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EFFECT OF PHOSPHORUS IN THE FORM OF ACID PHOSPHATE UPON MATURITY AND YIELD OF LETTUCE

By F. J. CRIDER



General view of lettuce fertilizer plots during the harvest season.

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figure 9, that there was a decided decrease in earliness, produced by increased amounts of blood meal when applied in excess of the rate of 300 pounds per acre. It was very evident that 500 or more pounds per acre of blood meal counteracted the effect of the early maturity produced by the acid phosphate. At the rate of 100 pounds of blood meal per acre, with like amount of acid phosphate, the average yield of mature heads at the first cutting was 13 percent; whereas, at the rate of 700 pounds of blood meal with a like amount of acid phosphate per acre, the average was only 2 percent at the first cutting.

The influence of the fertilizers was rather uniform on the plots with different soil treatments previous to planting.

The effect of acid phosphate alone, and in combination with blood meal, upon yield is shown in Table VIII. As in the case of the effect of acid phosphate upon maturity, increased amounts of this fertilizer above the rate of 300 pounds per acre, did not give a corresponding increase in yield. The increase in yield produced with 300 pounds of acid phosphate per acre, as compared with 100 pounds was very slight, amounting to only .03 pound per head.

In the use of acid phosphate and blood meal in combination there was no appreciable increase in size of the lettuce head when the rate of application was more than 300 pounds of each fertilizer per acre. (Table VIII and Fig. 9.)

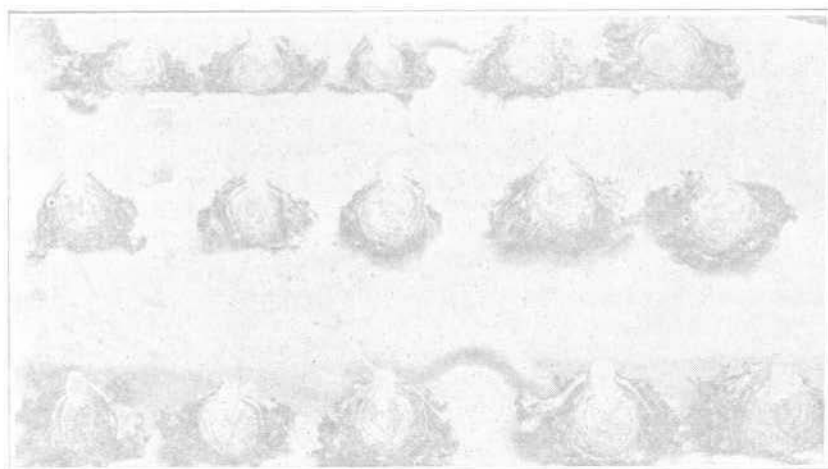


Fig. 9.—Showing the relative effect of different amounts of acid phosphate and blood meal in combination upon maturity and yield, as expressed in size and compactness of head. The arrangement of the heads in all respects is the same as shown in figure 8. Note the increased size of head over acid phosphate alone, shown in figure 8; also the looseness of head where the larger amounts of blood meal were used.

TABLE VII.—SHOWING EFFECT OF DIFFERENT AMOUNTS OF ACID PHOSPHATE ALONE, AND IN COMBINATION WITH BLOOD MEAL, UPON MATURITY, EXPRESSED BY THE PERCENTAGE OF MATURE HEADS AT FIRST CUTTING.

Previous treatment of land	Fertilizer	Amounts fertilizer per acre				
		0 lbs.	200 lbs.	500 lbs.	700 lbs.	Control
		Per- cent ma- tur- ity	Per- cent ma- tur- ity	Per- cent ma- tur- ity	Per- cent ma- tur- ity	Per- cent ma- tur- ity
Cotton, followed by cowpeas	Acid phosphate	19	24	34	18	3
	Acid phosphate and blood meal	25	14	5	4	
Cotton, followed by summer fallow	Acid phosphate	27	25	22	20	1
	Acid phosphate and blood meal	10	10	6	2	
Sweet potatoes, followed by cowpeas	Acid phosphate	2	6	7	6	0
	Acid phosphate and blood meal	5	9	4	1	
Average	Acid phosphate	16	18	21	15	1
	Acid phosphate and blood meal	13	11	5	2	

TABLE VIII.—SHOWING EFFECTS OF DIFFERENT AMOUNTS OF ACID PHOSPHATE ALONE, AND IN COMBINATION WITH BLOOD MEAL, UPON YIELD, AS EXPRESSED IN AVERAGE WEIGHT PER HUNDRED HEADS OF LETTUCE.

Previous treatment of land	Fertilizer	Amount of fertilizer per acre				
		100 lbs.	200 lbs.	500 lbs.	700 lbs.	Control
		lbs. let- tuce	lbs. let- tuce	lbs. let- tuce	lbs. let- tuce	lbs. let- tuce
Cotton, followed by cowpeas	Acid phosphate	181	148	143	147	112
	Acid phosphate and blood meal	158	140	114	139	
Cotton, followed by summer fallow	Acid phosphate	144	137	134	120	116
	Acid phosphate and blood meal	125	147	141	139	
Sweet potatoes, followed by cowpeas	Acid phosphate	130	12	119	125	127
	Acid phosphate and blood meal	140	145	143	155	
Average	Acid phosphate	135	138	132	131	117
	Acid phosphate and blood meal	139	144	133	145	



View of lettuce fertilizer plots, showing the effectiveness of acid phosphate in promoting earliness and size. Plot in the foreground, showing parts of three rows, fertilized with acid phosphate at the rate of 300 pounds per acre; adjacent plots not fertilized.

EFFECT OF PHOSPHORUS IN THE FORM OF ACID PHOSPHATE UPON MATUR- ITY AND YIELD OF LETTUCE

By F. J. CRIDER*

INTRODUCTION

Phosphorous is known to have a very important place in plant development but its use as a fertilizer has not been considered of primary importance in the growing of succulent crops such as lettuce. Heretofore, the use of commercial fertilizers of all kinds has been thought unnecessary and a waste of money in Arizona. Our fertile valley soils have produced excellent crops of lettuce and other truck crops without the application of artificial fertilizers, except in rare cases where light top dressings of sodium nitrate and ammonium sulphate were used. To the close observer, however, it has become evident that the quality of the lettuce produced on some of our trucking soils has gradually fallen below the standard of former years. On the other hand, the demand for a large, uniform, solidly-headed product has increased.

To determine the value and importance of commercial fertilizers in lettuce culture in Arizona, a series of fertilizer experiments was conducted by the author in 1922 and 1923, which led to the discovery that the phosphates in Arizona soils are not readily available and that the application of soluble phosphates in the form of acid phosphate has a most remarkable effect upon the lettuce plant. The investigations were made at the Yuma Experiment Farm upon soil which analyzed .095 percent phosphates (P₂O₅). This is equivalent to about 3,728 pounds of phosphorous per acre-foot and might be considered sufficient, if it were available to plants, to supply the needs of lettuce crops for many years.

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FIRST SERIES OF EXPERIMENTS

The fertilizers used in these experiments, together with the percentages of their leading constituents and the basic amounts of fertilizers used per acre, are given in Table I. The general plan of the experiments, with the arrangement of plots and the different fertilizer combinations, is shown in Table II. Each plot consisted of a single row 400 feet in length. One-half of the ground had previously been planted to cotton and the other half to alfalfa, which gave two distinct factors influencing the results.

The variety of lettuce used in the experiments was the New York Market, sometimes called the Los Angeles Market. This variety was introduced into the West by the Arizona Agricultural Experiment Station in 1914, and it proved to be of such splendid quality and adaptability that it is now grown almost exclusively by commercial lettuce growers throughout the entire region west of, and including, the Rocky Mountains.

The lettuce was planted in single rows 30 inches apart, and the plants were thinned to 12 inches apart in the row. The date of planting was December 14, 1922.

All the fertilizers were applied just previous to the time of planting except the sodium nitrate. Only one-half of this fertilizer was used at the time of planting, the other half being applied as a top dressing 6 weeks later. The fertilizers were applied in the drill by use of a Planet Junior distributor which mixed them well with the soil.

TABLE I.—SHOWING THE FERTILIZERS USED, THE AVAILABILITY OF THE LEADING CONSTITUENTS, AND THE RATE OF APPLICATION PER ACRE.

Fertilizer	Percentage of leading constituent	Basic rate of application per acre
Acid phosphate	14% phosphoric acid (P ₂ O ₅)	375 lbs.
Potassium sulphate	48% potash (K ₂ O)	150 lbs.
Sodium nitrate	16% nitrogen	250 lbs.
Blood meal	11% nitrogen	375 lbs.
Tankage	6% nitrogen	150 lbs.
Culohur		200 lbs.

TABLE II.—SHOWING ARRANGEMENT OF FERTILIZER PLOTS, THE FERTILIZER COMBINATIONS, AND THE QUANTITY OF THE DIFFERENT FERTILIZERS USED, PER ACRE BASIS, IN THE FIRST SERIES OF EXPERIMENTS.

Plot No.	Fertilizers	Previous treatment of land	
		Planted to cotton	Planted to alfalfa
1	Control	No fertilizer	No fertilizer
2	Tankage	150 lbs.	150 lbs.
3	Potassium sulphate	150 lbs.	150 lbs.
4	Sodium nitrate	250 lbs.	250 lbs.
5	Sulphur	200 lbs.	200 lbs.
6	Control	No fertilizer	No fertilizer
7	Blood meal	375 lbs.	375 lbs.
8	Acid phosphate	375 lbs.	375 lbs.
9	Acid phosphate Potassium sulphate	375 lbs. 150 lbs.	375 lbs. 150 lbs.
10	Acid phosphate Sodium nitrate	375 lbs. 250 lbs.	375 lbs. 250 lbs.
11	Control	No fertilizer	No fertilizer
12	Acid phosphate Sulphur	375 lbs. 200 lbs.	375 lbs. 200 lbs.
13	Acid phosphate Blood meal	375 lbs. 375 lbs.	375 lbs. 375 lbs.
14	Acid phosphate Blood meal Potassium sulphate	375 lbs. 375 lbs. 150 lbs.	375 lbs. 375 lbs. 150 lbs.
15	Acid phosphate Blood meal Sodium nitrate	375 lbs. 375 lbs. 250 lbs.	375 lbs. 375 lbs. 250 lbs.
16	Control	No fertilizer	No fertilizer
17	Acid phosphate Blood meal Sulphur	375 lbs. 375 lbs. 200 lbs.	375 lbs. 375 lbs. 200 lbs.
18	Acid phosphate Sodium nitrate Sulphur	375 lbs. 250 lbs. 200 lbs.	375 lbs. 250 lbs. 200 lbs.
19	Acid phosphate Sodium nitrate Blood meal Sulphur	375 lbs. 250 lbs. 375 lbs. 200 lbs.	375 lbs. 250 lbs. 375 lbs. 200 lbs.
20	Potassium sulphate Sodium nitrate	150 lbs. 250 lbs.	150 lbs. 250 lbs.
21	Control	No fertilizer	No fertilizer
22	Potassium sulphate Sulphur	150 lbs. 200 lbs.	150 lbs. 375 lbs.
23	Potassium sulphate Blood meal	150 lbs. 375 lbs.	150 lbs. 375 lbs.
24	Potassium sulphate Sodium nitrate Sulphur	150 lbs. 250 lbs. 200 lbs.	150 lbs. 250 lbs. 200 lbs.

TABLE II.—Continued.

Plot No.	Fertilizers	Previous treatment of land	
		Planted to cotton	Planted to alfalfa
25	Potassium sulphate Sodium nitrate Blood meal	150 lbs. 250 lbs. 375 lbs.	150 lbs. 250 lbs. 375 lbs.
26	Control	No fertilizer	No fertilizer
27	Potassium sulphate Sodium nitrate Blood meal Sulphur	150 lbs. 250 lbs. 375 lbs. 200 lbs.	150 lbs. 250 lbs. 375 lbs. 200 lbs.
28	Potassium sulphate Blood meal Sulphur	150 lbs. 375 lbs. 200 lbs.	150 lbs. 375 lbs. 200 lbs.
29	Sodium nitrate Sulphur	250 lbs. 200 lbs.	250 lbs. 200 lbs.
30	Sodium nitrate Blood meal	250 lbs. 375 lbs.	250 lbs. 375 lbs.
31	Control	No fertilizer	No fertilizer
32	Sodium nitrate Blood meal Tankage	250 lbs. 375 lbs. 150 lbs.	250 lbs. 375 lbs. 150 lbs.
33	Sodium nitrate Blood meal Sulphur	250 lbs. 375 lbs. 200 lbs.	250 lbs. 375 lbs. 200 lbs.
34	Sodium nitrate Blood meal Tankage Sulphur	250 lbs. 375 lbs. 150 lbs. 200 lbs.	250 lbs. 375 lbs. 150 lbs. 200 lbs.
35	Blood meal Sulphur	375 lbs. 200 lbs.	375 lbs. 200 lbs.
36	Tankage Sulphur	150 lbs. 200 lbs.	150 lbs. 200 lbs.
37	Control	No fertilizer	No fertilizer

RESULTS OF FIRST SERIES OF EXPERIMENTS

During the progress of the experiments, observations were made to determine the influence of the different fertilizers on growth, time of maturity, size, weight, and compactness of head. Acid phosphate produced the only striking effects. The effects of the phosphate were evident when it was used alone and with the other fertilizers. Of the different fertilizer combinations, acid phosphate and blood meal produced outstanding results.

EFFECT UPON GENERAL GROWTH

The influence of the acid phosphate was observed first on the growth of the young plants. The plants so fertilized grew faster



Fig. 1.—View of lettuce fertilizer plots 6 weeks after planting, showing the effect of acid phosphate upon the early growth of the plant. Plantings in the background fertilized with acid phosphate; plantings in the foreground, without acid phosphate.



Fig. 2.—Showing increased growth of young lettuce plants as the result of the application of acid phosphate. Left—with acid phosphate. Right—without acid phosphate. Picture taken 6 weeks after planting.

and the larger leaf surface in the early stages of growth was very pronounced where the phosphate was used alone or in combination with other fertilizers. This increased growth and size of the young plants obtained from applications of acid phosphate, are shown in figures 1 and 2. This lead in growth became still more noticeable as the plants became older. About the time heading started, however, the larger foliage occurred where the acid phosphate was combined with the nitrogenous fertilizers,

particularly blood meal. The use of nitrogenous fertilizers alone (without acid phosphate) produced no increase in size of foliage over the unfertilized or control plots.

EFFECT UPON MATURITY OF HEAD

Acid phosphate was found to have an outstanding effect in hastening maturity. The first mature heads in the plots appeared 93 days from planting, which was 20 days earlier than the lettuce produced on the control plots, or by the use of other fertilizers. This effect is understood best by observing Table III, which gives a tabulation of the percentage of the lettuce crop from each plot that was ready for harvest at the first general cutting, 107 days from the time of planting. It will be noted that over 50 percent of the crop was ready for harvest in all the plots where acid phosphate was applied, either alone or in combination with other fertilizers; whereas, only a very small percentage, and in most cases none, of the crop in the remaining plots had reached the proper stage of maturity for harvesting. The effect on the earliness of maturity is still further emphasized in figure 3. This photograph was taken on the date of the first general cutting, tabulated in Table III, and shows the comparative state of maturity of heads harvested from plots fertilized with the single forms of fertilizers and the controls. Heads representative of the average state of maturity were secured for the picture. Note the evidence of lack of maturity of all the heads, as shown by the looseness of texture, except the one fertilized with acid phosphate. It is easily seen that the head fertilized with acid phosphate is the only one of sufficient maturity and compactness to warrant being cut at that time.

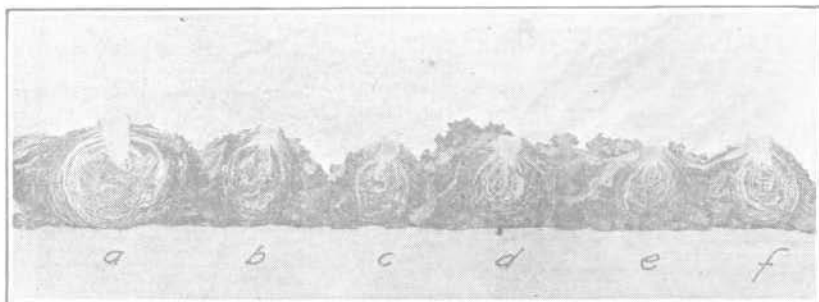


Fig. 3.—Comparative maturity of heads of lettuce from plots with the single treatments of fertilizer and the control plot. (a) Acid phosphate; (b) potassium sulphate; (c) sodium nitrate; (d) blood meal; (e) sulphur; (f) control, no fertilizer.

TABLE III.—SHOWING EFFECT OF DIFFERENT FERTILIZERS UPON MATURITY AND YIELDS, EXPRESSED IN PERCENTAGE OF MATURE HEADS AT FIRST CUTTING, AND AVERAGE WEIGHT PER 100 HEADS.

Fertilizer plots	Percentage of mature heads at first cutting			Weight per hundred heads		
	Follow- ing al- falfa	Follow- ing cot- ton	Av. of both fields	Follow- ing al- falfa	Follow- ing cot- ton	Av. of both fields
Control	0	0	0.0	102	89	95
Tankage	0	0	0.0	114	100	107
Potassium sulphate	0	0	0.0	104	91	97
Sodium nitrate	0	0	0.0	107	100	102
Sulphur	0	0	0.0	115	89	102
Blood meal	5	0	2.5	113	106	109
Acid phosphate	56	74	65.0	137	129	133
Acid phosphate Potassium sulphate	57	72	64.5	143	167	155
Acid phosphate Sodium nitrate	47	51	49.0	144	135	139
Acid phosphate Sulphur	51	23	37.0	155	133	144
Acid phosphate Blood meal	57	99	78.0	139	160	174
Acid phosphate Blood meal Potassium sulphate	32	51	41.5	166	133	149
Acid phosphate Blood meal Sulphur	78	96	67.3	158	137	157
Acid phosphate Sodium nitrate Sulphur	55	64	59.5	153	146	149
Acid phosphate Sodium nitrate Blood meal Sulphur	61	73	68.5	168	170	169
Potassium sulphate Sodium nitrate	8	0	4.0	114	105	109
Potassium sulphate Sulphur	0	0	0.0	115	105	110
Potassium sulphate Blood meal	0	8	4.0	108	104	106
Potassium sulphate Sodium nitrate Sulphur	0	0	0.0	114	110	112
Potassium sulphate Sodium nitrate Blood meal	0	0	0.0	115	113	114
Potassium sulphate Sodium nitrate Blood meal Sulphur	0	0	0.0	111	100	105

TABLE III—Continued.

Fertilizer plots	Percentage of mature heads at first cutting			Weight per hundred heads		
	Follow- ing fall	Follow- ing cotton	Average of both	Follow- ing fall	Follow- ing cotton	Average of both
Potassium sulphate						
Blood meal						
Sulphur	0	0	0.0	107	107	107
Sodium nitrate						
Sulphur	7	0	3.5	101	100	102
Sodium nitrate						
Blood meal	3	13	8.0	110	100	105
Sodium nitrate						
Blood meal						
Tankage	0	0	0.0	110	111	111
Sodium nitrate						
Blood meal						
Sulphur	0	0	0.0	105	100	101
Sodium nitrate						
Blood meal						
Tankage						
Sulphur	0	0	0.0	110	109	105
Blood meal						
Sulphur	4	0	2.0	101	100	102
Tankage						
Sulphur	3	0	1.5	103	100	101

EFFECT UPON YIELD AND SIZE

In addition to hastening maturity, the acid phosphate was found to have a decided influence on yield and size of head. The average weight per head from the acid phosphate plot was 1.33 pounds which was .38 of a pound greater than the average from the control plots and .28 of a pound more than the combined average from the plots on which other single forms of fertilizers were used. Expressed in weight per 100 heads, this is an increase of 38 pounds over the controls and 28 pounds over the other fertilizers, used singly. (Fig. 4.)

It is of particular interest that this increase in weight was greater with the use of acid phosphate than with the nitrogenous fertilizers. The increase in the average weight per head with phosphate over blood meal, sodium nitrate, and tankage was .24, .30, and .26 of a pound, respectively. This finding is important, since it has been generally understood that higher yields of lettuce may be expected from the use of nitrogenous fertilizers. The effects of all the fertilizers upon yield, as expressed in weight per hundred heads, are shown in Table III.

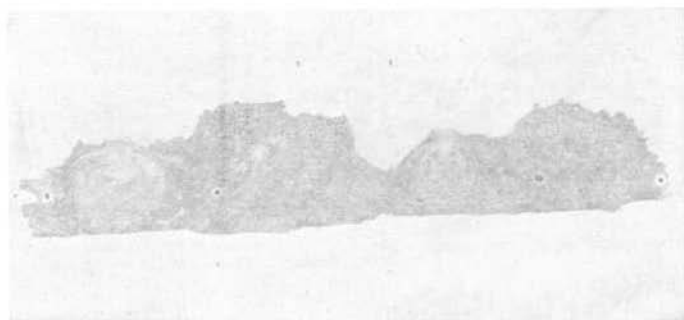


Fig. 4.—Showing the effect of acid phosphate upon the size and compactness of head. Left—average heads from acid phosphate plots. Right—average heads from unfertilized plots.

In studying the influence of acid phosphate in combination with the other fertilizers, it was found to produce a striking effect when used with blood meal. It increased both the *weight* and the *size* of the head. In actual figures, the increase in average weight per head obtained from the acid phosphate-blood meal combination over acid phosphate alone was .41 or nearly one-half of a pound. It will be seen from a study of Table III that acid phosphate in combination with the other fertilizers, gave some increase in yield, but the results were not so pronounced as they were with blood meal.

The effect of acid phosphate upon the size of head, when used alone or in combination with blood meal, is still further emphasized in Table IV. This table shows the size of head, as expressed in commercial grades or the number of heads per standard crate, using only the single fertilizers and the acid phosphate-blood meal combination. In comparing the different fertilizers used singly, it is seen that potassium sulphate, tankage, sodium nitrate, sulphur, and blood meal, as well as the controls, produced lettuce that graded 5 dozen heads per crate; whereas, the acid phosphate produced grades showing 31 percent of the 3 dozen, and 68 percent of the 4 dozen sizes. It is observed further that the acid phosphate-blood meal combination produced 78 percent of heads grading 3 dozen, and 22 percent grading 4 dozen, per crate. These figures represent the average sizes for crops produced on alfalfa and cotton ground. Wherever the acid phosphate was combined with a nitrogenous fertilizer the heads were larger, but the largest size occurred with blood meal. The increase in size of head due to combining blood meal with acid phosphate, over acid phosphate alone, is shown in figure 5.

The fact that none of the other fertilizers, when used singly,

produced heads which graded above 5 dozen per crate may be explained partly by the lateness of the season. However, this serves to emphasize *earliness* as an attainable factor through the use of acid phosphate.

TABLE IV.—SHOWING EFFECT OF ACID PHOSPHATE ALONE, AND IN COMBINATION WITH DIFFERENT FERTILIZERS, UPON SIZE, AS EXPRESSED IN COMMERCIAL GRADES.

Fertilizer	Grades according to size									Average grades for alfalfa and cotton plots		
	Following alfalfa			Following cotton								
	5	4	3	5	4	3	5	4	3			
	doz.	doz.	doz.	doz.	doz.	doz.	doz.	doz.	doz.	h'ds	h'ds	h'ds
per	per	per	per	per	per	per	per	per	per	per	per	
cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	cr'te	
	Per-	Per-	Per-	Per-	Per-	Per-	Per-	Per-	Per-	Per-	Per-	
	cent	cent	cent	cent	cent	cent	cent	cent	cent	cent	cent	
Control	100			100			100					
Potassium sulphate	100			100			100					
Tankage	100			100			100					
Sodium nitrate	100			100			100					
Sulphur	100			100			100					
Blood meal	100			100			100					
Acid phosphate		51	49		86	14			68.5	31.5		
Acid phosphate Potassium sulphate		49	51		80	20			64.5	35.5		
Acid phosphate Sodium nitrate		22	78		85	15			53.5	46.5		
Acid phosphate Sulphur		13	78		72	28			42.5	57.5		
Acid phosphate Blood meal			100		44	56			22.0	78.0		
Acid phosphate Blood meal Potassium sulphate			100		61	39			30.5	69.5		

An important consideration regarding the increase in size, caused by the addition of blood meal to the acid phosphate, is the fact that earliness is not sacrificed. In fact it is seen by observing Table III that the first general cutting yielded even a higher percentage of marketable heads from the phosphate-blood meal combination than from the phosphate alone, the actual difference being .13 percent in favor of the former. It should be stated, however, as shown in figure 5, that while the heads produced from the acid phosphate-blood meal combination were large, as well as early in maturing, they were a little less compact than were those produced by acid phosphate alone. In the former the foliage was distinctly heavier.

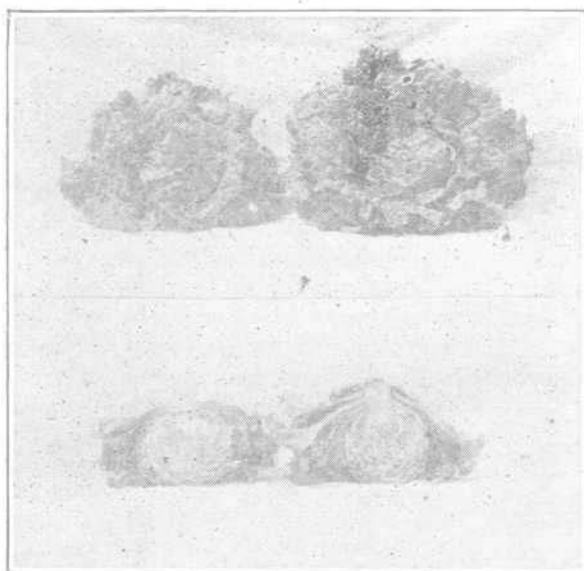


Fig. 5.—Acid phosphate versus acid phosphate and blood meal combined. Left—lettuce head from plot fertilized with acid phosphate alone; less leafy, smaller, but compact. Right—fertilized with both acid phosphate and blood meal; more leafy, larger, and less compact.

RELATIVE EFFECT OF FERTILIZERS AS INFLUENCED BY PRECEDING CROPS OF ALFALFA AND COTTON

Tables III and V show interesting data relative to the effects of the different fertilizers, as influenced by the preceding crops of alfalfa and cotton. It is noted that alfalfa, preceding the lettuce crop, had the effect of increasing the size of the head at the expense of early maturity. The average increase in weight of heads, for the different fertilizers, singly and in combination with acid phosphate, was .16 of a pound; the average decrease in earliness 5.37 days. The greatest increase in weight occurred where blood meal was used with acid phosphate, the least increase where blood meal and sodium nitrate were used with acid phosphate, due, in the latter case, to the looseness of the heads. The influence of the alfalfa on yield was distinctly seen, as evidenced by the control plots which gave an average increase in weight per head of .13 of a pound. The use of acid phosphate alone, following alfalfa, showed no striking increase in yield, being only .08 of a pound.

Decrease in the earliness of the lettuce crop, following alfalfa, was noted throughout the entire series of lettuce plantings.

TABLE V.—SHOWING THE RELATIVE INFLUENCE OF PRECEDING CROPS OF ALFALFA UPON WEIGHT PER HEAD AND TIME OF MATURITY OF LETTUCE.

Fertilizer	Increase in weight per head, following alfalfa as compared with lettuce following cotton	Decrease in number of days of crop, following alfalfa as compared with lettuce following cotton
Control	0 pound	2 days
Pankage	.14 pound	4 days
Potassium sulphate	.13 pound	2 days
Sodium nitrate	.07 pound	6 days
Sulphur	.53 pound	2 days
Blood meal	.07 pound	8 days
Acid phosphate	.00 pound	6 days
Acid phosphate Potassium sulphate	.24 pound	6 days
Acid phosphate Sodium nitrate	.00 pound	4 days
Acid phosphate Sulphur	.22 pound	6 days
Acid phosphate Blood meal	.33 pound	9 days
Acid phosphate Blood meal Potassium sulphate	.20 pound	5 days
Acid phosphate Blood meal Sodium nitrate	.05 pound	3 days
Acid phosphate Blood meal Sulphur	.18 pound	6 days
Acid phosphate Sodium nitrate Sulphur	.07 pound	10 days
Acid phosphate Sodium nitrate Blood meal Sulphur	.15 pound	6 days

SUMMARY OF RESULTS, FIRST SERIES OF EXPERIMENTS

Acid phosphate produced the only striking effects upon the lettuce plant, as follows:

- (a) Produced a more rapid growth of the young plants.
- (b) Hastened maturity by as much as two weeks.
- (c) Increased the weight and size of head.
- (d) Increased the compactness of head.

Combined with blood meal, acid phosphate increased the weight and size of the lettuce head above that of acid phosphate alone.

The increase in weight and size of head, resulting from the acid phosphate-blood meal combination, did not decrease materially the earliness of the crop.

Lettuce after alfalfa showed increased size of head but was not so early as lettuce following cotton.

SUBSEQUENT EXPERIMENTS

Realizing that additional data were necessary for dependable, conclusive results, a more comprehensive series of experiments was made the following year. Since the first series of experiments showed that acid phosphate alone, and in combination with blood meal, produced the only marked effects on the lettuce plant, the second series of experiments was planned with special reference to the influences of these two fertilizers.

EXPERIMENT A

Purpose:—To determine the effect of acid phosphate alone, and in combination with blood meal, upon the lettuce plant, as influenced by the time of planting.

Outline:—This experiment consisted of a series of plantings made at intervals of one week, from September 17 to December 31. The arrangement of plots, and the amounts of fertilizers used in each series are shown in Table VI. Each plot consisted of a single row 400 feet long. The rate of application of both acid phosphate and blood meal was 375 pounds per acre, the same as used in the experiments of the previous year. The variety of lettuce and method of planting were also the same as in the first experiments. The only difference in cultural methods was that of thinning the plants to 14, instead of 12, inches in the row. The lettuce crop was preceded by cowpeas, grown for seed production.

TABLE VI.—SHOWING ARRANGEMENT OF PLOTS IN EXPERIMENT A; ALSO THE RATE OF APPLICATION OF FERTILIZERS PER ACRE. (THE PLOTS WERE EXACTLY ALIKE THROUGHOUT THE SERIES.)

Plot No. 1	Control	
Plot No. 2	Acid phosphate	375 pounds
Plot No. 3	Blood meal	375 pounds
Plot No. 4	Acid phosphate	375 pounds
	Blood meal	375 pounds

Results:—The effect of acid phosphate on the time of maturity and yield was apparent throughout the whole series. The difference in time of maturity of the lettuce crop under the dif-

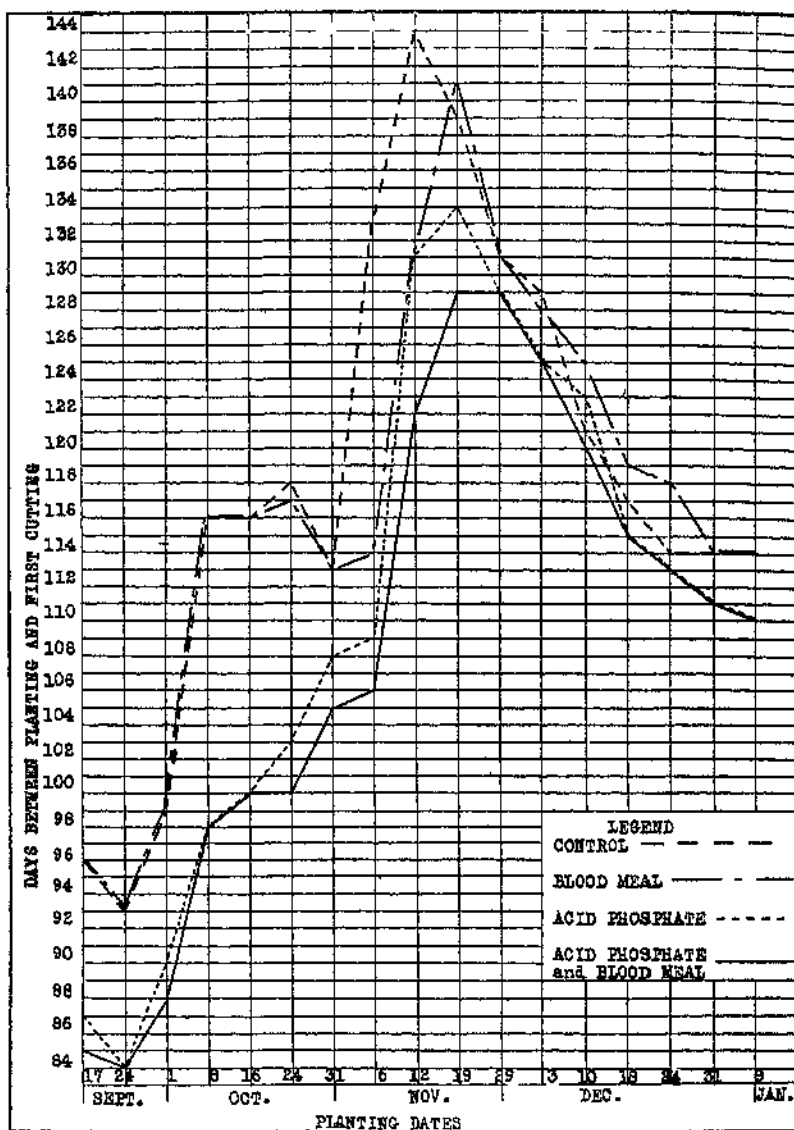


Fig. 6.—Showing the effect of acid phosphate and blood meal singly and in combination with each other, upon time of maturity, as influenced by the time of planting.

ferent treatments, as influenced by the time of planting, is shown in figure 6. The average number of days between planting and maturity was as follows:

Control plots.....	118 days
Blood meal.....	117 days
Acid phosphate.....	110 days
Acid phosphate and blood meal, combined.....	108 days

It is thus seen that acid phosphate when combined with blood meal shortened the time of maturity 10 days. This substantiated the findings of the previous year, namely, that the addition of blood meal in reasonable quantity did not counteract the influence of acid phosphate in inducing early maturity. At the same time, as shown in figure 7, the addition of blood meal gave a decided increase in yield over that of acid phosphate used alone. This average increase in weight per head for the entire series was 1.53 ounces. The increase in weight produced by acid phosphate alone, over the controls, was also apparent throughout the series, amounting to an average of 1.35 ounces per head.

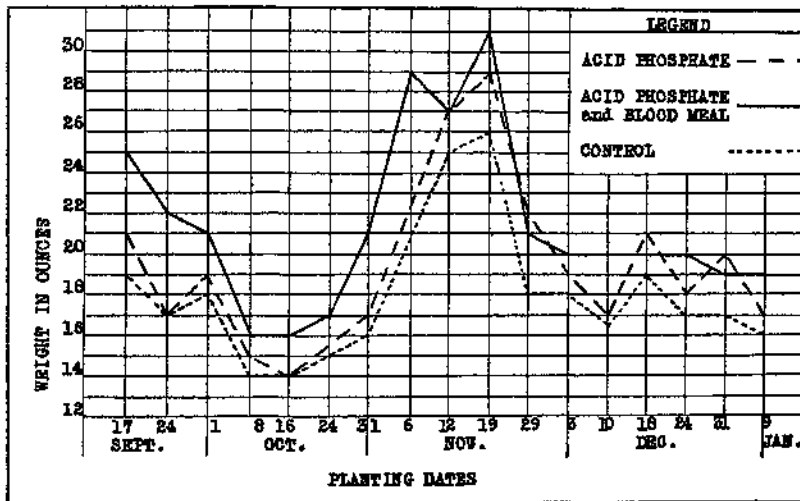


Fig. 7.—Showing the effect of acid phosphate alone, and in combination with blood meal, upon weight per head, as influenced by the time of planting.

The effect of acid phosphate, as influenced by the time of planting, was most marked in the earlier plantings, *i. e.*, from September 17 to the latter part of October. This was true with reference to its effect upon both the yield and the time of maturity, as shown in figures 6 and 7. It was thought that perhaps the acid phosphate would have a tendency to cause the early plantings to produce seed before heading, but this was not the

case. The heads produced from the earlier plantings were apparently as compact as were those from the later ones.

It is seen that the late fall and early winter plantings were decidedly longer in maturing, which was to be expected on account of the cooler weather. To offset this, however, the yields were greater from plantings made at this time.

Summary of Experiment A:—The results of this experiment are briefly as follows:

1. Acid phosphate had a decided influence in hastening maturity, and in increasing the size of head.
2. Blood meal combined with acid phosphate increased the weight of head without delaying the time of maturity.
3. The predominating effect of acid phosphate in hastening maturity was not influenced materially by the time of planting.
4. The effect of blood meal in combination with acid phosphate in increasing size was not influenced greatly by the time of planting.



Fig. 8.— Showing the relative effects of different amounts of acid phosphate alone upon maturity and yield, as expressed in size and compactness of head. Reading from left to right: Control; 100, 300, 500, and 700 pounds respectively of acid phosphate, per acre. Upper row, following cowpeas; middle row, following summer fallow; lower row, following cowpeas. Note that the greater amounts of fertilizer show very little increase in size and compactness of head over the lesser amounts used.

EXPERIMENT B

Purpose:—To determine the effect of acid phosphate alone, and in combination with blood meal, upon the lettuce plant, as influenced by the amount of fertilizer used.

Outline:—In this experiment each plot consisted of four rows.

400 feet in length, and subdivided crosswise into three areas according to the previous treatment of the land, as follows:

(1) Land planted to cotton the previous year, followed by cowpeas; (2) land planted to cotton the previous year, followed by summer fallowing; (3) land planted to sweet potatoes the previous year, followed by cowpeas. The varieties of lettuce and the method of planting and cultivating the crop were the same as those used in Experiment A. The date of planting was November 29, 1923.

The following plots, each consisting of three different soil treatments as already noted, with the rates of application of fertilizer per acre given below, made up this experiment:

- | | |
|----------------------------|----------------------------|
| 1. Control. | 11. Control. |
| 2. Phosphate, 100 pounds. | 12. Phosphate, 300 pounds. |
| 3. Control. | Blood meal, 300 pounds. |
| 4. Phosphate, 300 pounds. | 13. Control. |
| 5. Control. | 14. Phosphate, 500 pounds. |
| 6. Phosphate, 500 pounds. | Blood meal, 500 pounds. |
| 7. Control. | 15. Control. |
| 8. Phosphate, 700 pounds. | 16. Phosphate, 700 pounds. |
| 9. Control. | Blood meal, 700 pounds. |
| 10. Phosphate, 100 pounds. | 17. Control. |
| Blood meal, 100 pounds | |

Results:—The effect of different amounts of acid phosphate alone, and in combination with blood meal, upon maturity is shown in Table VII. These figures were obtained by determining the percentage of mature heads that were available in each plot at the first general cutting. In observing the average percentage of mature heads for the different subdivisions in each plot it was found that acid phosphate, when used alone, produced a decided increase in earliness over the control plots; but that increased amounts of this fertilizer, above 100 pounds per acre, did not have a corresponding influence. When applied at the rate of 100 pounds per acre the percentage of mature heads at the first cutting was 16 percent; and when applied at the rate of 700 pounds per acre the yield was only 15 percent. One hundred pounds per acre was the smallest amount of acid phosphate used, and it is possible that 50 to 75 pounds per acre might produce the desired effect in promoting earliness. (Fig. 8.)

In observing the effects of acid phosphate in combination with blood meal, it was found, as shown in Table VII and

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Summary of Experiment B:—Acid phosphate hastened maturity and increased the size of head when used at the rate of 100 pounds and 300 pounds respectively per acre; the use of greater amounts of acid phosphate produced no additional results.

Blood meal in combination with acid phosphate gave no appreciable effect in delaying maturity when used at the rate of 100 and 300 pounds respectively per acre; the use of greater amounts of blood meal delayed materially the time of maturity.

Blood meal in combination with acid phosphate gave no appreciable increase in yield when applied in quantities of more than 300 pounds per acre.

EXPERIMENT C

Purpose:—To determine the comparative effects of different fertilizers upon the lettuce plant.

Outline:—This experiment was a duplicate of the preliminary experiment conducted the previous year. It was planned for the purpose of securing more conclusive data on the relative effects of different fertilizers. There was one factor concerning the treatment of the land which should be mentioned. One-half of the land used for the preliminary tests with lettuce had been planted previously to cotton, and the other half to alfalfa, the lettuce crop following immediately after. Adjacent land was used for Experiment C, but during the interval between the two experiments, the land was planted to Irish potatoes. Therefore, one-half of the lettuce crop in Experiment C was planted a year after alfalfa had been grown on the land, and the other half a year after cotton.

The results of Experiment C can be summarized with the brief statement that the findings were identical with those of the preliminary experiment, as already described. Acid phosphate alone, and acid phosphate in combination with blood meal, produced the only outstanding results.

Table IX shows the relative effects of the different fertilizers, used singly and in combination with acid phosphate, upon the time of maturity and yield, expressed as the average for 2 years. It will be noted that, of the different fertilizers used singly, the most marked effect was produced by the acid phosphate, both with respect to earliness of maturity and yield. Of the different fertilizer combinations, blood meal with phosphate gave the largest yield, without lessening materially the time of maturity.

TABLE IX.—SHOWING RELATIVE EFFECT OF DIFFERENT FERTILIZERS USED SINGLY, AND IN COMBINATION WITH ACID PHOSPHATE, UPON TIME OF MATURITY AND YIELD, EXPRESSED AS THE AVERAGE FOR TWO YEARS.

Fertilizer plots	Percentage of mature heads at first cutting			Average weight per head		
	Fol- lowing alfalfa	Fol- lowing cotton	Aver- age of both fields	Fol- lowing alfalfa	Fol- lowing cotton	Aver- age of both fields
Control	0	0	0.0	1.07	.94	1.00
Tankage	1	0	0.5	1.15	1.08	1.11
Potassium sulphate	1	0	0.5	1.09	.92	1.05
Sodium nitrate	2	0	1.0	1.08	1.14	1.11
Sulphur	3	0	1.5	1.19	.96	1.07
Blood meal	2	6	4.0	1.16	1.16	1.16
Acid phosphate	56	58	57.0	1.87	1.39	1.38
Acid phosphate Potassium sulphate	54	56	55.0	1.43	1.67	1.55
Acid phosphate Sodium nitrate	46	51	48.5	1.42	1.44	1.43
Acid phosphate Sulphur	57	38	47.5	1.50	1.44	1.47
Acid phosphate Blood meal	59	68	63.5	1.67	1.64	1.65
Acid phosphate Blood meal Potassium sulphate	58	55	56.5	1.72	1.49	1.60

GENERAL SUMMARY

1. Acid phosphate alone had the effect of materially hastening maturity of the lettuce plant and at the same time slightly increasing the size and compactness of the head.
2. Blood meal combined with acid phosphate in reasonable amounts increased the weight and size of head without delaying the time of maturity.
3. Blood meal combined with acid phosphate in excessive amounts increased the size and looseness of the head at the expense of earliness.
4. The factors of early maturity and size of head produced by acid phosphate alone, and acid phosphate in combination with blood meal were not affected by the time of planting.
5. Additional quantities of acid phosphate, above the rate of 300 pounds per acre, had no influence in increasing earliness of maturity or size of head.
6. Planting lettuce on alfalfa ground had the effect of increasing the yield at the expense of earliness.

7. It is apparent from these experiments that the desired effects in the application of acid phosphate and blood meal may be obtained by the use of 100 to 300 pounds of each per acre.

8. Based upon the analysis of the soil, the striking results obtained by the use of acid phosphate show very definitely that the phosphates in Arizona soils are not readily available to plants.

9. The beneficial effects derived from the use of acid phosphate on lettuce, due to the unavailability of phosphates in Arizona soils, suggest that this form of fertilizer may be used to advantage with other crops, in hastening maturity and increasing quality.