soil Properties and Soil Moisture Levels

Field Number	Depth Inches	Soil Texture	pH	Lime %	Org. Matter %	Nitrogen % Total	Moisture in Soil at Fertilization $\%H_2O$	Moisture Equiv. $\% H_2O$
	0-12	Sandy Loam	7.2	0.06	1.03	.051	18.2	18.0
Wilcoxen	12-24	" "	7.2	0.03	.93	.050	17.4	18.2
D-6-52	24-36	" "	7.2	1.8	.70	.043	14.5	17.5
	36-48	" "	8.0	6.7	.48	.028	11.7	15.6
	48-60	" "	8.0	5.3	.23	.017	11.4	14.5
	0-12	Sandy Loam	7.1	0.2	.91	.049	13.8	12.9
Abbott	12-24	" "	7.2	0.0	.85	.051	13.8	16.0
D-7-52	24-36	" "	7.2	0.6	1.00	.052	13.7	17.2
	36-48	" "	7.8	1.4	.51	.029	12.8	17.1
	48-60	" "	7.9	3.0	.35	.021	12.4	16.9
	0-12	Loamy Sand	6.7	0.0	.92	.034	10.7	7.2
Brownell	12-24	" "	6.4	0.0	.68	.024	13.2	8.0
D-8-52	24-36	Sand	6.6	0.02	.45	.014	9.9	8.4
	36-48	"	6.9	0.04	.31	.009	9.2	8.1
	48-60	Loamy Sand	6.8	0.02	.23	.006	8.4	9.5
	0-12	Loamy Sand	7.2	0.07	1.40	.057	7.4	9.5
Bucklen	12-24	Sandy Loam	7.8	3.8	.82	.042	13.0	17.3
D-10-52	24-36	Sandy Clay Loam	8.0	8.3	.54	.021	15.2	18.8
	36-48	Loam	8.2	7.0	.34	.019	12.6	19.0
	48-60	"	8.2	5.6	.25	.018	14.4	19.8