1-1-1915

Experiments with Fertilizers

Firman E. Bear

October, 1915 Bulletin 155

West Virginia University
Agricultural Experiment Station
MORGANTOWN, W. VA.

DEPARTMENT OF SOILS

Experiments With Fertilizers

No Fertilizers HAY 1915 Fertilizer

BY
FIRMAN E. BEAR

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†In co-operation with the University of Chicago.

FERTILIZER FACTS.

Summarized from 15 years' experiments at the West Virginia Agricultural Experiment Station on the basis of crop values assumed in this bulletin.

1. Every ton of manure applied alone has produced an increase per ton, valued at $3.12.

2. Every dollar's worth of acid phosphate applied alone has given an average of $4.63 worth of increase.

3. Every dollar's worth of nitrate of soda applied alone has given an average of $.34 worth of increase.

4. Every dollar's worth of sulphate of potash applied alone has given an average of $.37 worth of increase.

5. Nitrate of soda and acid phosphate applied in combination have given 2¼ times as much increase per acre as acid phosphate alone, and $2.19 worth of increase for every dollar invested.

6. Nitrate of soda, sulphate of potash and acid phosphate applied in combination have given three times as much increase per acre as acid phosphate alone and $2.32 worth of increase for every dollar invested.

7. Every dollar invested in lime and applied in connection with complete fertilizer has given an increase valued at $1.35.

DIAGRAM OF FERTILITY PLOTS

PLOTS ONE-TENTH ACRE EACH

PLOT	
18	No Fertilizer
19	Nitrate of Soda, Acid Phosphate, Sulphate of Potash, Lime
20	Manure and Lime
21	No Fertilizer
22	Lime
23	Ash of Manure and Nitrate of Soda
24	No Fertilizer
25	Manure
26	Nitrate of Soda, Acid Phosphate and Sulphate of Potash
27	No Fertilizer
28	Acid Phosphate and Sulphate of Potash
29	Nitrate of Soda and Sulphate of Potash
30	No Fertilizer
31	Nitrate of Soda and Acid Phosphate
32	Sulphate of Potash
33	No Fertilizer
34	Acid Phosphate
35	Nitrate of Soda
36	No Fertilizer

Experiments With Fertilizers

By FIRMAN E. BEAR

The West Virginia Agricultural Experiment Station has conducted a series of fertilizer experiments since 1900 on the Experiment Station farm at Morgantown. Three bulletins, numbers 99, 112 and 131, have been published, giving the results of the fertilizer tests. The present publication is intended as a summary of the former bulletins together with additional data secured since the publication of Bulletin No. 131.

Plan of the Experiments.

The original plan of these experiments was devised by Horace Atwood. A part of the station farm lying along the Morgantown and Pt. Marion pike was laid off in tenth acre plots. Each plot was made two rods wide and eight rods long with a three foot space between plots. The plots were numbered serially from 18 to 36. In order to determine whether there was any in-equality in the soil every third plot was left unfertilized. Accordingly, plots 18, 21, 24, 27, 30, 33 and 36 are no-fertilizer, or check plots. Three of these check plots have been discarded as checks.

The tile drain passing near plot 18 became stopped up and the yields were abnormal.

Plot 24 had been used as a check until 1913 when by mistake this plot was given an application of manure intended for plot 25. Although the manure was raked off with a hand rake a few days later, the plot was ruined as a check plot. The yield of wheat on this plot in 1914 was 19.83 bushels per acre as compared to 5.92 bushels, the average of the other check plots. The yield of hay on plot 24 in 1915 was 2,660 pounds per acre as compared to 198 pounds, the average of the other checks.

It became necessary to discard plot 36 because this plot had a tendency to wash and did not give a fair check.

In the original report of the experiments the increase produced by the use of fertilizer was computed by taking the

average of the two nearest check plots and subtracting this from the yield of the fertilized plot. Since three of the check plots were discarded it was found necessary to take the average of all the remaining checks and subtract this from the yield of the plots receiving fertilizer.

The yield of the remaining check plots indicate that the soil is naturally fairly uniform in productivity. The total produce of these check plots since 1900 is as follows:

	Pounds Produce
Plot 21	38,500
Plot 27	41,940
Plot 30	39,250
Plot 33	36,615

The soil on which these fertilizer tests are being conducted is mapped by the U. S. Bureau of Soils as Dekalb silt loam. It has been formed by the disintegration of the grayish shales and fine grained sandstone overlying the Pittsburg vein of coal. The soil is naturally well drained, and easily tilled but has a tendency to dry out too rapidly. It is only moderately productive normally but can be made very productive if well treated. The original timber consisted mostly of oak and chestnut.

The Crops Grown.

No definite rotation was adopted but a variety of crops were grown in order to determine the effect of fertilizer treatment on a number of different crops.

Since 1900 there have been three crops of corn, two crops each of timothy, rye, clover, and wheat and one crop each of oats, cowpeas, potatoes, and timothy and clover mixed.

Fertilizer Treatment.

In order to magnify the effect and overcome the element of time to a certain extent, very liberal applications of fertilizer were made. The first application of fertilizer was made in the spring of 1900 as a top dressing on rye. Later applications have been made with a fertilizer drill, the fertilizer being applied immediately before planting the seed. In 1902 for the crop of clover, in 1907 for the crop of rye, and in 1908 and 1914 when the plots were seeded to timothy and clover no fertilizer was applied to any of the plots. The first year the carrier of phosphoric acid was Thomas slag, since then acid phosphate has been used.

The following shows the amount and kind of fertilizer applied annually to each plot, with the exceptions noted:

Plots 18, 21, 24, 27, 30, 33 and 36. No fertilizer.

Plot 19. 40 pounds sodium nitrate; 40 pounds acid phosphate; 15 pounds potassium sulphate (20 pounds in 1906); 100 pounds lime in 1900, 150 pounds lime in 1906 and 200 pounds lime in 1912.

Plot 20. Two tons stable manure; 100 pounds lime in 1900, 150 pounds lime in 1906, and 200 pounds lime in 1912.

Plot 22. 100 pounds lime in 1900 and in 1903, 150 pounds in 1906, and 200 pounds in 1912.

Plot 23. Ash from two tons of stable manure, together with an amount of nitrogen in the form of sodium nitrate equivalent to the nitrogen originally present in the stable manure. Applications made in 1900 and in 1901. Since then no further applications until 1912 when it received 40 pounds of a 4-16-4 fertilizer.

Plot 25. Two tons stable manure applied annually except in 1903.

Plot 26. 40 pounds sodium nitrate; 40 pounds acid phosphate; 15 pounds potassium sulphate (20 pounds in 1906.)

Plot 28. 40 pounds acid phosphate: 15 pounds potassium sulphate (20 pounds in 1906).

Plot 29. 40 pounds sodium nitrate; 15 pounds potassium sulphate (20 pounds in 1906).

Plot 31. 40 pounds acid phosphate; 40 pounds sodium nitrate.

Plot 32. 15 pounds potassium sulphate (20 pounds in 1906).

Plot 34. 40 pounds acid phosphate.

Plot 35. 40 pounds sodium nitrate.

1902, 1907, 1908, 1914 and 1915 no fertilizer applied on any of the plots.

1913 only ½ of original applications of fertilizer.

Total Amounts of Fertilizers Applied Per Acre From 1900 to 1915 Inclusive.

Plot	Nitrate of Soda Pounds per Acre	Acid Phosphate Pounds per Acre	Sulphate of Potash Pounds per Acre	Lime Pounds per Acre	Manure Tons per Acre
19	4200	4200	1625	4500	
20				4500	210
21					
22				5500	
23	30 Ash of 40 tons of manure until 1912				
24					
25					190
26	4200	4200	1625		
27					
28		4200	1625		
29	4200		1625		
30					
31	4200	4200			
32			1625		
33					
34		4200			
35	4200				

Plot 19
Lime and Fertilizer
5800 lbs. Hay

Plot 20
Lime and Manure
7400 lbs. Hay

Plot 21
No Fertilizer
100 lbs. Hay

Plot 22
Lime
750 lbs. Hay

Plot 28
Acid Phosphate
Sulphate of Potash
1440 lbs. Hay

Plot 29
Sulphate of Potash
Nitrate of Soda
360 lbs. Hay

Plot 31
Nitrate of Soda
Acid Phosphate
2590 lbs. Hay

Plot 34
1030 lbs. Hay
Acid Phosphate

POUNDS OF PRODUCE PER ACRE.

Plot	FERTILIZER	1900 RYE Grain	1900 RYE Straw	1901 WHEAT Grain	1901 WHEAT Straw	1902 CLOVER Hay	1903 CORN Grain	1903 CORN Stover	1904 COW PEAS Hay	1904 CORN Ensilage	1906 POTATOES Tubers	1907 RYE Grain	1907 RYE Straw
19	N, K_2O, P_2O_5, Lime	2076	3524	† 1665	3760	6700	6200	6800	6950	27700	6120	1170	3030
20	Manure, Lime	1578	2762	1840	4560	8850	7700	9400	6750	34700	13060	2140	4860
21	No Fertilizer	1186	2064	1140	1160	2050	2000	3800	1250	11200	2600	140	360
22	Lime	1077	1813	1010	1490	1500	1620	3200	1200	9800	1520	†130	330
23	Ash of Manure, N	2095	4845	1880	3320	7900	4410	5800	2750	15300	2500	170	280
24	No Fertilizer	1100	2070	1070	1830	2100	1770	3650	1350	12100	2610	140	380
25	Manure	1913	3587	1920	4580	9550	5230	6500	6100	34800	11300	1880	4420
26	N, K_2O, P_2O_5	2463	4317	1750	3950	7250	5620	7000	6300	29000	7030	1170	2530
27	No Fertilizer	1297	2583	1120	1780	2850	1980	3450	2200	12500	2850	160	290
28	P_2O_5, K_2O	1411	2739	1550	3350	5500	5160	6200	4400	16100	6360	850	1850
29	N, K_2O	1980	3560	1080	1820	2000	1500	3300	2300	15000	3520	140	260
30	No Fertilizer	1340	2540	1050	1650	2650	1820	3600	2100	10900	2140	160	250
31	N, P_2O_5	2267	4153	1550	3350	7900	5400	7000	5150	18900	3830	1020	2270
32	K_2O	1402	2678	1030	1670	2500	2000	3750	1950	11800	2630	140	360
33	No Fertilizer	1330	2600	1110	1990	2200	1930	3600	2450	8700	2400	120	280
34	P_2O_5	1360	2810	1390	2610	5400	4570	5750	3650	14100	3800	770	1930
35	N	1914	3716	930	1770	2600	1330	3300	2500	10200	2250	210	290

*Plots sown to timothy and clover but on account of unfavorable weather very poor crop in 1908. Plots were mowed and hay left on ground.

†Calculated yields.

POUNDS OF PRODUCE PER ACRE (Continued).

Plot	FERTILIZER	1909 TIMOTHY & CLOVER Hay	1910 TIMOTHY Hay	1911 TIMOTHY Hay	1912 CORN Grain	1912 CORN Stover	1913 OATS Grain	1913 OATS Straw	1914 WHEAT Grain	1914 WHEAT Straw	1915 CLOVER Hay	TOTAL PRODUCE
19	N, K_2O, P_2O_5, Lime	5600	9000	6090	4630	4190	875	2625	1720	4380	5800	120605
20	Manure, Lime	6800	10400	6240	5010	4600	1250	6000	1080	5420	7400	~~219000~~ 152400
21	No Fertilizer	755	1305	1130	1500	2900	220	680	350	710	100	38600
22	Lime	535	1240	1100	2470	3080	250	650	580	1270	750	36615
23	Ash of Manure, N	490	1120	890	3550	4620	530	1170	1490	3060	2100	69270
24	No Fertilizer	535	1180	900	1330	1400	280	420	*1190	*3010	*2660	43075
25	Manure	7800	9000	6640	4800	4400	1040	3760	1380	3420	5650	139670
26	N, K_2O, P_2O_5	4700	8700	6090	4890	4450	800	1800	1590	3460	3250	117910
27	No Fertilizer	505	1275	850	1550	2900	250	400	370	780	230	42170
28	P_2O_5, K_2O	1640	3475	2280	3170	4020	620	1130	1230	2520	1440	76995
29	N, K_2O	2125	3880	2390	2050	2300	380	820	560	890	360	52215
30	No Fertilizer	705	1375	930	1900	1990	290	710	370	780	230	39480
31	N, P_2O_5	4500	7300	4320	4080	4200	790	1410	1500	2450	2590	95940
32	K_2O	430	1285	850	2330	2400	330	570	380	820	260	41565
33	No Fertilizer	305	1260	570	1900	1920	300	550	330	770	230	36845
34	P_2O_5	845	3410	2290	2100	2050	750	1250	560	990	1030	63415
35	N	720	2885	1740	1400	1380	330	470	340	760	160	41195

*Abnormal yields due to an accidental application of manure which was subsequently removed with a rake.

INCREASE IN YIELD DUE TO FERTILIZER.

Plot	FERTILIZER	1900 RYE Grain bu.	1900 RYE Straw lbs.	1901 WHEAT Grain bu.	1901 WHEAT Straw lbs.	1902 CLOVER Hay lbs.	1903 CORN Grain bu.	1903 CORN Stover lbs.	1904 COW PEAS Hay lbs.	1905 CORN Ensilage lbs.	1906 POTATOES Tubers bu.	1907 RYE Grain bu.	1907 RYE Straw lbs.
19	N, K_2O, P_2O_5, Lime	14.73	1153	9.45	2078	4330	61.43	3180	5080	16620	60.00	18.32	2718
20	Manure, Lime	5.84	391	12.37	2878	6480	82.86	5780	4880	23620	175.67	35.64	4548
22	Lime	-3.11	-558	-1.47	-192	-870	-4.00	-420	-670	-1280	-16.68	-.25	18
23	Ash of Manure, N	15.07	1474	13.04	1638	5530	35.86	2180	880	4220	-.33	.46	-32
25	Manure	11.82	1216	13.70	2898	7180	47.57	2880	4230	23720	146.33	31.00	4108
26	N, K_2O, P_2O_5	21.64	1946	10.87	2268	4880	53.14	3380	4430	17920	75.17	18.32	2218
28	P_2O_5, K_2O	2.86	368	7.53	1668	3130	46.57	2580	2530	5020	64.00	12.61	1538
29	N, K_2O	13.02	1189	-.30	138	-370	-5.71	-320	430	3020	16.67	-.07	-52
31	N, P_2O_5	18.14	1782	7.53	1668	5530	50.00	3380	3280	7820	21.83	15.82	1958
32	K_2O	2.70	307	-1.13	-12	130	1.43	130	80	720	1.83	-.07	48
34	P_2O_5	1.95	439	4.87	928	3030	38.14	2130	1780	3020	21.33	11.18	1618
35	N	11.84	1345	-2.80	88	-230	-8.14	-320	630	-880	-4.50	1.18	-22
Average Yield of Check Plots		22.32	2371	18.30	1682	2370	27.14	3620	1870	11080	42.00	2.57	312

INCREASE IN YIELD DUE TO FERTILIZERS (Continued

Plot	FERTILIZER	1909 TIMOTHY & CLOVER Hay lbs.	1910 TIMOTHY Hay lbs.	1911 TIMOTHY Hay lbs.	1912 CORN Grain bu.	1912 CORN Stover lbs.	1913 OATS Grain bu.	1913 OATS Straw lbs.	1914 WHEAT Grain bu.	1914 WHEAT Straw lbs.	1915 CLOVER Hay lbs.
19	N, K_2O, P_2O_5, Lime	5039	7721	5214	42.77	1968	18.97	2073	22.75	3620	5602
20	Manure, Lime	6239	9121	5364	48.20	2378	30.69	5448	12.08	4660	7202
22	Lime	-26	-39	224	11.91	858	-.56	98	3.75	510	552
23	Ash of Manure, N	-71	-159	14	27.34	2398	8.19	618	18.92	2250	1902
25	Manure	7239	7721	5764	45.20	2178	24.13	3208	17.08	2660	5462
26	N, K_2O, P_2O_5	4139	7421	5214	46.49	2228	16.63	1248	20.58	2709	3062
28	P_2O_5, K_2O	1079	2196	1404	21.91	1798	11.00	578	14.58	1760	1242
29	N, K_2O	1564	2601	1514	5.91	78	3.50	268	3.42	130	162
31	N, P_2O_5	3939	6021	3444	34.91	1978	16.31	858	19.08	1690	2392
32	K_2O	-131	6	-26	9.91	178	1.94	18	.42	60	62
34	P_2O_5	284	2131	1414	6.63	-172	15.06	698	3.42	230	832
35	N	159	1506	864	-3.37	-842	1.94	-82	-.25	0	-38
Average Yield of Check Plots		561	1279	875	23.37	2222	8.38	552	5.92	760	198

VALUE OF INCREASE PER ACRE DUE TO FERTILIZER.

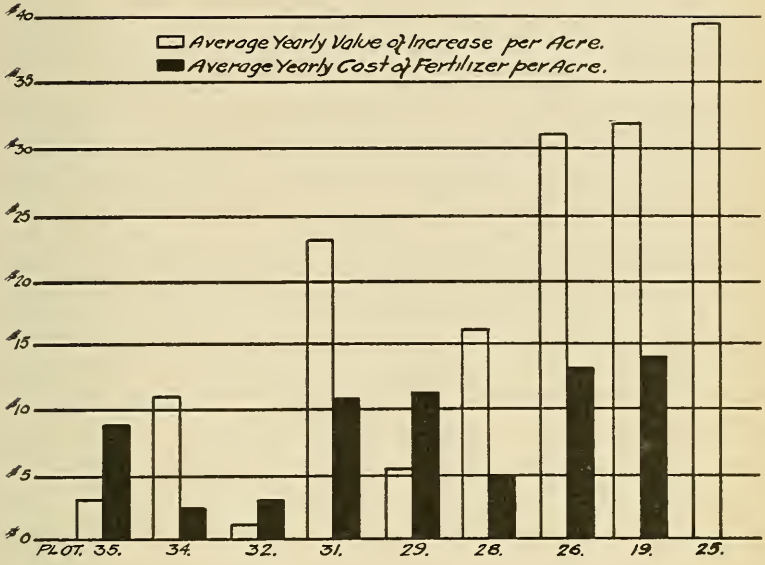
Plot	FERTILIZER	1900 RYE	1901 WHEAT	1902 HAY	1903 CORN	1904 COW PEAS	1905 CORN	1906 POTATOES	1907 RYE
19	N, K_2O, P_2O_5, Lime	$13.92	$14.18	$30.31	$47.88	$35.56	$33.24	$42.00	$20.54
20	Manure, Lime	5.36	18.95	45.36	68.30	34.16	47.24	122.97	38.10
22	Lime	-3.73	-1.88	-6.09	-3.65	-4.69	-2.56	-11.67	-.14
23	Ash of Manure, N	14.99	16.48	38.71	28.76	6.16	8.44	-.23	.27
25	Manure	11.91	20.27	50.26	38.12	29.61	47.44	102.43	33.52
26	N, K_2O, P_2O_5	21.10	16.00	34.16	42.99	31.01	35.84	52.62	19.29
28	P_2O_5, K_2O	3.06	11.32	21.91	36.72	17.71	10.04	44.80	13.31
29	N, K_2O	12.74	.06	-2.59	-4.51	3.01	7.84	11.67	-.18
31	N, P_2O_5	18.07	11.32	38.71	40.95	22.96	15.64	15.28	16.77
32	K_2O	2.79	-1.10	.91	1.26	.56	1.44	1.28	.07
34	P_2O_5	2.56	6.95	21.21	30.12	12.46	6.04	14.93	12.44
35	N	12.24	-2.44	-1.61	-6.09	4.41	-1.76	-3.15	.83
Average Yield and Value of Yield of Check Plots.....		$22.68	$21.60	$16.59	$26.69	$13.09	$22.16	$29.40	$2.71

VALUE OF INCREASE PER ACRE DUE TO FERTILIZER (Continued)

Plot	FERTILIZER	1909 TIMOTHY & CLOVER	1910 TIMOTHY	1911 TIMOTHY	1912 CORN	1913 OATS	1914 WHEAT	1915 CLOVER
19	N, K_2O, P_2O_5, Lime	$35.27	$54.05	$36.50	$32.71	$13.72	$30.66	$39 21
20	Manure, Lime	43.67	63.85	37.55	37.28	27.43	23.13	50.41
22	Lime	-.18	.27	1.57	9.89	.00	4.84	3.80
23	Ash of Manure, N	-.50	1.11	.10	23.77	5.24	23.60	13.31
25	Manure	50.67	54.05	40.35	34.83	18.88	22.88	38.23
26	N, K_2O, P_2O_5	28.97	51.95	36.50	35.79	10.60	26.30	21.43
28	P_2O_5, K_2O	7.55	15.37	9.83	18.74	6.40	18.25	8.69
29	N, K_2O	10.95	18.21	10.60	4.04	2.25	3.58	1.12
31	N, P_2O_5	27.57	42.15	24.11	27.64	9.49	22.36	16.74
32	K_2O	-.92	.04	-.18	6.89	.92	.55	.43
34	P_2O_5	1.99	14.92	9.90	3.88	8.53	3.83	5.82
35	N	1.11	11.24	6.05	-4.30	.66	-.24	-.27
Average Yield and Value of Yield of Check Plots.....		$3.93	$8.95	$6.13	$20.75	$5.15	$7.52	$1.39

AVERAGE YEARLY VALUE PER ACRE OF INCREASE.

Plot	FERTILIZER	First Five Years	Second Five Years	Third Five Years	15 Year Average	Yearly Cost of Fertilizer	Value of Increase Less Cost of Fertilizer
19	N, K_2O, P_2O_5, Lime	$28.37	$37.02	$30.56	$31.98	$14.10	$17.88
20	Manure, Lime	34.43	63.17	35.16	44.25	?	?
22	Lime	-4.01	-2.86	4.03	-.9[illegible]	.92	-1.87
23	Ash of Manure, N	21.02	1.82	13.20	12.01	?	?
25	Manure	30.03	57.62	31 03	39 56	?	?
26	N, K_2O, P_2O_5	29.05	37.73	26.12	30.97	13.35	17.62
28	P_2O_5, K_2O	18.14	18.21	12.38	16.24	4.95	11.29
29	N, K_2O	1.74	9.70	4.32	5.25	11.11	-5.86
31	N, P_2O_5	26.40	23.48	20.07	23.32	10.64	12.68
32	K_2O	.88	38	1.72	.99	2.71	-1.72
34	P_2O_5	14.66	10.06	6.33	10.37	2.24	8.13
35	N	6.51	1.65	.38	2.85	8.40	-5.55
Axerage Yearly Value per Acre of Produce of Check Plots		$20.13	$13.43	$8.19	$13.92		



35 Nitrate of Soda
34 Acid Phosphate
32 Sulphate of Potash
31 Nitrate of Soda and Acid Phosphate
29 Nitrate of Soda and Sulphate of Potash
28 Acid Phosphate and Sulphate of Potash
26 Nitrate of Soda, Acid Phosphate and Sulphate of Potash
19 Nitrate of Soda, Acid Phosphate, Sulphate of Potash and Lime
25 *Manure

*No estimate put on the cost of manure

The calculations of the value of the increase were made by using the average farm values of the products in West Virginia since 1900 as obtained from the Year Book of the U. S. Department of Agriculture, which were as follows: corn, $.65; wheat, $.95; oats, $.45; rye, $.75; hay $14.00; ensilage, $4.00; stover, $5.00; straw, $5.00. The following values were placed on the fertilizers and do not take into consideration the cost of delivering from the railway station to the farm and making the application: acid phosphate, $16.00; nitrate of soda, $60.00; sulphate of potash, $50.00; lime, $5.00. The fertilizer applications per acre during the experiment have totaled 4,200 pounds of nitrate of soda, 4,200 pounds of acid phosphte, 1,625 pounds of sulphate of potash, 4,500‡ pounds of lime and 190* tons of manure.

‡ 5,500 pounds lime on plot 22.
* 210 tons manure on plot 20.

CONCLUSIONS.

A study of the results from the experimental use of fertilizers at the West Virginia Agricultural Experiment Station justifies the following conclusions:

1. Manure is a material of sufficient fertilizing value to entitle it to more consideration than many farmers give it. Even when applied in such liberal quantities as it has been in these experiments, every ton of manure has produced an increase valued at $3.12.

2. The importance of acid phosphate as a crop producer is such that one need not hesitate to buy and apply it in liberal quantities.

3. If we subtract the value of the increase produced by nitrate of soda alone, from the value of the increase produced by acid phosphate and nitrate of soda in combination, it appears that for every dollar invested in acid phosphate $9.14 worth of increase crop was produced. This indicates that if more legumes had been grown on the soil and the amount of nitrogen in the soil had been increased thereby we could expect a greater return from the use of acid phosphate on the plot receiving acid phosphate alone.

4. The return per dollar invested in acid phosphate is decreasing as the years go by, where acid prosphate is used alone. This is probably because of the fact that nitrogen is becoming a seriously limiting factor. If legumes had appeared oftener in the rotation, this decrease would probably not have taken place.

5. Under the system of farming practiced in this experiment, complete fertilizers would be more desirable than acid phosphate alone. But this is not an ideal farming system for the economical maintenance of fertility. No attempt has been made to keep up the supply of organic matter, no manure has been applied to the fertilizer plots and only one leguminous crop has been grown every five years.

6. The results indicate that the complete fertilizer would have been less profitable if some catch crop had been plowed under and legumes had played a more prominent part in the rotation.

7. In determining which fertilizing material or mixture of fertilizing materials is the most profitable several things must be taken into consideration. In applying the complete fertilizer we may secure a larger yield but we also have more crop to handle, more fertilizer to haul to the farm and apply, more money invested in fertilizer and consequently a heavier risk to run, against which we must be insured. The complete fertilizer in these experiments gave three times as much increase as acid phosphate alone. But there was two and one half times as much fertilizer to handle, twice as much crop to take care of and six times as much money invested in fertilizer.