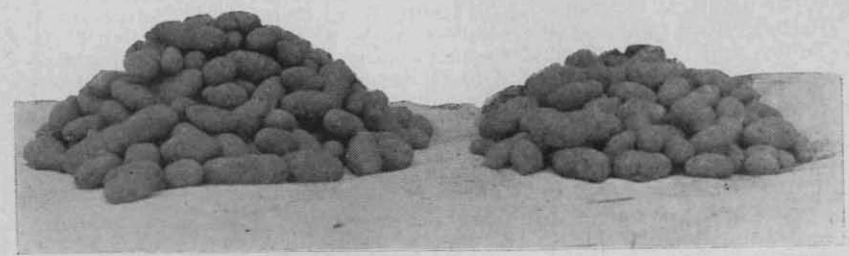
BULLETIN NO. 265 AUGUST 1945

UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION
Department of Agronomy

Influence of Commercial Fertilizers on Idaho Potatoes

An analysis of 10 years' results on the influence of commercial fertilizers and cropping history on yield and market grade of potatoes grown under irrigation.

H. W. E. LARSON AND HERMAN K. SCHULTZ



Nitrogen and phosphate. No fertilizer.

Published by the University of Idaho, Moscow, Idaho

Table of Contents

Acknowledgments

THE authors wish to acknowledge the various types of assistance received from specialists, county extension agents, farmer cooperators and commercial fertilizer companies. Special thanks are due Dr. J. E. Kraus, Associate Horticulturist (formerly on Idaho potato research), for his suggestions in the summarization of the data, and Mr. E. W. Whitman, formerly Extension Potato Specialist, for collection of data and kindly advice in conducting certain fertilizer demonstrations.

Former county extension agents who contributed by obtaining potato data during the 10-year period were: Harold Ball, D. T. Bolingbroke, W. D. Boyle, A. E. Duke, H. S. Gault, B. E. Kuhns, C. L. Mink, E. J. Palmer, W. W. Palmer, J. K. Robertson, V. A. Siple, I. W. Slater, C. R. Tulley, and Dan E. Warren. Present county extension agents who have assisted in the collection of data from potato fertilizer demonstrations are: T. J. Chester, G. W. Cleveland, V. S. Cross, C. W. Daigh, Drue Dunn, J. W. Heward, H. L. Hilfiker, Wesley Jenkins, P. M. Jesness, Claude G. Johnson, Ray O. Peterson, H. J. Shipman and L. M. Williams.

The kind cooperation of the many potato growers on whose farms the demonstrations were conducted was greatly appreciated.

Most of the commercial fertilizers required in carrying on these demonstrations were furnished gratis by a number of commercial fertilizer companies. These were Anaconda Copper Mining Co., Fertilizer Division, Columbia Steel Corporation, American Potash Institute, and Chilean Nitrate Educational Bureau. The Tennessee Valley Authority furnished part of the phosphate and nitrogen requirements at freight cost to the farmer.

Influence of Commercial Fertilizers on Idaho Potatoes

An analysis of 10 years' results on the influence of commercial fertilizers and cropping history on yield and market grade of potatoes grown under irrigation.

H. W. E. LARSON AND HERMAN K. SCHULTZ*

Introduction

POTATO growing is one of the major agricultural enterprises in Idaho, the State ranking second in the Nation. Idaho has long been distinguished for the high yields and high quality of its potato crops. The average acreage for the 10-year period, 1933 to 1942, was 121,000 acres with an average yield of 133 hundredweights per acre (221.7 bushels). The Russet Burbank ("Netted Gem") variety is grown almost exclusively. Although high yields of good quality potatoes have long been obtained in this region, there is an apparent need for additional plant nutrients from commercial fertilizer sources, *(1, 6, 7, 8, 11, 12)*.[1]

Numerous tests or demonstrations showing the value of various commercial fertilizers on farms located on the irrigated projects of the state have been conducted by the University of Idaho Extension Division for many years. Yield per acre and market grade, as influenced by applications of several kinds of fertilizers and by the previous cropping history, were the major factors considered in these tests. The potato crop responses obtained during the past 10 years, 1935-1944, from applications of commercial fertilizers on fields previously cropped to legumes and non-legumes were summarized and analyzed. The conclusions reached are based on the data obtained from these farm fertilizer demonstrations; however, references are made also to other results obtained in Idaho *(11, 12)* and in other states *(2, 3, 9)* where fertilizer effects have been studied on the potato crops grown under irrigation.

Scope of the Potato Fertilizer Demonstrations

All data were obtained from Extension demonstrations, which were conducted in cooperation with county extension agents and farmers on irrigated farms located in the potato-growing districts of 18 southern Idaho counties extending across the state.[2] The summary is based on results from the combined number of 226 tests, distributed by counties as follows: 38 tests in Cassia, 29 in Bonneville, 26 in Madison, 25 in Bingham, 22 in Fremont, 12 in Minidoka, 11 each in Canyon, Power, and Twin Falls, 10 in Teton,

*Extension Soils Specialist and Associate Agronomist respectively.

[1] Refers to "Literature cited," P. 15.

[2] All data from the Idaho potato demonstration tests have been reported by individual years, 1935 to 1944, in the annual reports of the Soils Specialist.

8 each in Jefferson and Jerome, 6 in Bannock, 3 in Elmore, 2 each in Gooding and Payette, and 1 each in Caribou and Lincoln counties.

Elevation was of no consequence in these tests, even though the range from Payette County to Teton County is nearly 4,000 feet. The various factors, soil texture, soil tilth, active organic matter supply, uniformity of moisture supply, and available plant food supply were noted by individual farms in the various potato-growing regions. An adverse condition with respect to these factors influenced the yield and quality, and often to a very marked degree.

A cropping history was obtained for nearly all of the fields on which fertilizer demonstrations were conducted. The fields were classified into two groups: those where potatoes followed a forage legume, usually alfalfa but often sweet clover or red clover; and those where potatoes were preceded by a non-legume crop, usually potatoes or sugar beets. Yield and other data were analyzed separately from these two groups of fields.

Commercial Fertilizers Applied

The annual commercial fertilizer consumption in Idaho has been rising steadily during the past 20 years. In 1925, Idaho used only 400 tons; in 1935, 3,000 tons; in 1940, 7,000 tons; in 1943, 11,000 tons; and in 1944, 20,000 tons. There was an unsatisfied demand for commercial fertilizers in 1944. Had enough commercial fertilizers been available to satisfy this demand, it is probable that about 30,000 tons would have been used. Phosphate fertilizers represented approximately two-thirds to three-fourths of the total amount consumed. Of this total, the potato crop received in the neighborhood of 30 percent.

The fertilizer carriers applied to the potatoes in demonstration plots were ammonium sulphate (nitrogen, designated in this bulletin as N), treble superphosphate (phosphorus, designated here in as P), and potassium sulphate or chloride (potassium, designated as K). Rates of application per acre were generally 125 to 250 pounds of ammonium sulphate, 100 to 200 pounds of treble superphosphate, and 200 pounds of potassium sulphate or chloride. Many of the demonstrations consisted of fertilizer rate studies as well as tests for the evaluation of different kinds of fertilizer. Results from different rates of application were averaged for each fertilizer since amounts of fertilizer applied will not be considered in this publication.

Methods of fertilizer applications varied in the different demonstrations. About one-half of the tests received the fertilizer in band placement by means of a planter attachment. A number of the potato plots received the fertilizer broadcast, and, in a few instances, with manure just prior to plowing under alfalfa.

Determination of Yield and Market Grade From Plots

Potato demonstration plots, as referred to here, were strips 3 to 5 rows wide the full length of the potato fields, which varied from 20 to 160 rods in length. Field plot designs were of the usual type employed in agronomic demonstrations where plots 1 and 4 are

checks with plots 2, 3, and 5 as unreplicated treated plots. Yield and other data were then corrected by use of the check plots as illustrated by Hayes and Garber *(4)*. Yield determination was based on the total produce from the entire rows which were bordered by similarly treated rows. All yields were calculated on the basis of hundredweight (cwt.) per acre.

Market grade, based on percentage of U. S. No. 1 potatoes,[1] was determined by grading about one-tenth to one-fifth of the produce from each of the treated and non-treated or check plots. Not all of the demonstrations were graded for quality—only those where time and facilities permitted.

An attempt was made to compare potato yield and market grade differences which were statistically significant with values required for economic significance. Economic increases depend upon the relative value of the yield increases and fertilizer cost, as discussed in a subsequent section on profitable returns from commercial fertilizers.

Potato Demonstration Results

The summarizations of the data obtained from the many potato fertilizer demonstrations over the past 10 years are given in the three following sections: 1. The effect of various fertilizers on potato yields. 2. The influence of previous cropping history on responses from commercial fertilizers. 3. The market grade of the tubers as influenced by commercial fertilizer treatment.

1. Effect of Commercial Fertilizers on Potato Yields

A relatively wide range in potato yields was obtained from the large number of demonstration farms. Even though the number of comparisons was not constant from year to year, the ratio between the number of demonstrations of each kind, for example, those for N (nitrogen) and for P (phosphate), were rather constant from year to year. On the basis of this fairly proportional yearly frequency of different fertilizer tests, comparisons were made among averages for the various treatment effects. The analysis of the potato yields indicated that the many farms gave widely different responses for all fertilizer treatments.

It was pointed out previously that the same kind of fertilizer treatments were not made in all demonstrations; therefore, averages of the non-treated or check plots in one group would differ from those in another. This necessitated making comparisons of average yields from particular treatments only with their corresponding checks. The average yields in cwt. per acre for the treated and check plots are given in Table 1. The first four comparisons in the table are between checks and the indicated fertilizer treatment, while the last two are comparisons among the check and the two indicated fertilizer treatments. In this latter case the NP and N, and the NP and P treatments were always applied in the same demonstrations, which permitted direct comparison.

[1]Refers to U. S. No. 1 standard grade as established by the United States Department of Agriculture.

Table 1.—Average potato yields in cwt. per acre for non-treated (check) and fertilized plots.

Comparison	Total number of demonstrations	Average potato yield in cwt. per A. for treatment of					Increased yield from fertilized plots*
		Check	N	P	NP	NPK	
N vs. Check	71	177.9	196.6	.....	.....	.....	18.7
P vs. Check	178	185.0	.....	205.5	.....	.....	20.5
NP vs. Check	77	195.1	.....	.....	223.0	.....	27.9
NPK vs. Check	47	207.0	.....	.....	.....	231.6	24.6
NP vs. N vs. Ck.	18	205.7	223.3	.....	233.3	.....	17.6, 27.6
NP vs. P vs. Ck.	48	195.2	.....	215.9	218.1	.....	20.7, 22.9

*All yield increases are significant at the 1 percent level except 17.6 cwt. which is significant at the 5 percent level.

The 71 nitrogen fertilizer demonstrations recorded in Table 1 gave an average difference in favor of the treated plots of 18.7 cwt. of potatoes per acre. A somewhat larger difference was obtained between the treated and check plots when phosphate fertilizers were applied. This average difference was 20.5 cwt. of potatoes per acre for 178 farm demonstrations. These average differences demonstrate the substantial gains that may be expected generally from the use of nitrogen and phosphate fertilizers when each is used singly.

When N and P were used in combination, designated in Table 1 as NP, an additional average yield increase was obtained over each fertilizer applied separately. The average difference for NP and check was 27.9 cwt. per acre in 77 farm tests, 27.6 cwt. in an 18 comparison group, and 22.9 cwt. in another set of 48 demonstrations. Statistically these average increases of potato yields are highly significant.

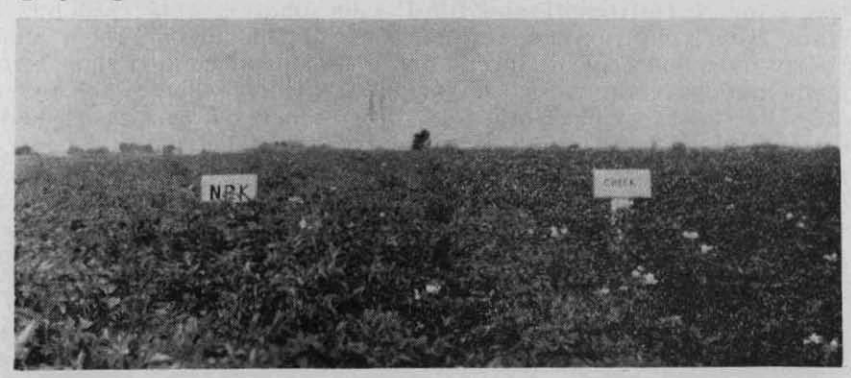


Figure 1.—The vigorous vine growth shown on the NPK treated plot, fertilized with 380 pounds of 7-15-14, was accompanied by a 41 cwt. increase of potatoes. Both labels are of equal height with the treatment plot label now partially submerged. This demonstration was conducted in 1939 on a sandy soil in Cassia County. (Other tests showed that the potash (K) was not necessary and that equally good results could be secured from an NP treatment.)

A complete fertilizer is one which contains all three major plant foods, nitrogen, phosphorus, and potassium. The 47 farm demonstrations with complete fertilizer, or NPK test, one of which is depicted in Figure 1, yielded an average increase of 24.6 cwt., over the checks, which is about the same increase as that received from NP. From these demonstrations and from other studies *(1, 6, 9)*, it is evident that potassium has little or no effect. This non-response from K seems to apply over the entire southern Idaho potato-growing region. Frequently, sandy soils are deficient in K, but an examination of the few data obtained on the very sandy soils in southern Idaho revealed that no consistent response from potash applications were obtained even in these soils.

Distribution of Yield Increases By Farms

In view of the fact that the average potato yields on the fertilized plots were significantly higher than the related check plots, it may be of interest to note how these yield differences were distributed individually by farms. Such a distribution of yield differences on the basis of frequency classes of 10 cwt. per acre for each fertilizer treatment is presented in Table 2. The number of farm demonstrations, for the four fertilizers considered, ranged from 47 for NPK to 178 for P.

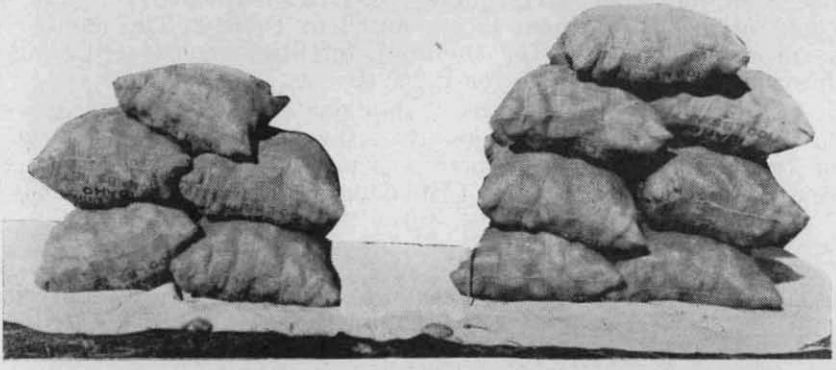
It will be noted from Table 2 that not all yield differences were in favor of the treated plots. In a few instances the application of fertilizer appeared to have a depressing yield effect while a relatively small percentage of the demonstrations gave no response.

Table 2.—Distribution of potato yield differences by farms between fertilizer treated and non-treated plots.

Yield increase of treated over non-treated plot in cwt./A.	Number of farms under different fertilizer treatments of			
	N	P	NP	NPK
76 plus	0	6	4	1
66 to 75	2	3	1	4
56 to 65	2	4	4	2
46 to 55	4	7	2	1
36 to 45	5	17	12	4
26 to 35	9	24	10	5
16 to 25	12	41	22	10
6 to 15	19	36	13	5
—4 to 5	13	22	8	11
—14 to —5	3	13	1	3
—24 to —15	2	5	1	1
All classes	71	178	78	47

The class of greatest frequency was that of the 20 cwt. yield gain. Two-thirds of all demonstrations yielded increases of 10 to 40 cwt. A few cases of yield increases of 75 or more cwt. per acre were recorded also. One of such cases is illustrated in Figure 2. The phosphate plots seemed to have a somewhat wider yield range than the nitrogen plots. These frequencies emphasize the wide range of yield differences that may be expected between fertilized and check plots. The increases in yields for all demonstrations are presented graphically in Figure 3.

It is of interest to add here that the magnitudes of the yield differences were fairly well distributed among the higher and lower yielding soils. Regardless of the reason for the high productivity of many fields, large responses were obtained on these from N and from P applications. Likewise, a number of low fertility fields did not respond to fertilizer applications. It appeared that in many instances where little or no response was obtained the most prob-



Check plot Fertilized plot

Figure 2.—Comparative potato yields from a demonstration made in 1940 in Madison County. Check plot yielded 264 cwt. and the fertilized plot, which received 150 lb. of 6-30-0, produced 370 cwt. of potatoes per acre.

able causes were due to time and method of fertilizer application, lack of active organic matter supply, and poor irrigation practices.

While the average yield differences were invariably in favor of the treated plots, the fertilizer responses were found to be significantly greater in some years than in others. The causes for this seasonal difference may be a combination of several soil and environmental factors, together with possible variations in irrigation practices. The interactions between seasons and fertilizer treatments were small and nonsignificant, indicating that the fertilizers reacted in a similar manner or direction each year.

Yields from More Productive Lands

When considering the average yields, it became apparent that these potato fertilizer demonstrations were conducted on some-

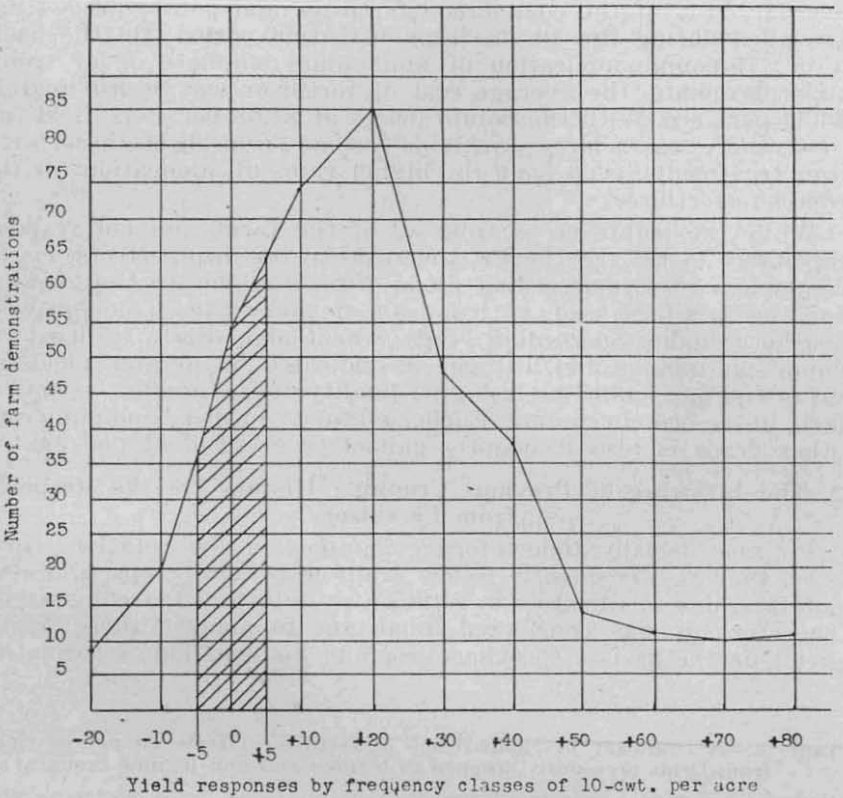


Figure 3.—Distribution of potato yield responses from commercial fertilizer applications. Cross-hatched area indicates the proportion of demonstrations in the 0 response class.

what better than average Idaho potato land. These demonstrations were made at the request of individual potato growers and each was accommodated in so far as funds and personnel would permit. In view of the number, location, and type of demonstrations made, it may be assumed that this group of farms is a representative sample of the more productive southern Idaho potato land. The average check yields were 178 cwt. per acre for the N demonstrations, 185 for the P demonstrations, and 195 for the NP demonstrations. Nitrogen-carrying fertilizer was generally applied where the soil fertility appeared the lowest, while the phosphates were applied where phosphates or a fertilizer balance seemed to be needed.

Value of Increased Yields

It was emphasized before that all average yield differences between treated and check plots, 17.6 to 27.9 cwt., were highly significant statistically. In order to judge the economic significance of these differences, we may make comparisons on the basis of

average costs of the commercial fertilizer and potato prices that prevailed during the 10-year demonstration period. On the basis of a 175-pound application of ammonium sulphate or of treble superphosphate, the average cost of fertilizer was approximately $4.50 per acre. With the potato prices at $1.08 per cwt., field run *(10)*, there was a large profitable income from all of these fertilizer treatments, even from the higher rates of application for the complete fertilizer.

While the potato crops from all of the farms did not respond profitably to the treatments, the residual fertilizer effects on the commonly grown succeeding crops often remunerate the growers for the fertilizer cost as has been demonstrated frequently in southern Idaho. Succeeding crops, wheat and alfalfa, utilized residual phosphates and nitrogen as indicated by greater yields of grain and hay and often in higher quality of the produce—particularly in the protein content. Earlier maturity in these and numerous other crops is also frequently gained from residual phosphates.

2. The Influence of Previous Cropping History On the Response from Fertilizers

Potatoes usually follow forage legumes in the rotation. However, they also frequently follow grain crops, row crops, and even potatoes, due to variation in rotation or unforeseen circumstances. Therefore, it was considered important to analyze these potato yields on the basis of previous cropping history. This information

Table 3.—A summary of comparisons of fertilizer effects on potato yields from fields previously cropped to legume and non-legume crops.

Treatment	Yield of potatoes in cwt. per acre produced in fields cropped previously to			
	Legume crop*		Non-legume crop	
	Cwt.	No. of farms	Cwt.	No. of farms
N	214.1		183.1	
Check	200.3	31	160.7	40
Difference**	13.8		22.4	
P	211.6		198.6	
Check	193.3	93	175.4	85
Difference	18.3		23.2	
NP	228.4		218.6	
Check	201.5	35	189.8	42
Difference	26.9		28.8	
NPK	235.2		227.1	
Check	214.5	26	197.8	21
Difference	20.7		29.3	

*Not necessarily any top growth of alfalfa or clover plowed under.

**All yield differences between check and treated averages on both legume and non-legume cropped land are significant at the 1 percent level.

was available for nearly all of the demonstration farms. The results of the yield analysis on this basis are presented in Table 3.

The average potato yield obtained from all check plots on the legume land, 199.0 cwt., was considerably higher than the yield from the check plots on the non-legume land, 178.1 cwt. These yield comparisons are made on the assumption that the number of farms in each demonstration category was adequate and represented the general Idaho situation. In all cases, the average fertilizer response was greater on the non-legume land than on the land where legumes had been grown the previous year. It is of economic importance to note that large increased yields were obtained when any of the fertilizers N, P, NP, or NPK were applied to land previously in legumes as well as to land not in legumes.

The general yield increase from the legume cropped land shows the importance of forage legumes in a rotation. When N was applied to potatoes on non-legume land, an 8.6 cwt. increase was obtained when compared to the tuber yields from similiar applications on legume land. (See Table 3, 22.4 — 13.8 = 8.6 cwt.) For the P applications on non-legume and legume land, the increase was smaller, 4.9 cwt. per acre. This smaller difference may be due partially to the residual effect from the phosphate that was applied in many cases to the previously grown alfalfa or clover crop. The application of P on forage legumes is a recommended practice in the irrigated sections of Idaho. It may be concluded from these results on N, P, NP, and NPK that a lesser response from commercial fertilizers may be expected on land the first year following a forage legume crop. Vigorous alfalfa and clover crops impart their nitrogen and organic matter to the succeeding potato crops. Figure 4 illustrates a commonly recommended practice in this regard.

3. Market Grade as Influenced by Fertilizer Treatments

Besides increasing the yield of crops, fertilizer applications may influence the quality of the produce. On the basis of preliminary findings, McDole *(8)* reported that the quality of potatoes in southern Idaho was improved as shown by the increase in yield of U. S.

Table 4.—The effect of commercial fertilizer applications on the market grade of potatoes as determined by percentage of U. S. No. 1 tubers.

Fertilizer applied	Number of demonstrations	Average percentage of U. S. No. 1 potatoes from		
		Check plots	Treated plots	Difference
	Number	%	%	%
N	25	73.0	73.0	0.0
P	84	69.6	70.8	1.2
NP	46	71.2	74.5	3.3*
NPK	20	65.8	66.1	0.8

*This difference is statistically significant at the 5 percent level.

No. 1's when applying various fertilizers. Harrington *(3)* has reported Russet Burbank (Netted Gem) total yields and yields of U. S. No. 1's for a number of years, in several irrigation districts in Montana. He concluded that phosphorus distinctly showed its value by increasing the yields, by improving the grades, by developing the netting of the variety, and by the accentuation of other desirable qualities.

Comparisons based on percentage of U. S. No. 1 potatoes from the check and fertilizer treated plots in this study are recorded in Table 4. These recorded values are average percentages for the number of comparisons indicated in the tabulation.

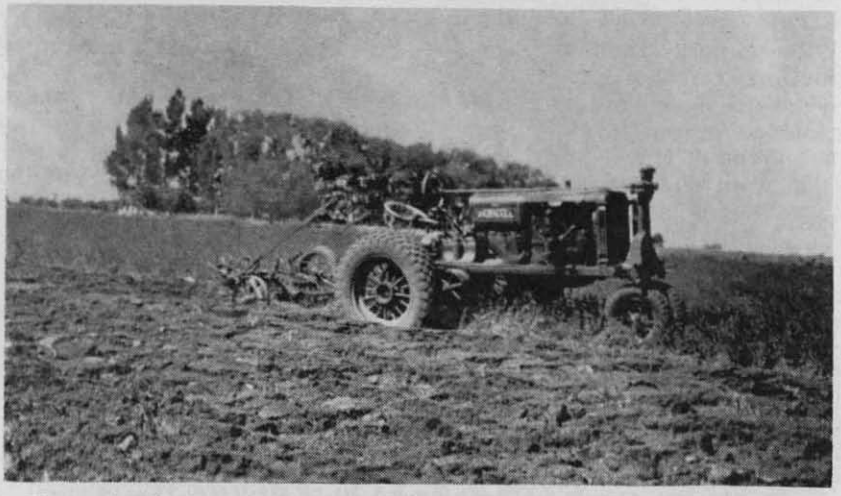


Figure 4.—Spring plowing of alfalfa for potatoes was profitable on this field in Minidoka County. It is recommended that as much growth of legume be plowed under as can be obtained previous to potato planting time.

Very small differences were obtained between the average percentages of U. S. No. 1 potatoes when fertilized by N, P, and NPK, and their respective checks. Only those potatoes from NP treated plots, when compared to their corresponding checks, were of improved market grade, as shown by a significant difference of 3.3 percent of U. S. No. 1 tubers. A steady increase in quality from fertilizer applications, as reported from Montana, was not obtained here. On a comparative basis, the number of demonstrations conducted in Idaho are large, with but very small average quality differences appearing.

Increase in U. S. No. 1 Potatoes From Yield and Grade

The comparative increase of U. S. No. 1 potatoes in cwt. per acre due to increase in total yield and due to increase in quality as expressed by grade is presented in Table 5. For the construction of this summary table, the yields from all demonstrations *(Table 1)*, rather than only those graded, were used for the computation of

these weight increases of U. S. No. 1's. The calculation of yield increase and of grade increase for the P treatment will be given here for the purpose of illustrating the method of calculation employed. The yield increase, (205.5 — 185.0) × 69.6% equals 14.3 cwt. The increase from grade, (205.5 × 69.6%)—(205.5 × 70.8%), equals 2.5 cwt. The sum of these two weights, 14.3 and 2.5 equals (205.5 × 70.8%) — (185.0 × 69.6%) equals 16.8 cwt. for the total increase.

Table 5.—Summary of increases of U. S. No. 1 potato yields in hundredweights due to total yield and market grade for each fertilizer treatment.

Fertilizer	Average yields in cwt. from		Percentage U. S. No. 1 potatoes		Cwt. increase in U. S. No. 1 potatoes from		
	Treated plots	Check plots	Fertilizer increase	Check	Yield increase	Grade increase	Total increase
N	196.6	177.9	0.0	73.1	13.7	0.0	13.7
P	205.5	185.0	1.2	69.6	14.3	2.5	16.8
NP	223.0	195.1	3.3	71.2	19.9	7.4	27.3
NPK	231.6	207.0	0.8	65.8	16.2	0.1	16.3

It is readily seen that even when a small average increased percentage of quality potatoes for any of the fertilizer treatments is obtained, the cwt. increases in U. S. No. 1's from increased yield and from increased grade, when added together, becomes sizable. Any increase in percentage of U. S. No. 1's was net gain over the already significant increase in total yield. It will be remembered that there was no market grade improvement from N treatments and that the increased percentages for the P and NPK treatments were non-significant statistically.

The percentage of U. S. No. 1 potatoes is only one of the quality factors, but this is the factor of immediate financial interest to the potato grower. The demonstrations checked for market grade were a representative sample of the entire group of demonstrations. Observations made at harvest time indicated that no differences in grade could be seen on the plots of tubers from any of the fertilized and their respective check plots. While these quality results are not entirely in agreement with those obtained by others (referred to previously) who have conducted potato tests in the irrigated sections of the West, there was a large increase in the amount of U. S. No. 1 potatoes per acre as was reported also by the other workers. The discrepancy in percentage of U. S. No. 1's may have been due to the use of recommended cultural methods employed in experimental plots as contrasted to methods used in general field practice, since Kraus *(5)* has recently reported that a higher percentage of marketable potatoes can be produced under irrigation by improved cultural methods.

The percentage of U. S. No. 1's in this study had a relatively small effect on the yield per acre of quality potatoes. However, as

long as there is no significant decrease in the percentage of No. 1's from a fertilizer application, the gain in yield will bring about a substantial increase of marketable potatoes. In this study, any yield increase of U. S. No. 1's from the percentage increase of U. S. No. 1's was net gain, since the yield increase alone was sufficiently large for a profitable gain from fertilizer application.

SUMMARY

1. A study was made of the influence of nitrogen, phosphorus, and potassium fertilizers when applied singly or in combinations on the yield and quality of Idaho potatoes grown in demonstration plots over a 10-year period, 1935-1944, in 18 counties of southern Idaho.

2. Potato yield increases which were highly significant, statistically and economically, were obtained on the irrigated southern Idaho desert soils from the applications of 175 pounds (average) each of ammonium sulphate and treble superphosphate and mixtures of these two fertilizer carriers.

3. Nitrogen plus phosphate treated plots outyielded the nitrogen and the phosphate treated plots where either fertilizer was applied separately. The difference between the nitrogen plus phosphate response and the complete fertilizer response was small and non-significant.

4. The single element fertilizer phosphate appeared to be the most important plant nutrient, but nitrogen was also important in the production of high potato yields.

5. There was no apparent response from the addition of potassium to the nitrogen and phosphate combination fertilizer.

6. Greater fertilizer responses were obtained on fields which were in non-legume crops the previous year than those in legume crops. The average potato yields from the check plots previously in alfalfa or clover were significantly higher than those yields from check plots previously in a non-legume crop.

7. The average percentage of U. S. No. 1 potatoes was only slightly increased by the application of commercial fertilizers. Only in the case of the nitrogen plus phosphate fertilizer group of demonstrations was the average increase of 3.3 percent significant statistically. Average yield increases were sufficiently large to bring about a substantially greater quantity of U. S. No. 1 potatoes per acre for all treatments.

Literature Cited

1. Bennett, E. R. GROWING THE IDAHO POTATO. Idaho Agr. Ext. Div. Bul. 141. 1942.

2. Harrington, F. M. PHOSPHATE INVESTIGATIONS IN MONTANA. 1936. Mont. Agr. Expt. Sta. Bul. 334. 1937.

3. Harrington, F. M. A REPORT OF PHOSPHATE INVESTIGATIONS IN MONTANA FOR 1939. Mont. Agr. Expt. Sta. Bul. 378. 1940.

4. Hayes, H. K., and Garber, R. J. BREEDING CROP PLANTS. New York: McGraw-Hill Bok Co. Ed. 2. 1927.

5. Kraus, J. E. PROGRESS REPORT OF POTATO RESEARCH. Idaho Agr. Expt. Sta. Cir. 85. 1942.

6. Larson, H. W. E. FERTILIZERS FOR IDAHO FARMS. Idaho Agr. Ext. Div. Bul. 138. 1941.

7. Larson, H. W. E., and Baker, G. O. A PRELIMINARY REPORT ON THE RELATIVE VALUE OF VARIOUS PHOSPHATE FERTILIZERS FOR SOUTHERN IDAHO SOIL CONDITIONS. Idaho Agr. Ext. Div. Bul. 129. 1939.

8. McDole, G. R. FERTILIZER TRIALS IN THE POTATO GROWING DISTRICTS OF IDAHO. Report of the soils specialist. Mimeo. 1931.

9. Metzger, C. H. GROWING BETTER POTATOES IN COLORADO. Colo. Agr. Expt. Sta. Bul. 446. 1938.

10. Nybroten, A. N. THIRTY-FIVE YEARS OF FARM PRICES TO IDAHO FARMERS. Idaho Agr. Expt. Sta. Bul. 260. 1945.

11. Toevs, J. L., and Baker, G. O. PROGRESS REPORT OF PHOSPHATE AND OTHER FERTILIZER INVESTIGATIONS AT THE ABERDEEN BRANCH EXPERIMENT STATION, University of Idaho. Idaho Agr. Expt. Sta. Bul. 330. 1939.

12. Toevs, J. L., Baker, G. O., Snyder, R. S., and Stamberg, O. E. PHOSPHATE FERTILIZATION PAYS. Idaho Agr. Expt. Sta. Cir. 44. 1945.