Fertilizers for Oklahoma Potatoes

By EARL F. BURK

The Right Fertilizer Produces Profitable Crop Increases.
Center: No fertilizer; yield 37 bu. per acre.
Right: 800 lbs. 4-4-4; yield 120 bu. per acre.
Left: 800 lbs. 4-6-4; yield 143 bu. per acre.

What fertilizer will be the right one depends on soil, climate, and moisture supply. Recommendations for various sections of Oklahoma are given on pages 3 to 5.

OKLAHOMA AGRICULTURAL EXPERIMENT STATION

Oklahoma A. and M. College, Stillwater

W. L. BLIZZARD, *Director* LIPPERT S. ELLIS, *Vice Director*

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CONTENTS

FERTILIZERS FOR OKLAHOMA POTATOES

By EARL F. BURK
Assistant Professor of Horticulture

The first potato growers to use commercial fertilizers in this state followed recommendations that had been found beneficial in other parts of the country. Because the moisture, temperature, and soil conditions in Oklahoma are somewhat different from those of other states, these recommendations did not always work out satisfactorily here. Tests were therefore undertaken by the Oklahoma Agricultural Experiment Station to find the most beneficial fertilizers and rates of application under Oklahoma conditions. These tests, were conducted during the years 1930 to 1937 at eight localities in the state. The results are presented in this bulletin. The location and duration of each test is shown in Table 1.

GENERAL RESULTS AND RECOMMENDATIONS

RATIOS AND RATES OF APPLICATION

Results of these tests indicate that, where there is some doubt as to what fertilizer to use for potatoes, a tentative recommendation would be a 4-12-4* fertilizer on the heavier and a 6-12-6 on the lighter soil types. These will come closest to fitting all conditions with the least chance for detrimental effects during drought.

From 400 to 600 pounds per acre would likely be a desirable quantity, since the cash returns from the potato crop will generally justify the application of larger quantities of fertilizer than would be applied to cotton and other field crops.

With one or two exceptions, the results from these fertilizer tests do not indicate the advisability of using more potash than nitrogen in the mixed fertilizers. This is contrary to some concepts and fertilizer practices in certain sections of the state.

Varying soil and climatic conditions, of course, make it imposible to recommend one kind and rate of fertilizer for all locations. The variation in the soils used in these tests is shown by the varying fertilizer requirements for maximum potato production given in Table 1. Other soils used for potato production in the state may differ in requirements from those

* The fertilizer constituents are given in the order: nitrogen, phosphoric acid, and potash. A 4-8-4 formula indicates 4 percent nitrogen, 8 percent prosphoric acid, and 4 percent potash. This is maintained throughout the bulletin in referring to those elements, following the usual form of presenting fertilizer analyses.

Figure 1.—Yield data in fertilizer tests were based on the center two rows of four-row plots. Here these rows are being harvested, graded, and weighed to find the effects of the various fertilizer treatments used.

studied. In such cases, the recommendations given in Table 1 for the soil type most similar to the one in question would likely be the best to use. Generally, the sandier the soil the greater the need for nitrogen, and the greater the percentage of clay in the soil the less the need for potash.

SUGGESTIONS CONCERNING APPLICATION OF THE RECOMMENDATIONS

Fertilizer tests extending over a period of one or two years do not give sufficient data for making definite recommendations. However, results from only one year, if interpreted conservatively, often give some clue or indication that may be helpful in formulating a fertilizing program until more extended tests have been completed.

The recommendations given in Table 1 are all based on use of leguminous green manure crops, particularly on the sandier soils (See pages 32 to 34). Application of the recommendations under practical conditions should be made only after a study

TABLE 1.—Potato Fertilizer Recommendations.

Location of Test	Length of Test* (Years)	Soil Type	FERTILIZER RECOMMENDED**	
			Rate (Lbs. per Acre)	Grade
Stillwater; Exp. Sta. farm	5	Fine sandy loam	400	6-12-6
Heavener; Experiment farm	4	Fine sandy loam	600	6 -8-4
Lone Grove; Exp. farm	5	Very fine sandy loam	267	6-12-6
Idabel; Herron farm	4	Silty clay loam	400	4-12-0
Idabel; Cabeness farm	1	Fine sandy loam with small gravel	800	6- 8-4
Muskogee; Kreipke farm	1	Dark, silty clay loam	400	6-12-6
Muskogee; Brown farm	2	Very fine sandy loam	300-400	6-12-6
Muskogee; Scott farm	2	Very fine sandy loam	400	6-12-9
Ft. Gibson; Stevens farm	1	Sandy silt loam	250-400	6-12-6
Porter; Jameson farm	1	Dark very fine sandy loam	legume in rotation	
		Lighter soils	300-500	4-12-4
Roland; Mayfield farm	1	Fine sandy loam	400-600	4-12-4
Guthrie; Johnson farm	1	Very fine sandy loam	400	4-12-4
			300	Superphosphate (20%) with leguminous green manure

* Fertilizer recommendations given for locations where tests were conducted for only one or two years should be considered only as tentative. More tests should be conducted before specific recommendations can be formulated.

** In combination with all of the recommendations, particularly those for the sandier soils, a leguminous green manure should be used to add humus and at least a part of the nitrogen.

of the relation between fertilizer treatment and moisture supply (See pages 28 to 32).

Generally the soil fertility is lower in the eastern half than in the western half of the state. In the eastern section a longer period of cultivation and heavier rainfall have caused a greater loss of nutrients from the soil. Therefore, considering the lower rainfall, greater evaporation and on the whole a higher soil fertility in the western part of Oklahoma, it may be assumed as a general rule that lighter applications of fertilizer should be made in the western and central parts of the state and heavier applications in the eastern section.*

* The first step in determining what treatment a soil needs in order to grow potatoes is to have a chemical analysis made of the soil. A limited number of such analyses can be made by the soils laboratory of the Oklahoma A. and M. College. Information on how to take soil samples can be secured from your county agent or by writing to the Agronomy Department of the college at Stillwater.

Figure 2.—Fertilizer was applied to the test plots by means of a long-tubed funnel. More recent work indicates that the sideband method of application is preferable.

In making the tests reported in this bulletin, the mixed fertilizers were applied to the bottoms of the furrows, just prior to planting, by using a large funnel with a long tube (See Figure 2). The fertilizer was then mixed in the soil with a hand garden cultivator or with sweeps on a two-row field cultivator. More recent experiments have shown that applying fertilizer in bands two inches to either side of the seed piece gives better results with less chance of injury to either the seed piece or sprouts when heavy applications are made (12). The results of these fertilizer tests should therefore be considered in the light of the method of fertilizer application which was used.

RELATION BETWEEN COST OF FERTILIZER AND INCREASED YIELDS

In the final analysis, fertilizer should be applied only if it increases yields and quality enough to produce a profit over and above the total cost of the fertilizer and its application.

Table 2 shows the yields of No. 1 potatoes produced with and without the use of fertilizers, value of the increases due to fertilizers, and cost of fertilizer recommended for each location where the fertilizer tests were conducted. Such data will give a conservative idea of what might be expected as a result of the use of fertilizers. The value of the gain in potatoes as given in Table 2 is only the U. S. No. 1 size and does not consider the increase in No. 2, nor the possibility of No. 1A grade which often results from proper fertilization.

TABLE 2.—Yield, Increase and Profits From the Use of Fertilizer.

Place	YIELDS* OF NO. 1 POTATOES (BU.)			Value of gain in potatoes at 60¢ per bu.	Cost of recommended fertilizer**
	Unfertilized	Fertilized	Gain		
Stillwater	62	99	34	$22.20	$ 7.60
Heavener	21	105	84	50.40	10.50
Lone Grove	14	63	49	29.40	5.07
Idabel (Herron)	67	116	49	13.80	4.60
Idabel (Cabeness)	28	147	119	71.40	14.00
Muskogee (Kreipke)	95	137	42	25.20	7.60
Muskogee (Brown)	152	173	21	12.60	5.70
Muskogee (Scott)	72	115	43	25.80	8.20
Ft. Gibson	65	102	37	22.20	4.75
Porter	----	----	----	----	----
Roland	116	172	56	33.60	6.60
Guthrie	50	97	47	28.20	6.60

* The yields given for the non-fertilized or check plots are taken from the averages in tests. The yields given for the fertilized are either the actual yields or calculated yields based on the actual yields for the lowest amount of fertilizer in Table 1.

** Cost of fertilizer is based on 1939 quotations for ton lots. This does not include cost of application, which may range from $.75 to $1.50 per acre.

RESULTS AND RECOMMENDATIONS BY LOCALITIES

STILLWATER

Tests were conducted on the experiment station farm nine miles south of Stillwater near Perkins for five years, 1930 to 1934. (See tables 3 to 7.) The soil is a Canadian fine sandy loam 12 to 24 inches in depth, which has a sandy clay subsoil. The rainfall for four of the five growing seasons during this period was considerably below normal for that locality.

Prior to the initiation of the potato fertilizer studies, the land had been used for cotton production and had never been fertilized with commercial fertilizer. When the fertilizer test was being conducted, a two-year rotation was followed. Sweet potatoes were planted on alternate years with the Irish potatoes for 2 of the 3 potato blocks, and potatoes in the third block followed watermelons, potatoes, cabbage or cow peas. The watermelon and cabbage crops received the same fertilizer as the potatoes.

TABLE 3.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Nitrogen; Stillwater, Oklahoma.

	No treatment	0-8-4	2-8-4	4-8-4	6-8-4	8-8-4	10-8-4
1930	101	131	186	212	232	233	245
1931*	15	28	33	22	24	20	22
1932	93	128	117	129	89	90	83
1933	71	106	124	95	106	90	75
1934	23	40	40	32	37	42	40
Average	61	87	100	98	97	105	93

F value: required at 5 percent, 2.51; found 1.12. (See appendix page 41, for method of analysis.)

All fertilizers applied at rate of 800 pounds per acre.

* Low yields for the 1931 season are attributed to the growth of a winter rye crop which was plowed in just prior to planting the potatoes (see text p. 33).

TABLE 4.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Phosphorus; Stillwater, Oklahoma.

	No treatment	4-0-4	4-4-4	4-6-4	4-8-4	4-10-4	4-12-4
1930	106	135	179	212	217	211	203
1931	17	22	30	30	24	24	32
1932	86	80	112	97	122	105	97
1933	70	77	117	113	94	102	115
1934	23	25	37	40	32	42	32
Average*	60	67	95	98	97	96	96

F values: required at 1 percent, 3.67; found 4.13.

All fertilizers applied at rate of 800 pounds per acre.

* Difference required for significance: 22 bushels.

TABLE 5.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Potash; Stillwater, Oklahoma.

	No treatment	4-8-0	4-8-2	4-8-4	4-8-6	4-8-8
1930	108	179	212	220	230	198
1931	16	26	22	24	25	31
1932	73	95	87	110	89	105
1933	59	107	75	84	67	65
1934	23	32	33	32	33	32
Average	56	87	86	94	89	86

F values: required at 5 percent, 2.51; found 2.34.

All fertilizers applied at rate of 800 pounds per acre.

In interpreting the results of the tests at Stillwater, consideration should be given to the fact that for the last four of the five years, May and June rainfall was far below average. Considerable weight should therefore be given to the response received in the first year (1930) when moisture probably was not a limiting factor.

On the basis of the studies conducted at Stillwater during the five-year period, it first appears that 400 pounds of a 4-8-0 would be the fertilizer recommendation. However, in light of

TABLE 6.—Yields in Bushels Per Acre in Relation to Rate of Application of a 4-8-4 Fertilizer; Stillwater, Oklahoma.

	No treatment	400 lb. /A.	600 lb. /A.	800 lb. /A.	1000 lb. /A.	1200 lb. /A.
1930	106	182	205	217	220	272*
1931	14	22	20	22	17	21
1932	87	128	132	122	104**	113
1933	77	115	97	101	96	88
1934	25	30	42	33	33	42
Average	62	96	99	99	94	122

F values: required at 5 percent, 2.71; found 2.0.

* In 1930 only one series was run, therefore it would seem wise to discount to some extent the exceptionally high yield for the 1,200-pound rate of application.

** In 1932 some of the potatoes were stolen from some plots, and it was impossible to get accurate yields. One of the three plots of 1,000-pound applications from which the above is an average showed an increased yield above the 800-pound application, while two showed a loss. In the light of the above and the fact that there was abundant rainfall during May and June, it is considered reasonable to believe that the average for 1000-pound application in 1932 should have been higher. The resulting five-year average for the 1000-pound would also be closer to the average yield for the 800-pound treatment.

TABLE 7.—Precipitation Records for Period of Potato Fertilizer Tests at Stillwater, Oklahoma.
(Inches of rainfall)

	April	May	June
1930	2.51	7.47	4.76
1931	3.37	1.71	2.72
1932	.97	1.65	5.87
1933	2.36	5.01	.06
1934	2.60	2.18	1.43
1930 to 1935	2.36	3.60	2.97
10 years prior to 1930	4.88	4.50	4.66
1893 to 1930*	4.02	5.01	3.95
5 years following 1934	1.95	4.55	5.27

* The data for average rainfall 1893 to 1930 and for the 10-year average prior to 1930 were taken from rainfall records at Stillwater, which is nine miles from the experiment station farm. The other data are from records taken at Perkins, which is 2 miles from the experimental farm.

the responses obtained during years of more rainfall in June and the probability that over a long period the rainfall will more likely approximate the normal, rather than the subnormal of 1931 to 1934, the recommendations should be altered to agree with a more favorable moisture supply. Recommendations to fit the normal conditions therefore should include more nitrogen and potash than is suggested by the five-year summaries presented. Hence the recommendations would be the equivalent of 600 lbs. of 4-8-4, and this would be most economically supplied as 400 lbs. of 6-12-6.

If a green manure crop were grown in rotation with the potatoes, it would supply organic matter as well as part of the nitrogen. When some nitrogen is supplied by the green manure crop, 400 lbs. of a 4-12-4 fertilizer should be satisfactory.

HEAVENER

The fertilizer studies were conducted at the Heavener experimental farm for a period of four years, 1931 to 1934 inclusive, in an upland sandy loam previously used for general farm crops and very low in organic matter. The potatoes were grown in a two-year rotation with oats. The fertilizer was applied only to the potatoes and just prior to planting.

A summary of the results (See Tables 8 to 12) shows that, in the 800-pound applications, 4 to 6 percent of nitrogen, 8 percent of phosphorous, and 4 percent of potassium gave the most significant returns. In the rate test, a 400-pound application gave a significant increase, with good indications for worthwhile response from 600 or 800 pounds.

From this, the deduction is made that a 600-pound application of a 6-8-4 fertilizer under such conditions would have been the most economical for potatoes in rotation with oats.

Since this upland soil is very low in organic matter, it appears desirable that a program for soil improvement be adopted. Cow peas or lespedeza as a green manure crop following small grain would fit into the potato-oats rotation following the oat crop, and should provide some nitrogen as well as organic matter. Assuming that a ton of cow peas provides the equivalent of about 16 pounds of nitrogen to the potato crop, the nitrogen in the fertilizer may be reduced proportionately. Thus, when such a green manure crop is grown, it is possible that 600 pounds of a 3-8-4 should be sufficient. However, it would be more economical to apply 400 pounds of 4-12-6 which provides approximately the same amount of nutrients.

TABLE 8.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Nitrogen; Heavener, Oklahoma.

	No treatment*	0-8-4	2-8-4	4-8-4	6-8-4	8-8-4
1931	33	89	135	179	165	160
1932	44	48	95	109	126	129
1933	47	71	117	136	156	168
1934	16	55	82	80	94	85
Average**	35	66	107	126	136	136

F values: required at 5 percent, 2.9; found 4.31.
* Average of 11 check plots each year.
** Difference required for significance: 23 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 9.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Phosphorous; Heavener, Oklahoma.

	No treatment	4-0-4	4-4-4	4-6-4	4-8-4	4-10-4	4-12-4
1931	33	33	141	143	179	157	173
1932	44	57	97	113	109	109	122
1933	47	87	100	116	136	134	95
1934	16	19	67	72	80	70	88
Average*	35	49	101	111	126	118	120

F values: required at 1 percent, 4.01; found, 12.7.
* Difference required for significance: 29 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 10.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Potash; Heavener, Oklahoma.

	No treatment	4-8-0	4-8-2	4-8-4	4-8-6	4-8-8	4-8-10	4-8-12
1931	33	130	153	179	176	161	178	166
1932	44	118	110	109	118	115	128	119
1933	47	109	89	136	113	119	122	139
1934	16	71	88	80	89	95	91	92
Average*	35	107	110	126	124	123	130	129

F values: required at 1 percent 3.51; found 18.4.
* Difference required for significance: 21 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 11.—Yields in Bushels Per Acre in Relation to Rate of Application of a 4-8-4 Fertilizer; Heavener, Oklahoma.

	No treatment	200 lb./A.	400 lb./A.	600 lb./A.	800 lb./A.	1000 lb./A.
1931	33	98	165	159	179	174
1932	44	74	87	100	109	114
1933	47	65	92	118	136	139
1934	16	50	70	59	80	85
Average*	35	72	104	109	126	128

F values: required at 1 percent 4.56; found 9.6.

* Difference required for significance: 33 bushels.

*TABLE 12.—Precipitation Record for Period of Potato Fertilizer Tests at Heavener, Oklahoma.**

(Inches of rainfall.)

	April	May	June
1931	3.35	4.40	1.89
1932	1.80	3.61	10.06
1933	6.14	5.51	.83
1934	1.65	4.14	1.24
Average 1931-1934	3.26	4.42	3.51
Average prior to 1932	5.48	4.56	4.40

* The rainfall records listed in this table were taken at Poteau, 10 miles north of Heavener.

LONE GROVE

Fertilizer studies were conducted at the Lone Grove experimental farm for five years, 1931 to 1935 inclusive. (See Tables 13 to 17.) The upland Durant fine sandy loam on which the potatoes were grown had previously been farmed to cotton and was quite low in fertility. During the tests, the potatoes were rotated with oats the same as at the Heavener station. Fertilizer was applied only to the potatoes.

A summary of the data indicates that 2 percent nitrogen, 4 percent phosphorus and 2 percent potash were the best percentages in an 800-pound application. In the rate test, 400 pounds of 4-8-4 gave best results.

From the above results, it is concluded that the best application would be the equivalent of 400 pounds of 4-8-4. It would be more economical to apply this as 267 pounds of 6-12-6.

Since the soil on which these tests were conduced was low in organic matter, it appears desirable that a rotation of a leguminous green manure crop to provide humus should be adopted in connection with the fertilizer program. An increase of organic matter in the soil should result in increased returns for the fertilizer applied.

TABLE 13.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Nitrogen; Lone Grove, Oklahoma.

	No treatment	0-8-4	2-8-4	4-8-4	6-8-4	8-8-4	10-8-4
1931	10	36	36	38	43	24	22
1932	24	64	94	102	53	46	45
1933	23	44	63	75	62	52	54
1934	31	63	74	55	57	58	50
1935	30	63	100	108	108	110	112
Average*	24	54	73	76	65	58	57

F values: required at 1 percent 3.67; found 6.98.
* Difference required for significance: 18 bushels.
All fertilizers applied at rate of 800 pounds per acre.

Figure 3.—Fertilizer increased potato yield four times in one test at Lone Grove. The two center rows received 4-8-4 at rate of 600 lbs. per acre and produced 110 bushels per acre. The two adjoining rows received no fertilizer and produced 24 bushels per acre.

TABLE 14.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Phosphorus; Lone Grove, Oklahoma.

	No treatment	4-0-4	4-4-4	4-6-4	4-8-4	4-10-4	4-12-4	4-16-4
1931	10	14	44	45	38	43	38	36
1932	24	14	47	47	102*	43	77	87
1933	23	34	65	64	75	74	76	69
1934	31	32	60	58	55	71	58	56
1935	30	87	95	95	108	101	105	99
Average**	24	36	62	60	76	66	71	69

* Although this yield is questionable as used in the phosphorus test, it does not materially change the final results.
F values: required at 1 percent, 3.53; found, 4.93.
** Difference required for significance: 23 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 15.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Potash; Lone Grove, Oklahoma.

	No treatment	4-8-0	4-8-2	4-8-4	4-8-6	4-8-8	4-8-10	4-8-12
1931	10	25	40	38	47	48	48	46
1932	24	49	90	102	72	68	103	78
1933	23	72	81	75	99	87	82	79
1934	31	58	54	55	71	59	48	47
1935	30	81	112	108	124	130	137	105
Average*	24	57	77	76	83	78	82	71

F values: required at 1 percent, 2.23; found, 15.6.
* Difference required for significance: 15 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 16.—Yields in Bushels Per Acre in Relation to Rate of Application of a 4-8-4 Fertilizer; Lone Grove, Oklahoma.

	No treatment	200 lb./A.	400 lb./A.	600 lb./A.	800 lb./A.	1000 lb./A.	1200 lb./A.
1931	10	21	44	51	38	41	28
1932	24	80	83	104	102	100	74
1933	23	56	83	72	75	71	65
1934	31	58	74	65	55	51	64
1935	30	37	87	100	109	106	96
Average*	24	50	74	78	76	74	65

F values: required at 1 percent 3.67; found 11.7.
* Difference required for significance: 16 bushels.

TABLE 17.—Precipitation Record for Period of Potato Fertilizer Tests at Lone Grove, Oklahoma.*
(Inches of rainfall.)

	April	May	June
1931	1.22	1.08	.60
1932	3.33	2.90	5.92
1933	2.66	9.23	.06
1934	2.46	2.40	.73
1935	1.84	13.16	9.86
Average 1931 - 1935	2.30	5.75	3.43
Average prior to 1932	4.39	4.70	3.80

* The rainfall records listed in this table were taken at Ardmore, eight miles east of Lone Grove.

IDABEL

Bottomland Tests on Herron Farm

Idabel, Oklahoma, near the Red River Valley, is the potato producing center of the southeastern part of the state. Cooperative fertilizer tests were conducted for four years, 1934-1937 inclusive, on the Leonard G. Herron farm 10 miles west of Idabel. (Tables 18 to 22.) The soil was a silty clay loam in the Red River bottoms. The tests were conducted on the same plots each year and the potatoes were usually followed by a fall crop of corn which was not fertilized.

TABLE 18.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Nitrogen; Herron Farm, Idabel, Oklahoma.

	No treatment	0-8-4	4-8-4	8-8-4
1934	96	104	125	125
1935*	91	107	126	117
1936	145	173	162	146
1937	116	128	136	137
Average**	112	128	137	131

F values: required at 5 percent, 3.86; found 5.49.
* There was a superabundance of rainfall in 1935.
** Difference required for significance: 13 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 19.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Phosphorus; Herron Farm, Idabel, Oklahoma.

	No treatment	4-0-4	4-4-4	4-8-4	4-12-4
1934	96	114	124	125	113
1935	91	114	122	126	130
1936	145	146	155	162	176
1937	116	110	115	136	127
Average*	112	121	129	137	137

F values: required at 1 percent, 5.41; found 7.26.
* Difference required for significance: 11 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 20.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Potash; Herron Farm, Idabel, Oklahoma.

	No treatment	4-8-0	4-8-4	4-8-8	4-8-12
1934	96	130	125	121	125
1935	91	111	126	136	129
1936	145	175	162	163	153
1937	116	143	136	141	138
Average*	112	140	137	140	136

F values: required at 1 percent, 5.41; found 9.6.
* Difference required for significance: 11 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 21.—Yields in Bushels Per Acre in Relation to Rate of Application of a 4-8-4 Fertilizer; Herron Farm, Idabel, Oklahoma.

	No treatment	200 lb./A.	400 lb./A.	600 lb./A.	800 lb./A.	1000 lb./A.	1200 lb./A.
1934	96	107	110	118	125	132	114
1935	91	101	102	102	126	130	123
1936	145	164	166	161	162	174	169
1937	116	109	125	135	136	128	125
Average*	112	120	125	131	137	143	134

F values: required at 1 percent, 4.61; found 6.16.
* Difference required for significance: 11 bushels.

TABLE 22.—Precipitation Records for Period of Potato Fertilizer Tests at Idabel, Oklahoma.
(Inches of rainfall.)

	April	May	June
1933	5.15	7.44	1.77
1934	4.07	1.19	2.57
1935	6.46	11.03	9.66
1936	.97	5.17	.03
1937	3.20	5.57	4.35
Average 1934 to 1937 inclusive	3.68	5.74	4.15
Average prior to 1932	4.61	6.14	4.5

In comparing yields with rainfall distribution at Idabel, the date of harvest should be considered. Harvest was June 1 in 1933; June 5 in 1934; May 28 in 1935; June 8 in 1936; June 9 in 1937.

The results indicate that in the 800 pound applications, 2 percent of nitrogen, 6 percent phosphorus and no potash gave best yields. The 800 pound applications of 4-8-4 proved superior in the rate test. From this, it would appear that an application of 16 pounds of nitrogen, and 48 pounds of phosphorus as found in 800 pounds of 2-6-0 would be advisable. This would be equivalent to 400 pounds of 4-12-0. It would be preferable to use mixed forms of nitrogen, using 40 pounds of ammonium sulphate (20 percent) and 50 nitrate of soda (16 percent) and mixing it with 240 pounds of superphosphate (20 percent). This fertilizer should be used at the rate of 330 pounds per acre in order to be equivalent to 400 pounds of 4-12-0.

In the light of results secured at this location, it appears that the response to both nitrogen and potash is relatively low, especially to potash. This is in agreement with what should be expected with a clay loam soil which had not yet been exhausted by intensive corn and cotton program. Under such circumstances, it is probable that the inclusion of cow peas or some other leguminous crops used as a green manure together with an application of about 240 pounds of superphosphate would meet the fertilizer requirements of the potato crop.

In cases where the soil in this area has been subjected to a more exhaustive system of cropping it would probably be desirable to apply a complete fertilizer, such as a 4-12-4 and apply it at the rate of 500-600 pounds per acre.

IDABEL

Upland Tests on Cabeness Farm

Commercial potato production in the southeastern part of the state in the vicinity of Idabel is not limited to bottom land. Some of the smoothest and highest grade potatoes are produced on sandy upland soil. Therefore, fertilizer tests including ratio and rate studies similar to tests on the bottom land were conducted in 1933 at the C. M. Cabeness farm 8 miles southeast of Idabel. (See Tables 22 to 26.) The soil was a very sandy loam containing a proportion of very small gravel and locally is called "buckshot soil." The season was excellent for the test, and, the yield differences between the various treatments are for the most part outstandingly significant. Because of this fact, even in the light of the test being for only one year, the findings are considered of some importance in making tentative recommendations for such soils.

Figure 4.—Potato fertilizer test on upland near Idabel. Extreme left, no treatment, yield 42 bushels per acre. Left of center, 800 lbs. 6-8-4, yield 174 bushels per acre. Right of center, 800 lbs. 2-8-4, yield 144 bushels per acre.

Even though the data secured for the one year gives very strong evidence of a lack of response to potash, there is some question as to the advisability of recommending a fertilizer for a sandy soil without some potash in it. Ordinarily, a soil as sandy as this one is low in potash, but whether or not this soil contains sufficient potash bearing clay for the potato crop cannot be stated positively without further tests.

TABLE 23.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Nitrogen; Cabeness Farm, Idabel, Oklahoma.

	No treatment	0-8-4	2-8-4	6-8-4	8-8-4	10-8-4
Series 1	48	91	169	193	189	190
Series 2	35	48	118	154	174	192
Average*	42	70	144	174	182	191

F values: required at 1 percent, 10.97; found, 184.5.
* Difference required for significance: 30 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 24.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Phosphorus; Cabeness Farm, Idabel, Oklahoma.

		4-0-4	4-4-4	4-6-4	4-10-4	4-12-4	4-16-4
Series 1	40	80	85	119	103	131	115
Series 2	34	60	154	166	155	186	181
Average*	37	70	120	144	129	159	148

F values: required at 5 percent, 4.28; found, 6.51.
* Difference required for significance: 50 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 25.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Quantities of Potash; Cabeness Farm, Idabel, Oklahoma.

	No treatment	4-8-0	4-8-2	4-8-6	4-8-8	4-8-10	4-8-12
Series 1	28	123	113	122	102	103	114
Series 2	89	191	197	177	194	181	175
Average*	59	158	155	150	148	142	145

F values: required at 5 percent, 4.38; found, .43.
* Difference required for significance, 84 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 26.—Yields in Bushels Per Acre in Relation to the Rate of Application of a 4-8-4 Fertilizer; Cabeness Farm, Idabel, Oklahoma.

	No treatment	200 lb./A.	400 lb./A.	600 lb./A.	800 lb./A.	1000 lb./A.	1200 lb./A.
Series 1	64	127	167	174	184	178	179
Series 2	28	64	93	118	159	179	170
Average*	46	96	130	146	171	179	175

F values: required at 1 percent, 8.47; found, 11.98.
* Difference required for signifance: 40 bushels.

Therefore, until further evidence is available, it would seem logical to include some potash, possibly 4 percent, along with 6 percent and 8 percent of nitrogen and phosphorus respectively (6-8-4). It would appear advisable to use a 3-4-2 ratio sufficient to supply about 48 pounds of nitrogen, 64 pounds of phosphorus and 32 pounds of potash. This would be equivalent to 800 pounds of 6-8-4 and preferably in a more economical form of 600 lbs. of 8-12-6 if available.

MUSKOGEE

Scott Farm

In 1936 and 1937, tests were conducted on the W. N. Scott farm 12 miles southeast of Muskogee in the Arkansas River Valley. (See Tables 27 to 33.) The soil is a Yahola very fine sand and has been under cultivation for many years.

Because of the limited area available, the "ratio" series was reduced in 1937; and it is therefore difficult to make unqualified recommendations, especially concerning phosphorus and potash. Analysis of the results must also take into consideration that rainfall was below normal for the region during both seasons but was nearest the average in 1937.

On the basis of the data available, it appears that for this Arkansas Valley fine sandy soil a fertilizer with a 1:2:1.5 ratio such as a 4-8-6 should prove desirable. When applied in the row, a quantity of 600 pounds per acre should be satisfactory. From the standpoint of economy, 400 pounds of a 6-12-9 is more desirable. The data for 1936 indicate that relatively less potash (400 lbs. of 4-12-4) would be required when there is a moisture deficiency.

Figure 5.—W. N. Scott, Muskogee, displays results of tests made on his farm in the Arkansas River Valley. The untreated plot on the left made 81 bushels per acre. Application of 4-8-4 at 800 pounds per acre produced 120 bushels per acre on the plot at the right.

TABLE 27.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Amounts of Nitrogen; Scott Farm, Muskogee, Oklahoma; 1936.

	No treatment	0-8-4	4-8-4	8-8-4
Series 1	86	113	125	110
Series 2	82	97	106	127
Series 3	77	112	116	107
Series 4	87	90	118	113
Average*	82	103	116	114

F values: required at 1 percent, 6.99; found, 12.41.
* Difference required for significance: 13 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 28.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Amounts of Phosphorus; Scott Farm, Muskogee, Oklahoma; 1936.

	No treatment	4-0-4	4-4-4	4-8-4	4-12-4
Series 1	86	110	128	125	125
Series 2	82	103	133	106	107
Series 3	77	113	103	116	152
Series 4	82	122	110	118	137
Average*	82	112	119	116	130

F values: required at 1 percent, 5.41; found, 8.32.
* Difference required for significance: 18 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 29.—Yields in Bushels Per Acre in Relation to Fertilizers Supplying Varied Amounts of Potash; Scott Farm, Muskogee, Oklahoma; 1936.

	No treatment	4-8-0	4-8-4	4-8-8	4-8-12
1	86	115	125	132	113
2	82	127	106	105	115
3	77	115	116	148	122
4	82	112	118	105	123
Average*	82	117	116	123	118

F values: required at 1 percent, 5.41; found, 9.56.
* Difference required for significance: 15 bushels.
All fertilizers applied at rate of 800 pounds per acre.

TABLE 30.—Yields in Bushels Per Acre in Relation to Rate of Application of a 4-8-4 Fertilizer; Scott Farm, Muskogee, Oklahoma; 1936.

	Check	200	400	600	800	1000	1200
Series 1	86	103	88	113	125	123	98
Series 2	82	122	120	136	106	122	103
Series 3	77	100	107	107	116	107	93
Series 4	82	95	102	122	118	130	145
Average*	82	105	104	120	116	121	110

F values: required at 1 percent, 4.01; found, 4.51.
* Difference required for significance: 18 bushels.

TABLE 31.—Yield Data in Relation to Fertilizers Supplying Various Quantities of Nitrogen, Phosphorus and Potassium; Scott Farm, Muskogee; 1937.

	4-8-0	4-8-4	4-8-8	4-12-4	8-8-4	⅔ C.S.M.**
Total yield:						
Pounds per plot	55.9	61.1	67.1	58.1	62.5	62.5
Bushels per acre	112	122	134	116	125	125
Marketable yield:						
Pounds per plot*	52.8	58.2	63.0	55.3	59.3	59.3
Bushels per acre*	106	116	126	111	119	119
Percent of total	95	95	94	95	95	95

F values: required at 1 percent, 11.3; found, 12.7.
* Difference required for significance: 5.6 lbs. per plot: 11.3 bushels per acre.
** 4-8-4 fertilizer with ⅓ of the nitrogen as sodium nitrate and ⅔ as cottonseed meal.

TABLE 32.—Yield Data in Relation to Applications of a 4-8-4 Fertilizer; Scott Farm, Muskogee; 1937.

	No treatment	200 lb./A.	400 lb./A.	600 lb./A.	800 lb./A.	1000 lb./A.
Total yield:						
Pounds per plot	42.3	55.8	62.2	67.0	68.9	65.5
Bushels per acre	85	112	124	134	138	131
Marketable yield:						
Pounds per plot*	39.6	51.6	58.6	62.7	65.4	62.3
Bushels per acre*	79	103	117	125	131	124
Percent of total	94	93	94	94	95	95

F value: required at 1 percent, 3.86; found, 14.1.
* Difference required for significance: 6.2 lbs. per plot, 12.5 bushels per acre.

TABLE 33.—Precipitation Records for Period of Potato Fertilizer Tests at Muskogee, Oklahoma.
(Inches of rainfall.)

	April	May	June
1931	3.85	2.18	2.01
1932	1.44	1.21	9.37*
1933	5.15	7.44	1.77**
1934	2.74	4.31	2.69
1936	1.41	1.84	.60
1937	3.01	2.52	3.02***
Av. 1931 through 1937	2.93	3.25	3.24
Av. prior to 1932	4.9	4.45	4.23

* Although there was a large total rainfall for this month, there was no appreciable rainfall until the 12th. This was too late to be utilized, the potatoes being harvested about that time.
** There was no rainfall in June of this year until the 13th.
*** Most of this rainfall was distributed over the first half of the month of June, which was the critical period for response from potash.

MUSKOGEE

Brown Farm

The soil of the John Brown farm upon which tests were made in 1932 and 1933 was a Yahola very fine sandy loam. The farm is located 6 miles north and east of Muskogee. An onion crop was grown on the land in 1931 and a crop of turnips as a green manure crop turned under just prior to the planting of each potato crop.

The best results were obtained from 400- and 600-pound applications of a 4-8-4 fertilizer. The yield response to phosphorus was greater than to either nitrogen or potash. There was no indication of increased yields from applications of more

than 4 percent potash added to an 800 pound treatment of 4-8-0. A tentative recommendation based on the two years of test is 300 to 400 pounds per acre of a 6-12-6.

FT. GIBSON

Kreipke Farm

Fertilizer tests were carried on in 1931 in cooperation with Mr. O. C. Kreipke on his farm two miles south of Ft. Gibson (Table 34). The land used was a dark Brewer silty clay loam which had been in alfalfa two years prior to the test.

Since the moisture supply for the season of this test was only about one-half of normal for Muskogee, it would be logical to expect profitable returns from larger quantities of fertilizer in a normal season than was found to give maximum yields for the year of this test. Therefore the tentative recommendation would be 600 pounds of a 4-8-4 fertilizer, which is more economically supplied as 400 pounds of a 6-12-6.

*TABLE 34.—Potato Yields in Fertilizer Tests; Kreipke Farm, Muskogee; 1931.**

Rate of application (Lbs. per acre)	Mixture N-P-K	Av. yields in bushels per acre
No treatment	------	136
800	0-8-4	146
800	4-8-4	161
800	6-8-4	161
800	8-8-4	157
800	10-8-4	153
800	4-0-4	150
800	4-6-4	155
800	4-10-4	174
800	4-8-0	130
800	4-8-2	155
800	4-8-6	148
800	4-8-8	133
800	4-8-12	113
1200	4-8-4	147
400	4-8-4	169

* The results from this test should be interpreted with an understanding that the season was abnormally cool at first and had a rainfall far below normal. (See Table 32.) When the potatoes were harvested, much of the fertilizer was still undecomposed. There is little doubt that with a greater rainfall the maximum yields would have been higher. These yields are based on potential yields calculated from the no-treatment or check plots distributed uniformly throughout the test area.

FT. GIBSON

Kreipke Farm

Fertilizer tests were carried on in 1931 in cooperation with Mr. O. C. Kreipke on his farm two miles south of Ft. Gibson a Reinach silt loam. Although the yields were not entirely consistent, due largely to poor drainage and to variability in soil which was not apparent at planting time, the results did give indications of the relative values of the fertilizers.

Treatments and partial summary of results:

Check	100 bu.	600 lbs.	4-0-4	119 bu.
300 lbs.	4-8-4	124 bu.	600 lbs.	4-4-4	155 bu.
600 lbs.	4-8-4	135 bu.	600 lbs.	4-12-4	135 bu.
600 lbs.	0-8-4	147 bu.	600 lbs.	4-8-0	152 bu.
600 lbs.	8-8-4	109 bu.	600 lbs.	4-8-8	124 bu.

Additions of nitrogen and potash above 4 percent were noticeably detrimental. This might be expected in view of the fact that the soil was low in organic matter and there was only one-half inch of rain from May 25 to June 11. The harvest date was June 20. It appears that a 300 to 600 lb. application of a 4-8-4 was profitable and might be expected to give even greater returns under more favorable conditions. This fertilization may be more economically applied as 250 to 400 pounds of 6-12-6. An increase in organic matter in the soil would also be very beneficial.

PORTER

Jameson Farm

One set of fertilizer tests was conducted cooperatively for one year, 1934, with Mr. E. Jameson, located in the Choska bottoms near Porter, Oklahoma. The Choska bottoms, a strip of land in the Arkansas River Valley, is a large fertile area about three miles wide and ten miles long, composed of dark, very fine sandy loam. The land on which the test was conducted had been well cared for by rotation and green-manuring during previous years.

The results of the fertilizer tests showed only a slight indication of response from nitrogen and phosphorus, but it would appear logical to expect some response to all these elements in seasons of more normal rainfall.* Based on this one-year test

* There was only ½-inch of rainfall from May 16 to June 11. This was apparently the critical moisture period so far as potash was concerned. The potatoes were dug June 21.

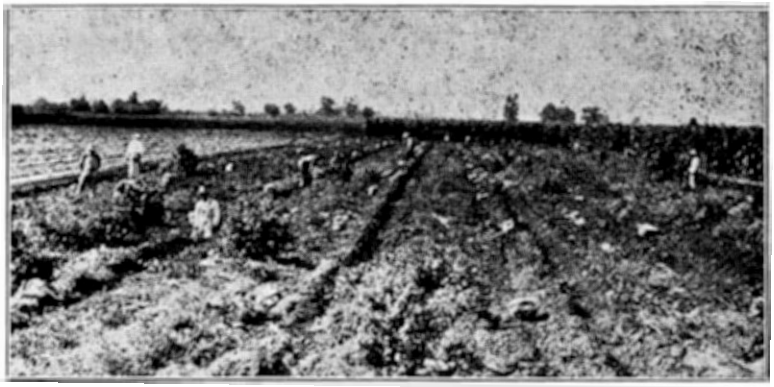

Figure 6.—Grading and weighing potatoes from fertilizer test plots at the Jameson farm near Porter.

and the knowledge that the soil tested rather high in phosphorus and potash, it appears that on the darker, more fertile soils in this area sufficient fertility for potatoes could be maintained by a rotation of crops including a leguminous green manure. On the more sandy soils in this area where green manures have not been used regularly, 300- to 500-pound applications of a 4-12-4 would seem advisable. Further tests are necessary to make specific recommendations.

ROLAND

Mayfield Farm

In 1936, a fertilizer test was conducted at the J. M. Mayfield farm, near Roland, Oklahoma, west of Ft. Smith. The soil was a fine sandy loam previously farmed to general crops, including potatoes and corn.

From the results of this one year's test (See Tables 35 and 36); the suggested fertilizer application is 400 to 600 pounds of a 4-12-4 and a green manure crop at least every second year.

GUTHRIE

Johnson Farm

A test carried on in 1935 in cooperation with Arthur Johnson was located in the Cottonwood Creek valley one mile north of Guthrie, on a very fine sandy loam which was probably high in potash. Harvest delay because of rains caused some rotting of the tubers and resulted in some incomplete yield records. The results obtained (Table 37), however, indicate as a tentative

TABLE 35.—Potato Yields from Some of the Fertilizer Treatments on the Mayfield Farm; Roland, Oklahoma.

Rate of application (Lbs. per acre)	Mixture N-P-K	Yields in bushels per acre
No treatment	------	116
800	0-8-4	143
800	4-8-4	169
800	8-8-4	165
800	4-0-4	163
800	4-12-4	172
800	4-8-0	171
800	4-8-8	179*
800	4-8-12	176*
400	4-8-4	160
800	0-4-0	139
800**	4-8-4	153

** One-half of nitrogen supplied in organic form as cotton seed meal.

* A possible explanation for a favorable response from potash even though the moisture supply was rather low in May is that the low rainfall in April likely prevented the plants from making more vegetative growth than they could later maintain. The .34 inches of rain on May 28 and 1.62 inches on June 2 likely gave the potash a chance to function to advantage with the relatively small plants before harvest on June 10.

TABLE 36.—Precipitation Record for Period of Potato Fertilizer Tests on the Mayfield Farm; Roland, Oklahoma.*

Period of Rainfall	April	May	June
Average prior to 1936	3.94	4.82	3.72
1936	.73	1.96	2.39

* The rainfall records listed in this table were taken at Ft. Smith, Arkansas, 4 miles east of the tests on the Mayfield farm.

TABLE 37.—Potato Yields from Some of the Fertilizer Treatments on the Johnson Farm, at Guthrie, Oklahoma; 1935.

Rate of application (Lbs. per acre)	Mixture N-P-K	Yields in bushels per acre
No treatment	----	81
800	0-8-4	90
800	4-8-4	115
800	4-0-4	73
800	4-12-4	114
800	4-8-0	100
800	4-8-12	92
400	4-8-4	112
300	20 percent superphosphate	134

recommendation either 400 pounds of a 4-12-4 fertilizer or 300 pounds of 20 percent superphosphate per acre. It would be preferable to precede the superphosphate treatment with a leguminous green manure crop.

FACTORS AFFECTING USE OF FERTILIZERS

MOISTURE SUPPLY AND FERTILIZATION*

Importance of Moisture Supply

The tests reported in this bulletin were in agreement with those at other experiment stations which have shown that:

1. There is a close relationship between the amount and distribution of the rainfall and the responses of the potato crop to each of the three fertilizer elements, nitrogen, phosphorus, and potassium.

2. The amount and distribution of rainfall are important factors in determining both the total yield and the grade.

Effect of Moisture on Utilization of Plant Nutrients

Crop response to the various fertilizer treatments was influenced to a large extent by the moisture supply in the soil, with potash being affected most and phosphorus least, and nitrogen intermediate.

Potash.—Response to potash was mostly influenced by the amount of rainfall during the last four weeks prior to harvest. Heavy rainfall during this period increased yields for the heavier potash applications, and light rainfall during this time decreased the yields from the heavier rates.

Injury frequently resulted from use of 32 to 48 pounds of potash per acre in a complete fertilizer when moisture was deficient during the last three or four weeks of the growing season, and the injury was proportional to the quantity of pot-

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* Rainfall is for the most part an index of the moisture supply available. However, exceptions may be found when rainfall data are used in place of actual soil moisture determinations. Only a part of the precipitation may enter the soil so as to be of benefit to the plant. There may be water losses due to runoff because of heavy showers, rolling topography, and poorly prepared seed bed. The loss of absorbed moisture is favored by a porous sub-soil, improper tillage, lack of humus or excessive evaporation. Each affects the ultimate utilization of the rainfall.

The studies reported herein are based on rainfall in relation to fertilizer response, and therefore may not show the relations as accurately as those based on soil moisture. For example, the differences in response to rate of application of fertilizer at Stillwater and at Muskogee indicate a greater difference in precipitation than actually existed. This is probably due to the greater rate of evaporation at Stillwater.

ash applied. The lowering of yields resulting from high applications of potash was always correlated with a deficiency of moisture during the last month of the growth period.

For seasons having rainfall amounting to three inches or more during the last month of the growing period, the yields gradually increased in response to applications of potash up to 8 and 10 percent in the case of certain soils which apparently were deficient in potash.

Similar responses to potash in relation to moisture were found in tests conducted in Arkansas in 1920 to 1925.

From the results obtained in these experiments, it appears that potash must be used conservatively when the moisture supply is limited either because of the porous nature of the soil or because of lack of rainfall. With more humus to increase the water-holding capacity of the soil, it would logically appear that better responses from potash might be expected.

Nitrogen.—Responses for nitrogen were somewhat similar to those for potash. Although they were not so definitely correlated with the moisture supply during the last month of potato growth, they were especially influenced by the amount of rainfall during the four to eight weeks preceding harvest. The yields were in direct proportion to the rainfall. Where the rainfall was low during this period, applications above 16 to 32 pounds of nitrogen per acre reduced the yields.

Observations indicated that excess nitrogen with ample moisture late in the season resulted in excess top growth at the expense of food storage and tuber growth.

Nitrogen deficiencies were more prevalent on the lighter, sandier soils.

Phosphorus.—Unlike potash and nitrogen, the smaller applications of phosphorus (32 and 48 pounds per acre) resulted in increased production in the seasons when there was a shortage of moisture during the critical few weeks of growth previous to harvest. Application of phosphorus greater than 32 or 48 pounds per acre under such conditions resulted in no appreciable increase or decrease in production. Apparently the phosphorus hastened maturity and kept the plants in a less vegetative condition which enabled them to endure drouth better and to continue to make tuber growth.

During seasons of ample moisture for the last month of potato growth, the plants on the phosphorus-treated plots gradually increased in production as phosphorus was increased from

8 percent to 10 and 12 percent. Similar responses from phosphorus alone were secured in less extensive tests. Thus, the use of phosphorus as a fertilizer, whether alone or in a mixture with nitrogen and potassium, was not only an assurance of a better crop under conditions of more or less limited moisture supply but also a good investment for securing increased yields when moisture conditions were favorable.

Complete Fertilizer.—Within certain limits, the amount of fertilizer utilized by a crop is in proportion to the quantity of moisture available in the soil. In the rate of application tests, the potato yields increased with increased applications of a 4-8-4 fertilizer up to 800 to 1000 pounds per acre during growing seasons with ample rainfall (4 inches or more) for the last month of growth.

With low precipitation, more especially toward the close of the growing season, maximum yields resulted from applications of 400 to 600 pounds per acre and larger applications usually resulted in decreased yields. There was evidence that these decreases in yields were due to increases in the amounts of nitrogen and potash applied and not to an excess of phosphorus.

Effect of Moisture Supply on Yield and Grade

A special analysis was made of the results at Stillwater with the object of determining the effect of distribution of rainfall on yield and grade. The sandy loam with a sandy clay subsoil on which these tests were made does not have a great water storing capacity, and the rainfall prior to planting time does not greatly influence the ultimate crop as long as there is ample moisture to effect germination and to start growth.

The potatoes grown in these tests matured during the latter part of June. The analysis shows that the most critical period as regards moisture supply is the two months of May and June (Table 38 and Figure 7).

The highest average yields were produced in 1930 and 1933, the two years of highest rainfall during the month of May. The highest percentages of U. S. No. 1 grade were produced in 1930 and 1932, the two years of highest rainfall during June.

In 1932 and 1933, there was a close relationship between the high rainfall in May and the higher yield, regardless of the June rainfall. Likewise, the high percentage of No. 1 potatoes is correlated with the greater amount of rain in June.

TABLE 38.—Showing the Direct Correlation Between the Amount of Rainfall During May and June and the Total Yields and High Percentage of No. 1 Potatoes.*

	RAINFALL (INCHES)			AV. OF ALL TREATMENTS		Date harvested
	May	June	May & June	Total yield	Percent of U.S. No. 1	June
				bu. /A.		
1930	7.47	4.76	12.23	200	93.6	26
1931	1.71	2.72	4.43	45	50.1	22
1932	1.65	5.87	7.52	109	90.5	30
1933	5.01	.06	5.07	125	64.1	22
1934	2.18	1.43	3.61	63	49.8	26

* For distribution of rainfall by 14-day periods, see Figure 7.

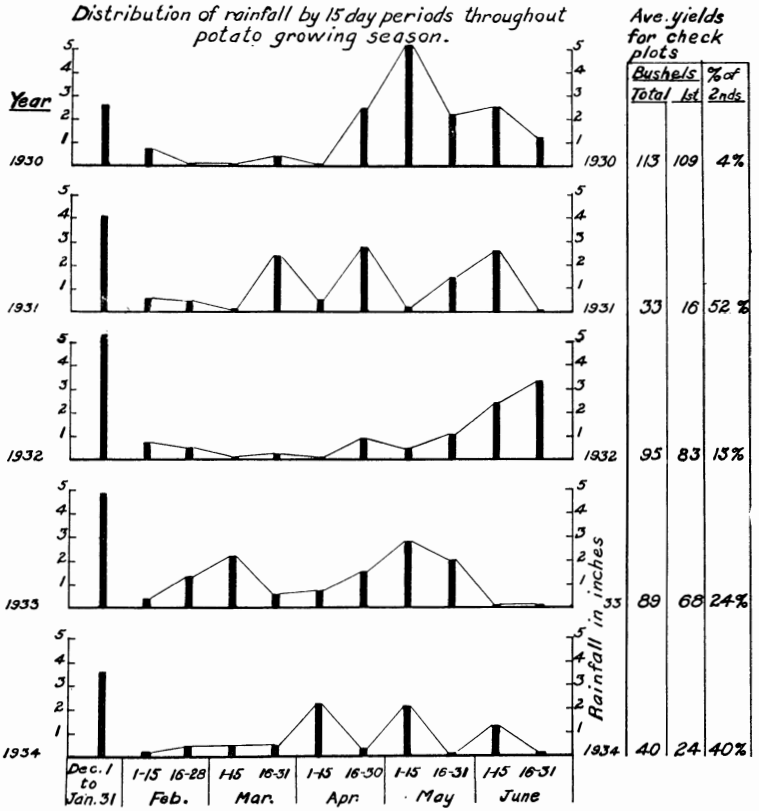

Figure 7.—Effect of amount and distribution of rainfall on total yield and grade of potatoes. Low yield in 1931 is explained on page 33.)

The data may therefore be interpreted to mean that the rainfall in May to some extent determines the number of tubers set, while the rainfall in June determines the size attained by the tubers that set in May. This is in keeping with results of tests at other experiment stations.

Effect of Ridging on Moisture Supply

Since the tests reported here dealt with fertilization rather than cultural practices, no study was made of the effect of cultivation. However, because cultivation is a factor in conserving the supply of soil moisture, attention is called to results of experiments carried on at Ithica, New York (*9*). In the New York experiment, level, moderate ridging, and extreme ridging methods of culture were compared. It was found that the soil moisture in the first 12 inches of soil decreased with the increasing height of ridge. In these same unirrigated plots, yields were greatest with level culture and decreased with the height of ridge. The number of tubers per plant was also decreased by ridging. Hence, there was a positive correlation between the set and growth of tubers and a type of culture which maintains the optimum moisture supply to the plant.

If ridging is practiced, it should be moderate. The cultivator should be narrowed with each successive cultivation, allowing the ridge to become broadened on top. Cultivation should be shallow and only for weed control in order to prevent unnecessary damage to the roots. It should cease at or before blossoming of the plants, which coincides with the period of tuber setting.

GREEN MANURE CROPS

The fertilizer tests reported in this bulletin did not directly include the testing of legumes or green manures and organic matter as a source of nitrogen. However, there were variations in the humus contents of the soils on which the tests were conducted, and marked yield increases resulted for those soils which had received leguminous green manures or other organic matter. These observations are in agreement with results of experiments in other states.

The importance of a continuous supply of organic matter in the soil can hardly be overemphasized in potato production. Organic matter keeps the soil in a more friable condition and increases its waterholding capacity, and this in turn promotes biological activity and results in the release of larger quantities of plant nutrients.

If the organic matter is derived from legumes, it also adds nitrogen to the soil and thereby materially reduces the amount required in the commercial fertilizer. That many Oklahoma soils need the nitrogen supplied by a leguminous green manure has been shown by analysis of 249 samples of virgin Oklahoma soils and an equal number of samples from adjacent cultivated soils (*4*). The average loss of nitrogen during approximately 35 to 40 years of cultivation was 37 percent, or about 1 percent per year.

Many of the more successful commercial potato growers have found green manure crops profitable in rotation with the potato crop. Cowpeas, hairy vetch and alfalfa are most commonly used. Other possibilities are sweet clover, soy beans, lespedeza, and Austrian winter peas. Local conditions will determine which legume is most desirable.

Some growers in the vicinity of Muskogee sow turnips as a green manure crop in the fall and plow them under in late winter when preparing the seed bed for potatoes. The advantages claimed for the turnip crop are that it absorbs and holds nutrients which might otherwise be lost by leaching during the fall and winter, and that the turnips when turned under decay quickly and release readily available nutrients for use by the potato crop.

With the exception of turnips, green manures preceding the potato crop should be plowed under in the fall, allowing time for some decomposition before the advent of cold weather.

Vetch must be grown the year previous to the potato crop. This allows for the full development of the vetch crop, which would not be possible if the vetch were seeded for the fall and winter preceding the potato crop.

Green manure crops such as rye which grow late into the winter should be avoided because they deplete the soil of available nutrients and moisture needed for the potato crop. This was illustrated by the 1931 yields at Stillwater (Tables 3 to 6). Prior to the potato crop that year, a green manure crop of rye was grown and not plowed under until about two weeks before planting the potatoes. The rye had greatly depleted the moisture supply, causing the potatoes to get a late start. It also was too slow in decomposing to be of full value to the potato crop and thus caused low yields in all plots. Similar results have been reported from Missouri (*10*).

In Kansas (*4*), the moisture supply was found to be inadequate during dry seasons when the potato crop followed alfalfa.

In this case the alfalfa was plowed late in the fall. More favorable results were secured during the same seasons when the potatoes followed sweet potatoes or early harvested corn. Undoubtedly the late growth of the deep rooted alfalfa left the soil in a dryer condition than did the sweet potatoes and corn.

When moisture is not a limiting factor, it has been shown that alfalfa and sweet clover are excellent green manure crops for use preceding potatoes in the rotation (3, 5). These crops add an abundance of organic matter and nitrogen and decidedly improve the soil structure. For areas where the rainfall is likely to be limited, it seems advisable to plow alfalfa by September 1 or, for the first year following the alfalfa, to grow some crop other than potatoes which requires less moisture early in the season.

ORGANIC VS. INORGANIC SOURCES OF NITROGEN

Cottonseed meal as a source of organic nitrogen was compared with inorganic source (one-half nitrate of soda and one-half ammonium sulfate) in some of the tests. Except at Heavener, the nitrogen from inorganic sources gave better results. When cottonseed meal was used to supply one-half of the nitrogen in a complete fertilizer, yields were slightly lower than when all inorganic nitrogen was used. These results are similar to those reported from both Arkansas (*1*) and Louisiana (*8*), and disagree with experimental results from North Carolina (*12*) and Maryland (*6*).

Cottonseed meal used alone as a fertilizer gave a small increase above non-treated plots, but lower yields than the complete fertilizer.

RELATION BETWEEN YIELD INCREASE AND GRADE

A further study of the yields resulting from the fertilizer tests at the Cabeness farm at Idabel (See page 18) shows that there was distinct positive correlation between the increased yields and the increase in the size of the tubers (See Table 39). The proportion of No. 1 grade was increased from 62 percent for the non-fertilized plots up to 86 percent for the highest yielding fertilizer plots. Although the data in this table shows the increase in size as U. S. No. 1 potatoes, the increase often places the potatoes in grade No. 1A, which ordinarily increases the market value of the crop.

TABLE 39.—Showing Correlation of Increase in Grade 1 Potatoes with Total Increase Caused by Fertilizer; Cabeness Farm, Idabel, Oklahoma; 1933.

Rate	Treatment	YIELDS IN BUSHELS			Percent
		No. 1	No. 2	Total 1, 2	No. 1
Check	None	28	17	45	62
200	4-8-4	69	27	96	72
400	4-8-4	104	26	130	80
600	4-8-4	120	26	146	82
800	4-8-4	147	24	171	86
800	0-8-4	44	26	70	63
800	2-8-4	118	26	144	82
800	4-8-4	147	24	171	86
800	4-0-4	52	18	70	74
800	4-4-4	94	26	120	78
800	4-6-4	121	23	144	84
800	4-8-4	147	24	171	86

RESPONSE OF THE POTATO TO DIFFERENT PLANT NUTRIENTS

NITROGEN

When the supply of other nutrient elements is adequate, the presence of nitrogen results in a darker green foliage with a greater capacity for the manufacture of carbohydrates. Therfore an adequate supply of nitrogen makes possible rapid growth and a greater set of tubers. An excess amount of nitrogen is detrimental. It may cause excessive vegetative growth which monopolizes the carbohydrate supply, leaving little to be stored in the tubers. This may result in many potatoes which are all small in size. Excessive vegetative growth also tends to delay maturity of the tubers.

A deficiency of nitrogen usually results in small, woody stemmed plants with poorly developed lateral branches and yellowish foliage (*11*).

PHOSPHORUS

The external indications of phosphorus deficiencies are not readily identifiable in the potato plant.

Experimental results elsewhere (*7, 9*) have shown that phosphorus promotes root formation, causing greater extention and deeper penetration into the soil. Such root behavior was considered beneficial if drought conditions prevailed. In cer-

tain sections of the United States the importance of phosphorus for root crops such as turnips and rutabagas is recognized. In the absence of phosphorus the roots of these crops do not develop normally, but remain permanently dwarfed.

Neither in the tests reported here nor in experiments elsewhere is there evidence that an excess of phosphorus in the soil is detrimental to the development of plants as indicated by crop yields.

POTASSIUM

A pronounced deficiency of potassium may be recognized by browning and drying of the edges of the leaves. This is possibly the result of less resistance to water loss from the leaves (7). Unlike phosphorus, the application of excessive amounts of potassium salts to the soil may be injurious to a crop, retarding maturity and resulting in decreased yields.

PRACTICAL SUGGESTIONS ON BUYING FERTILIZERS

Growers are interested in receiving the greatest value for every dollar expended for fertilizers. This may be accomplished by discrimination in the purchase of high grade fertilizers. Fertilizers classed as "high grade" are those which carry a comparatively high content of plant nutrients (that is, a total of 18 percent or above). Certain of the low grade fertilizers, with less than 18 percent, may be further cheapened by using the less available forms of nitrogen, phosphorus, and potash. The average nutrient content of complete fertilizers sold in the United States in 1914 was 12 percent, whereas in 1938 it was above 18 percent. This shows that as more is learned about fertilizers the growers are becoming aware of the economy of buying the higher grades.*

An Oklahoma state law, enacted in 1935, stating that "No mixed fertilizer will be registered or sold in Oklahoma containing less than 16 units (total percent) of available plant food" is further evidence of the recognition of the greater economy in the use of higher grades of fertilizer. Such state laws not only protect the farmer from the unnecessary expense of low grade fertilizers, but also protect manufacturers who are attempting to sell fertilizers which will best suit their customers' needs.

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* In 1930 a 4-8-4 mixture was still considered a fairly high-grade fertilizer. Having a total of only 16 percent, it just meets the minimum requirements for sale in Oklahoma at the present time.

There is still some question concerning the desirability of low applications (200 to 400 lbs.) of extremely high analysis fertilizers (40 to 50 units) to potatoes.

The tests presented in this bulletin were conducted with the 4-8-4 fertilizer as a basis for comparison. However, the recommendations are transposed into terms of the more concentrated mixtures. For example, when 600 lbs. of 4-8-4 fertilizer was found to be best, an application of 400 lbs. of 6-12-6 is recommended. The same quantity of nutrients is provided by the two fertilizers, i. e., 24 lbs. nitrogen, 48 lbs. phosphoric acid, and 24 lbs. of potash. Growers are advised to use the higher and more economical grades which supply the same amount of plant nutrients in a desirable form and in the same ratio.

It appears desirable that the potato fertilizer to be applied at time of planting should contain a mixed source of nitrogen, preferably the inorganic sources, nitrate of soda and ammonium sulphate. Some organic nitrogen, not to exceed 20 percent, may be included for improvement of fertilizer texture, although it is true that to be effective with the early potato crop the nitrogen must be largely available during the first two months of growth. When the mixed fertilizers on the market do not conform to the specifications desired for fertilization, the separate nutrients may be bought and the fertilizer mixed to fit requirements. In Table 40 are some suggested combinations from the more common separate materials to use in mixing equivalents to meet the recommended grades and rates that are summarized in Table 1. Table 41 gives the comparative prices quoted for fertilizers at Stillwater in 1939.

In many sections cooperative buying of fertilizers by the growers has been employed successfully for the purchasing of mixed goods and separate materials. By this method the small grower can secure fertilizer at the same price as the large grower.

Brand names are frequently given fertilizers indicating that they are especially useful for some special crop. This is often misleading because a certain analysis of fertilizer may be required for one type of soil to grow good potato crops while one of an entirely different analysis is needed to meet the deficiencies of another soil. For example, a 4-8-8 is sometimes called a potato fertilizer. It is true that this is a good potato fertilizer in some sections in the East where there is a pronounced deficiency of potash, but the numerous fertilizer tests carried on in Oklahoma show that in only one of the sections tested was there a sufficient lack of potash to warrant the use of a fertilizer containing a greater percent of potash than of

nitrogen. Not only is the application of a fertilizer containing a greater amount of any element than is needed a waste, but in the case of adding more nitrogen or more potash than can be utilized, the results may actually be reductions in yields. Hence, in choosing the fertilizer for a particular location, the "brand" name is of little importance in comparison with the guaranteed analysis.

TABLE 40.—Suggestions for Home Mixing of Fertilizers.

Recommended fertilizer and rate of application per acre	Materials and amounts to use in making the equivalents of the recommended fertilizers
1. 400 lbs. of 6-12-6	60 lbs. ammonium sulphate (20%) 80 lbs. sodium nitrate (16%) 106 lbs. superphosphate (45%)* 50 lbs. muriate of potash (48%) 396 lbs. total
2. 400 lbs. of 4-12-0	40 lbs. ammonium sulphate 54 lbs. sodium nitrate 106 lbs. superphosphate 200 lbs. total
3. 600 lbs. of 6-8-4	90 lbs. ammonium sulphate 120 lbs. sodium nitrate 106 lbs. superphosphate 50 lbs. muriate of potash 366 lbs. total
4. 400 lbs. of 6-12-9	60 lbs. ammonium sulphate 80 lbs. sodium nitrate 106 lbs. superphosphate 72 lbs. muriate of potash 318 lbs. total
5. 400 lbs. of 4-12-4	40 lbs. ammonium sulphate 54 lbs. sodium nitrate 106 lbs. superphosphate 34 lbs. muriate of potash 234 lbs. total

NOTE: When the ingredients are mixed as listed in each of the five fertilizer equivalents above, there will be a different rate of application per acre for each. That rate will be the total weight of the ingredients. For example, in No. 2, a 200-pound application of the mix supplies the same nutrients as 400 lbs. of 4-12-0.

* When 45 percent superphosphate is not available a 20 percent superphosphate may be substituted. 240 lbs. of the 20 percent is equivalent to 106 lbs. of the 45 percent. The cost of the 20 percent, based on Table 41, is 8 percent more than for the same amount of phosphorus purchased as 45 percent.

*TABLE 41.—Showing Comparative Retail Prices of Different Kinds of Fertilizers; 1939.**

Fertilizer	Cost per ton	Cost per 100 lbs. at ton rate	Cost of fertilizer element per lb.
Ammonium sulphate (20% nitrogen)	$47.00 per ton	$2.35	$ .118
Nitrate of soda (16% nitrogen)	49.00 per ton	2.45	.153
Superphosphate (18 phosphoric acid)	24.00 per ton	1.20	.067
Superphosphate (20% phosphoric acid)	26.00 per ton	1.30	.065
Superphosphate (20% phosphoric acid)**	24.00 per ton	1.20	.060
Superphosphate (45% phosphoric acid)**	48.00 per ton	2.40	.053
Muriate of potash (50% potash)	49.00 per ton	2.45	.049
4-8-4	30.00 per ton	1.50	
4-12-4	33.00 per ton	1.65	
6-12-6	38.00 per ton	1.90	
6-8-4	35.00 per ton	1.75	

* Quoted by local dealers in Stillwater, 1939. These prices are not fixed and will fluctuate considerably from year to year. However, the table offers a relative comparison in prices for the different elements and mixtures.

** Quotation f. o. b. Oklahoma City.

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APPENDIX

Methods Used in Making Tests

All of the tests were conducted according to the same general plan. The fertilizers were mixed from materials in the following forms: Nitrogen equally from nitrate of soda (16 percent nitrogen) and ammonium sulfate (20 percent nitrogen); phosphorus as superphosphate (15 percent phosphoric acid); and potassium as muriate of potash (48 percent potash). The mixtures were applied without the addition of filler.

A 4-8-4 basic formula was used for both the ratio and the rate of application studies.

Using a 4-8-4 fertilizer, the rate of application was at a minimum of 400 pounds per acre at Stillwater and 200 pounds per acre elsewhere, and increased to a maximum of 1,200 pounds per acre by 200-pound increments. Check plots were left unfertilized in each test.

Just prior to planting, the mixed fertilizers were applied to the bottoms of the furrows, using a large funnel with a long tube (See Figure 3). The fertilizer was then mixed in the soil with a hand garden cultivator or with sweeps on a two-row field cultivator. The results of these fertilizer tests should be considered in the light of this method of fertilizer application. Experiments have since proven that applying the fertilizer in bands two inches to either side of the seed piece gives better results with less chance of injury to either the seed piece or sprout when heavy applications are made (12).

The Bliss Triumph variety was used for all the tests. The size of the seed pieces was 1 to 1½ ounces at Stillwater, while at other places the size was the same as that used by the grower for the commercial crop and usually was smaller than that used at Stillwater. The planting depth was about four inches with the rows moderately ridged. The sets were dropped by hand one foot apart in rows 36 inches apart at Stillwater, Heavener and Lone Grove, and 34 inches apart elsewhere.

The approximate planting and harvesting dates respectively for each of the locations were: Stillwater, March 10 and June 26; Idabel and Lone Grove, February 20-28 and June 1-10; Heavener, Ft. Smith and Muskogee, March 1-8 and June 10-20.

Some variation in emergence of sprouts was noted in the various plots throughout the trials and plant stands were determined at times by count. However, the yields were not adjusted for missing hills since it was not possible to do so accurately with the data as taken (8).

Harvesting was accomplished in most instances with the aid of a plow and the potatoes were graded according to size into two grades. Grade No. 1 was composed of tubers with a diameter of 1⅞" or greater and Grade No. 2 included tubers 1½" to 1⅞" diameter.

At Stillwater, only the No. 1 grade was considered in the analysis of the first year yields because the No. 2 and cull grades were recorded as one. At the other localities the grades No. 1 and 2 were combined to represent the marketable harvests and the results interpreted on the basis of these yields.

The data on all but 7 of the 28 fertilizer ratio and rate tests conducted from 1930 to 1937 were analyzed by the analysis of variance method. The mean yields for the various treatments for the several years are computed and the difference necessary for significance between these means determined. This procedure did not always prove to be successful because the fertilizer trials encountered some very dry seasons along with others in which the moisture was normal or above. This resulted in marked variations in the response to a given fertilizer treatment depending upon the seasonal moisture supply, and therefore the interaction between year or season and fertilizer treatment (error) was at times quite high. Under such circumstances, it was necessary in interpreting the data to consider the results for a given year as well as the means for the several years.

Rainfall was given careful consideration in analyzing each of the fertilizer tests and also in arriving at the final recommendations based upon the results.

A study of the rainfall has shown that there is a close relationship between the amount and distribution of the rainfall and the responses of the potato to each of the three fertilizers, nitrogen, phosphorus, and potassium. Therefore, a table showing the average rainfall for each of the months of the potato growing seasons of the test is given for each of the localities in which the tests were conducted.