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Effects of Liming and Green Manuring on Crop Yields and on Soil Supplies of Nitrogen and Humus: Results of 20 years' experiments in a cowpea-wheat rotation

University of Tennessee Agricultural Experiment Station

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UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
Knoxville

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By
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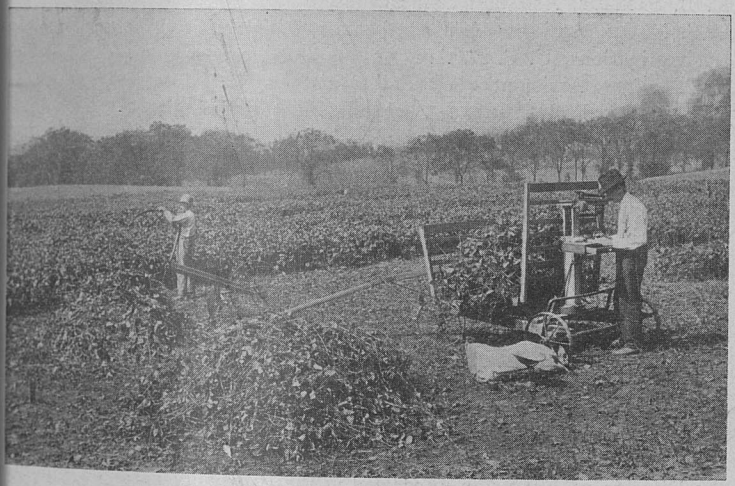

Harvesting the cowpea crop

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Bulletins of this Station will be sent, upon application, free charge, to any farmer in the State.

EFFECTS OF LIMING AND GREEN MANURING ON CROP YIELDS AND ON SOIL SUPPLIES OF NITROGEN AND HUMUS

By
C. A. Mooers

INTRODUCTION

The influence of the cowpea crop on the productivity of the soil is a subject of debate among practical farmers. Some have found cowpeas to benefit the soil, even when the crop was removed for hay. The effect on close, heavy soils is to make them more open and porous, so that for the time they seem rejuvenated, especially when well supplied with plant food. Soils impoverished by long cropping in cotton, corn, or the like, may be improved by a good crop of cowpeas, because of the residue of roots, stubble, and fallen leaves. Some farmers, on the other hand, especially those who have fertile loams, such as are found in the Central Basin, complain that cowpeas make the soil too open and granular, causing greatly increased damage from erosion. They also contend that this crop does little to increase the productiveness of the soil, and in that particular is not to be classed with red clover.

At a number of experiment stations, particularly in the South and West, work has been done with a view to determining the effect of cowpeas on succeeding crops of various kinds. The literature on the subject was reviewed in an article on "Green Manuring" by A. J. Pieters, of the Bureau of Plant Industry, U. S. Department of Agriculture, published in the Journal of the American Society of Agronomy in 1917 (Vol. 9, No. 2, 3, and 4). The general conclusion reached in this review is that the residual effect of a cowpea crop turned under was marked, "while that of the stubble was sometimes evident but slight". Much the same conclusion can be reached from a perusal of later work. Most of the experiments, both those reviewed and those carried out since then, were not continued long enough for the satisfactory demonstration of the influence of this crop. Recently, however, a publication[1] by Garner, Lunn, and Brown gives results for a 12-year period in a 2-year rotation of wheat, cowpeas, and tobacco, the cowpeas being turned under in comparison with other green-manure crops. During the initial years the tobacco crops following cowpeas were large, but the trend for the period was decidedly downward.

[1] Garner, W. W., Lunn, W. M., and Brown, D. E. Effects of crops on the yields of succeeding crops in the rotation, with special reference to tobacco. Jour. Agr. Research (U. S.). 30: 1095-1132. Dec. 1925.

For many years agricultural writers have called attention the divergent views and practices of farmers in regard to lim Adam Dickson, in his "Treatise on Agriculture", published in E burgh in 1765, pointed out that there were two opposite opini one that lime acts only as a soil stimulus, "making the soil which it is mixed exert itself", and the other that "it prom vegetation by enriching the land and adding to the quantity vegetable food." This latter opinion, he says, "is supported by serving that in some places lime is applied regularly once in or five years; that the land seldom gets any other manure, bu kept almost constantly in tillage and with the assistance of lowing carries very good crops". His final observation is "one is led to conclude that lime acts both ways; not only ma land exert itself in the nourishment of vegetables but also enri it."

In recent years much attention has been given by agricultu investigators to the subject of liming. Data have been obtai with regard to both the lime requirements of various soils and relative response of different crops. In addition considerable cess has attended the efforts to determine the underlying reacti involved in liming. This latter sort of investigation is especia valuable, because every advance in this direction tends to rational and judicious use of an important soil amendment.

This publication deals principally with the results obtained 2 series of experiments, one conducted for 20 years at Knoxv in the eastern part of the State, and the other for 16 years Jackson, in the western part of the State—a rotation of cowp and wheat being used at each place. The 2 crops were grown nually under various conditions of liming, manuring, and fertiliz in connection with both the turning under and the removal of cowpea crops. In addition, comparable data were obtained at Kn ville in a parallel series of experiments in a 5-year rotation corn, wheat, soybeans, and clover and grass, extending over same 20-year period.

The liming data from the Knoxville experiments are of spec interest for two reasons; first, the effects of liming with bu lime are followed in the cowpea-wheat rotation as long as cernible in either crop production or changes in the nitrogen co tent of the soil; second, the data obtained after reliming in rotation, supplemented by those from the 5-year rotation, af the proof of much that has been a matter of surmise on the p not only of Adam Dickson but of many others since his day. T is, the data show that for certain crops, including not only cer but also such legumes as cowpeas and soybeans, the periodical li ing of the land may act almost entirely as a soil stimulant—t stimulation being of limited duration and following the law diminishing returns—while for certain other crops, such as alsi and red clover, periodical liming may continue for an indefinite to be highly effective.

RESULTS OBTAINED AT THE KNOXVILLE STATION IN THE COWPEA-WHEAT ROTATION

PREVIOUS PUBLICATIONS

Two Tennessee Station bulletins, No. 90 and 96, give the results for the first 5 years of the experiments. No. 90 relates to the utilization of various phosphates; No. 96 discusses (1) "the effect of liming on the crop production", and (2) "the effect of liming and green manuring on the soil content of nitrogen and humus". These bulletins give numerous details concerning the experiments. Those of most importance to the present purpose are reviewed in the following pages and all the experimental data are included in the tables contained in this bulletin.

SOIL AND PLOTS

The soil is designated by the Bureau of Soils, of the U. S. Department of Agriculture, as Cumberland loam. The surface soil is brownish-colored, 8-10 inches deep, of excellent texture, and underlaid by a rather heavy dark-red subsoil, extending to a depth of probably 20 feet or more. The drainage is excellent. Prior to the experiments the land had been in grass for a number of years, and was in a state of high productivity for cereal crops, although it required liming for a crop like red clover. Tables 11 and 12 give chemical and mechanical analyses of this soil.

The plots were each 33 x 30 ft., or 1/40 acre, and were separated by a 2-ft. path. Diagram 1 shows their arrangement and the fertilizer and liming scheme.

CROPS AND SOIL MANAGEMENT

The first crop grown was cowpeas, in 1905. The application of lime was made after the disposal of this crop, but before the wheat seeding of that year. The liming was at the rate of 1,800 pounds per acre of burnt lime, and attention is called to the fact that reliming, which was at the rate of 1 ton per acre, was not made until 12 years later. On 14 plots the cowpea crops have been turned under as green manure, from 6 others they have been removed, and 1 plot has been kept in bare fallow during the summers. A few crop changes were necessitated. In 1917 spring oats were substituted for wheat, which was ruined by the unusually severe winter of 1916-1917; in 1919 soybeans were substituted for cowpeas; and in 1924 barley was substituted for wheat, due to a serious wheat disease which made its appearance in the crop harvested that year. The yields of both the oats and the barley, how-

ever, were calculated on the basis of 60 pounds per bushel, same as the wheat.

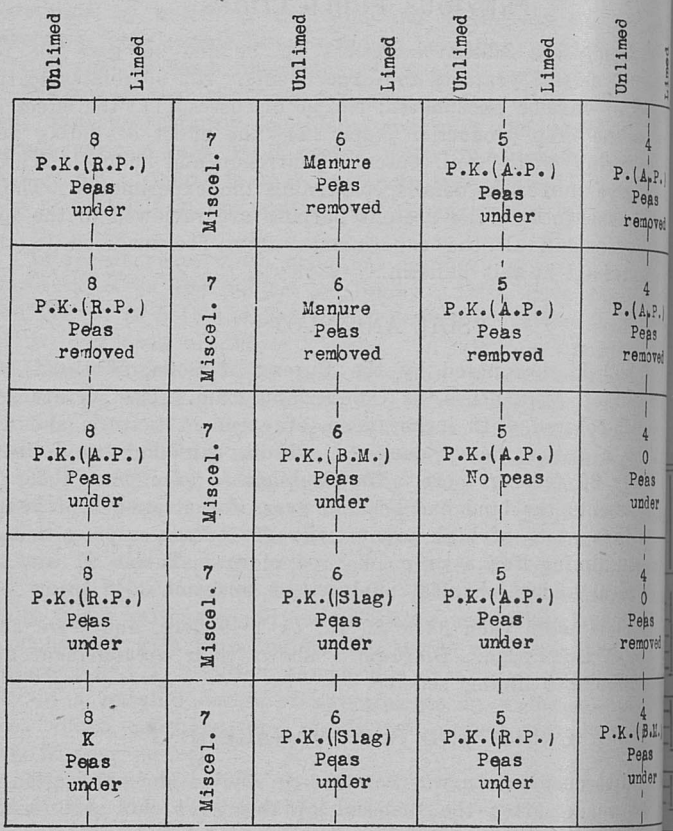


Diagram 1—Experimental field, cowpea-wheat experiments—Knoxville

It should be stated that to prevent as far as possible the location of the soil, reversals in the direction of both plowing harrowing were made each year. Also the pea vines to be tu under were raked first away from the plow and then back the open furrow, where they were covered at the next round. result of these measures was to maintain marked uniformity growth over every plot, and yearly the sharp definition betw the plots grew more pronounced.

DATES OF PLANTING AND HARVESTING

The dates of planting wheat varied from October 9 to 25, with October 18 as the average. The dates of harvest varied from June 3 to 23, with June 12 as the average.

The dates of planting cowpeas varied from June 23 to July 15, with July 9 as the average. The hay crops were cut from September 8 to October 13, with September 23 as the average.

DISCUSSION OF THE PLOT DATA

Table 16 gives in detail the yields per acre of legume hay and the small grains for each plot, together with the fertilizer treatments, and the disposition of the legumes.

Table 1 presents a summary for the 20-year period of the average annual yields from the various plots, which are grouped so as to facilitate comparisons.

TABLE 1—*Average annual yields per acre of* (1) *cowpea hay and* (2) *wheat under both limed and unlimed conditions for the* 20-*year period* 1905-1925.

Fertilizer	Disposition of cowpea crop	Cowpea hay			Wheat					
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Av. of limed and unlimed	
					Grain	Straw	Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
None	Turned under	0.74	0.83	0.79	20.3	1.15	20.2	1.12	20.3	1.14
K	" "	1.13	1.12	1.13	21.9	1.32	20.0	1.31	21.0	1.32
P	" "	0.90	0.84	0.87	23.9	1.29	20.3	1.08	22.1	1.19
PK	" "	1.17	1.08	1.12	24.7	1.39	23.9	1.34	24.3	1.37
PK	" "	1.19	1.09	1.14	26.3	1.45	23.2	1.31	24.8	1.38
Average of F5 and I5		1.18	1.09	1.13	25.5	1.42	23.6	1.33	24.6	1.38
PK (R.P.)	Turned under	1.08	1.10	1.09	27.0	1.60	26.4	1.62	26.7	1.61
PK (R.P.)	" "	1.12	1.04	1.08	25.2	1.44	22.6	1.33	24.3	1.39
PK (R.P.)	" "	1.11	0.99	1.05	23.8	1.44	21.7	1.29	22.8	1.37
Average of F8, J5, and I8		1.10	1.04	1.07	25.3	1.49	23.6	1.41	24.6	1.46
PK (B.M.)	Turned under	1.10	1.03	1.07	23.3	1.45	21.5	1.30	22.8	1.42
PK (B.M.)	" "	1.16	0.91	1.04	25.9	1.46	21.7	1.27	23.8	1.37
Average of J4 and H6		1.13	0.97	1.06	24.6	1.46	21.6	1.29	23.3	1.40
PK (T.S.)	Turned under	1.07	0.99	1.03	24.9	1.54	21.9	1.37	23.4	1.46
PK (T.S.)	" "	1.14	0.95	1.05	25.9	1.51	22.6	1.25	24.3	1.38
Average of J6 and I6		1.11	0.97	1.04	25.4	1.53	22.3	1.31	23.9	1.42
PK	No peas grown				18.7	1.04	15.5	0.93	17.1	0.98
P	Removed	0.70	0.58	0.64	17.2	0.89	13.3	0.69	15.3	0.79
PK	"	1.10	0.89	1.00	16.9	0.87	14.7	0.81	15.8	0.84
PK (R.P.)	"	1.04	0.92	0.98	16.1	0.79	15.3	0.79	15.7	0.79
None	"	0.60	0.55	0.58	13.6	0.69	10.4	0.60	12.0	0.64
Average of G4, 5, 8, and I4		0.86	0.74	0.80	16.0	0.81	13.4	0.72	14.7	0.77
Manure	Removed	1.39	1.37	1.38	26.1	1.52	25.5	1.44	25.0	1.40
Manure & P	"	1.39	1.32	1.35	26.1	1.35	24.0	1.33	25.0	1.34
Average of F6 and G6		1.39	1.35	1.37	26.1	1.44	24.8	1.39	25.4	1.41

Interpretation of symbols: R. P.—Rock phosphate; T. S.—Thomas slag phosphate; B. M.—Bone meal; P.—Acid phosphate (unless otherwise specified); K.—Muriate of potash.

RESPONSE TO POTASH

The yields from the 3 plots F4, G4, and H4, which receiv no potash, can be compared with those from the 3 plots F5, G and J8, which received annually 50 pounds of muriate of pota per acre, the treatments otherwise being the same in the 2 se The average annual increases per acre attributable to potash we as follows:

			Cowpea Hay	Wheat	
				Grain	Straw
			Lbs.	Bu.	Ton
Set 1—F5	versus	F4	500	2.2	0.18
Set 2—G5	versus	G4	720	0.5	0.05
Set 3—J8	versus	H4	680	0.7	0.18
Average	increase		633	1.1	0.14

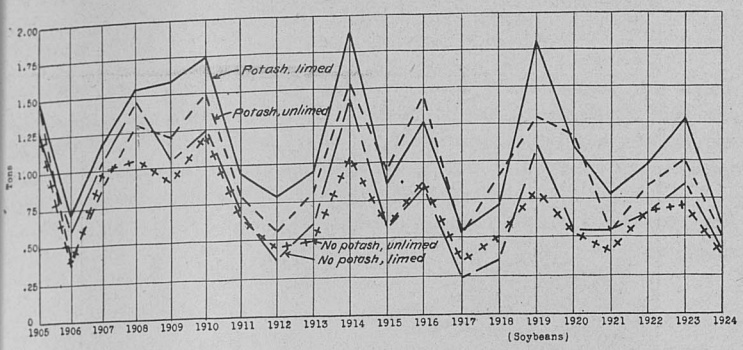
COMMENTS ON THE RESULTS

1. In each set the potash-treated plots produced materia more cowpea hay than the corresponding plots which received n potash. For the 20-year period the average annual gain attribu able to potash amounted to 633 pounds of hay per acre. It is i interest to note that the gain was nearly as great in sets 1 a 3, where the cowpea crops were turned under, as in set 2, whe the cowpea crops were removed.

2. The wheat crops were only slightly greater from the plo receiving potash; the average annual gain for the period being 1 bushels of grain and .14 ton of straw. Since in 2 of the 3 se the cowpea crops were always turned under, this increase migh well be due to the larger cowpea crops rather than to any dire influence of the added potash on wheat production.

EFFECTS OF LIMING AS INFLUENCED BY THE POTASH SUPPLY

Chart 1 shows the average annual yields of cowpea hay, und both the limed and unlimed conditions, from plots F4 and G which received no potash, compared with the averages from F and G5, which received each year 50 pounds of muriate of pota per acre. All the plots received an annual application of the sa amount of acid phosphate and the disposal of the cowpea cro was the same for the 2 sets, the crops being turned under on F and F5 and removed from G4 and G5. Not only did the pota salt increase the yields of hay, but where it was used the effe of liming was much more pronounced. In fact, on this soil lim without potash was in every case of low effectiveness on the co



———— Yields of hay on limed section of plots receiving potash.

– – – – – – – – Yields of hay on unlimed section of plots receiving potash.

– ——— – ——— Yields of hay on limed section of plots not receiving potash.

+ + + + + + + Yields of hay on unlimed section of plots not receiving potash.

Chart 1—Effects of liming on the yields of cowpea hay as influenced by potash—Knoxville

Plot F6
Manure
Crops removed

Plot H4
No treatment
Crops turned under

Comparative growth of cowpea plants—1916 crop

Plot F4
Acid phosphate

Plot F5
Acid phosphate
Muriate of potash

Comparative growth of cowpea plants from plots where crops were turned under—1916 crop

Plot I4
No treatment

Plot G4
Acid phosphate

Plot G5
Acid phosphate
Muriate of potash

Comparative growth of cowpea plants from plots where crops were removed—1916 crop

pea crop, and there was no indication that it increased the availability of the soil potash. This conclusion is in harmony with the findings[2] at this Station in lysimeter experiments with a soil of the same type, there being somewhat less potash in the drainage water from the limed tanks than from the unlimed.

With regard to the wheat crop, it is noticeable that, contrary to the results with cowpeas, liming was highly effective on plots F4 and G4.

POTASH IN RELATION TO PLANT DISEASES

In general the cowpea crops on the plots were considered good throughout the period. The plants were well inoculated from the outset, and there was little trouble from mildew or other disease, except in the case of the no-potash plots. On these plots not only were decreasing yields in evidence but the plants were frequently unhealthy, especially on the limed sections.

RESPONSE TO PHOSPHATING

The yields from the 3 plots H4, I4, and J8, which received no phosphate, can be compared with those from the 3 plots F4, G4, and F5, which received annual applications of phosphate, the treatments otherwise being the same for the two sets.

The average annual increases per acre attributable to phosphate were as follows:

	Cowpea Hay	Wheat	
		Grain	Straw
	Lbs.	Bu.	Ton
Set 1—F4 versus H4	160	1.8	0.05
Set 2—F5 versus J8	—20	3.3	0.05
Set 3—G4 versus I4	120	3.3	0.15
Average increase	87	2.8	0.08

The phosphate applications failed to produce marked returns in the yield of cowpea hay, the average annual increase being only 87 pounds per acre. On the other hand, the increase in the yield of wheat was considerable, amounting to an annual average of 2.8 bushels per acre.

POTASH VERSUS PHOSPHATE

The effects of potash and phosphate on the two crops were decidedly different. The former increased in particular the yield of cowpea hay, while the latter increased the yield of wheat. These results are in harmony with the general findings in field trials on soils only moderately deficient in these two elements of plant food.

[2] MacIntire, W. H., Shaw, W. M., and Young, J. B. A 5-year lysimeter study of the supposed liberation of soil potassium by calcic and magnesic additions. Soil Sci. 16: 4. Oct. 1923.

THE COMPARATIVE VALUES OF DIFFERENT PHOSPHA

At the outset of the experiments it was hoped that mate differences between the results from different phosphates would pear in the crop yields. But the yields obtained were so nea alike that distinctions cannot be made with certainty. In f the differences found would not have been unexpected had only kind of phosphate been used throughout at a constant rate, for

Plot F4—fertilized with phosphate only

Plot F5—fertilized with phosphate and potash

Effects of potash on growth of cowpeas—1920 crop

In spite of the soil deficiency in potash, which became increasingly evident in cowpea crop, the effect was scarcely discernible in the yields of wheat

two plots can be counted upon to have exactly the same nat productivity, and some allowance for such inequality must be m even where several are averaged. A soil highly responsive to p phating is a prime essential to a satisfactory comparison of t kind.

FARMYARD MANURE

In the case of the 2 plots F6 and G6 the cowpea crops w removed, but 4 tons per acre of good-quality farmyard ma from the general farm pit was applied annually.

EFFECT ON CROP YIELDS

The yields were uniformly high, and in the case of the cowpea crop were appreciably larger than those obtained under any other condition. The average annual yield of cured hay per acre for the 20-year period was 1.37 tons. This was 520 pounds more than that from plots F5 and F8, fertilized with phosphate and potash, where the cowpea crops were turned under, and 760 pounds more than the average from G5 and G8, fertilized the same as F5 and F8, but having the cowpea crops removed annually. The average grain yield from F6 and G6 was 25.4 bushels. This was identical with that from F5 and F8, and 9.6 bushels larger than the average from G5 and G8. Tables 2, 3, and 4 give the data, and charts 2 and 3 present graphically the yields obtained annually under each of these 3 conditions. The charts show that the yields of cowpea hay were well maintained throughout the period in all cases, but that there was a continued downward tendency in wheat yield even under the most favorable conditions.

TABLE 2—*Average annual yields per acre of crops grown on plots F6 and G6, which received 4 tons of manure each year—(all crops removed annually).*

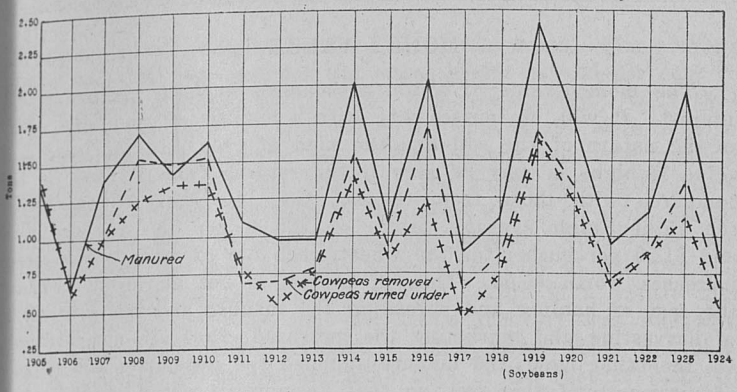
Year	Cowpea hay			Wheat					
				Limed		Unlimed		Average of limed and unlimed	
	Limed	Unlimed	Average of limed and unlimed	Grain	Straw	Grain	Straw	Grain	Straw
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
1905- 6	(1.35)	(1.35)	1.35	(37.0)	(2.00)	(37.0)	(2.00)	37.0	2.00
1906- 7	0.67	0.67	0.67	29.0	1.85	31.5	1.88	30.3	1.87
1907- 8	1.41	1.37	1.39	24.0	1.30	21.9	1.23	23.0	1.27
1908- 9	1.78	1.60	1.69	23.5	1.48	22.5	1.36	23.0	1.42
1909-10	1.48	1.37	1.43	27.5	1.79	26.7	1.81	27.1	1.80
1910-11	1.68	1.58	1.63	24.4	1.33	24.2	1.35	24.3	1.34
1911-12	1.20	0.99	1.10	34.0	1.78	31.0	1.71	32.5	1.75
1912-13	0.94	1.02	0.98	32.5	1.80	27.8	1.80	30.2	1.80
1913-14	0.98	0.96	0.97	27.6	1.36	25.3	1.37	26.5	1.37
1914-15	1.99	2.06	2.02	23.3	1.14	22.9	1.08	23.1	1.11
1915-16	0.89	1.26	1.08	23.6	1.32	22.7	1.32	23.2	1.32
1916-17	2.02	2.04	2.03	28.4	0.70	26.7	0.70	27.6	0.70
1917-18	1.02	0.78	0.90	24.7	1.22	20.6	1.14	22.7	1.18
1918-19	1.15	1.09	1.12	21.5	1.66	20.5	1.55	21.0	1.61
1919-20	2.64	2.17	2.41	21.9	1.33	20.5	1.24	21.2	1.29
1920-21	1.64	1.84	1.74	26.7	1.65	26.7	1.60	26.7	1.63
1921-22	0.98	0.91	0.95	17.7	1.53	16.4	1.34	17.1	1.44
1922-23	1.18	1.16	1.17	22.7	1.40	20.7	1.28	21.7	1.34
1923-24	1.92	1.79	1.86	21.7	1.35	20.7	1.34	21.2	1.35
1924-25	0.82	0.83	0.83	32.7	0.72	30.2	0.70	31.5	0.71
Average	1.39	1.34	1.37	26.2	1.44	24.8	1.39	25.5	1.42

TABLE 3—*Average annual yields per acre of crops grown on plots and F8—cowpea crops turned under—phosphate and p applications the same as for G5 and G8, where cowpea cr were removed.*

Year	Cowpea hay			Wheat				
	Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average limed unlimed
				Grain	Straw	Grain	Straw	Grain
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.
1905- 6	(1.43)	(1.43)	1.43	(35.8)	(2.15)	(35.8)	(2.15)	35.8
1906- 7	0.67	0.57	0.62	31.1	2.31	30.9	2.14	31.0
1907- 8	1.00	1.02	1.01	29.0	1.55	25.1	1.43	27.1
1908- 9	1.55	1.50	1.53	27.2	1.75	26.7	1.70	27.0
1909-10	1.59	1.38	1.49	28.2	1.93	27.3	1.75	27.8
1910-11	1.59	1.47	1.53	29.2	1.65	26.7	1.61	28.0
1911-12	0.68	0.69	0.69	31.9	1.67	31.4	1.70	31.7
1912-13	0.86	0.56	0.71	29.8	1.71	27.8	1.74	28.8
1913-14	0.80	0.80	0.80	26.8	1.46	25.2	1.51	26.0
1914-15	1.61	1.48	1.55	23.6	1.26	23.2	1.13	23.4
1915-16	0.86	0.98	0.92	22.2	1.23	21.9	1.23	22.1
1916-17	1.65	1.83	1.74	20.3	0.82	27.2	0.73	23.7
1917-18	0.66	0.65	0.66	25.7	1.48	19.0	1.14	22.4
1918-19	0.73	1.02	0.88	23.2	1.53	22.2	1.32	22.7
1919-20	1.92	1.44	1.69	23.9	1.34	22.1	1.35	23.0
1920-21	1.24	1.37	1.32	26.4	1.75	26.8	1.95	26.6
1921-22	0.76	0.67	0.72	17.2	1.43	16.2	1.40	16.7
1922-23	0.92	0.89	0.91	20.2	1.36	22.9	1.56	21.6
1923-24	1.39	1.34	1.37	18.3	1.13	18.4	1.15	18.4
1924-25	0.61	0.66	0.64	26.7	0.63	26.5	0.62	26.6
Average	1.13	1.09	1.11	25.8	1.51	25.2	1.47	25.5

TABLE 4—*Average annual yields per acre of crops grown on plots and G8—cowpea crops removed as hay—phosphate and p applications the same as for F5 and F8, where cowpea cr were turned under.*

Year	Cowpea hay			Wheat				
	Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed unlimed
				Grain	Straw	Grain	Straw	Grain
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.
1906- 7	0.76	0.45	0.61	23.0	1.25	21.2	1.35	22.1
1907- 8	1.07	0.94	1.01	21.2	1.05	16.4	0.87	18.8
1908- 9	1.26	1.24	1.25	16.9	1.04	16.8	0.97	16.9
1909-10	1.48	1.22	1.35	19.9	1.09	15.5	0.94	17.7
1910-11	1.47	1.25	1.36	16.4	0.79	14.2	0.72	15.3
1911-12	0.88	0.68	0.78	17.5	0.80	18.3	0.85	17.9
1912-13	0.60	0.58	0.59	16.5	0.76	16.6	0.78	16.6
1913-14	0.81	0.72	0.77	17.0	0.89	16.0	0.88	16.5
1914-15	1.58	1.19	1.39	15.2	0.59	12.5	0.58	13.9
1915-16	0.88	0.79	0.84	14.5	0.70	14.5	0.72	14.5
1916-17	1.28	1.17	1.23	17.2	0.48	16.2	0.47	16.7
1917-18	0.45	0.45	0.45	16.6	0.80	9.7	0.50	13.2
1918-19	0.67	0.80	0.74	11.2	0.67	11.9	0.75	11.6
1919-20	2.02	1.25	1.64	12.8	0.74	12.0	0.67	12.4
1920-21	1.15	1.24	1.20	16.2	0.95	16.2	1.05	16.2
1921-22	0.74	0.56	0.65	11.2	0.75	10.9	0.80	11.1
1922-23	0.99	0.81	0.90	11.2	0.71	9.5	0.66	10.4
1923-24	1.31	0.95	1.13	11.0	0.62	10.7	0.59	10.9
1924-25	0.57	0.42	0.50	14.7	0.39	11.6	0.35	13.2
Average	1.07	0.91	0.99	16.5	0.83	15.0	0.80	15.8

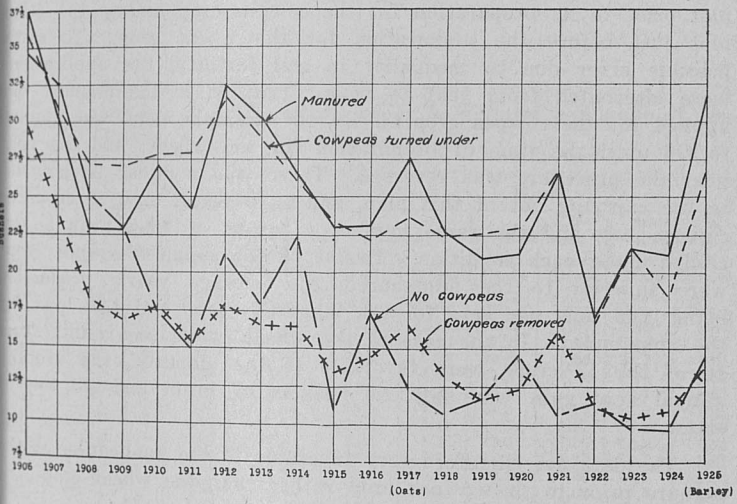


Plots F6, G6—Cowpeas removed as hay; 4 tons per acre manure applied annually.

Plots F5, F8—Cowpeas turned under annually; acid phosphate and muriate of potash used as fertilizers.

Plots G5, G8—Cowpeas removed as hay annually; fertilized same as F5 and F8.

Chart 2—Yields of cowpea hay under various conditions—Knoxville



Plots F6, G6—Received 4 tons manure per acre annually; cowpea crops removed as hay.

Plots F5, F8—Wheat after cowpea crops turned under; fertilized same as H5.

Plot H5—Wheat after summer fallow; acid phosphate and muriate of potash used as fertilizers.

Plots G5, G8—Wheat after cowpeas removed as hay; fertilized same as H5.

Chart 3—Yields of wheat under various conditions—Knoxville

MONEY VALUE

The money value of a ton of manure in farm practice is
interest. It will, of course, vary with a number of conditions, su
as the nature of the soil and the kind of crop. In this case t
value is high, as may be seen if the returns from F6 and G6
compared with those from G5 and G8. Assigning to the cr
the rather high average prices of $20.00 per ton for the h
and $1.50 per bushel for the wheat, each ton of manure gave cr
increases worth $5.50. This, of course, is not all profit, becau
the cost of hauling and spreading the manure and the extra c
of harvesting and marketing the increased crops are not includ
On the other hand, the manure supplied the phosphate and pota
requirements of this soil, so that an annual saving of $3.50 p
acre could be allowed as the approximate cost of the fertili
applications made to G5 and G8.

FOR WHICH CROP SHOULD THE MANURE BE APPLIED?

Beginning in 1911 and continuing to the end of the 20-y
period, in 1925, the yearly application of manure was made to t
plot prior to its preparation for the cowpea crop and to the oth
plot just before the preparation for the wheat crop. To av
possible error due to inequality in soil fertility, the applicati
were alternated from year to year. That is, if the manure w
applied for the cowpea crop on F6, for example, none was appl
to G6 until the time of preparation for the wheat; and the ne
year the procedure was reversed. There was a minor irregularit
in the carrying out of this plan, and as a result only 13 crops
cowpea hay and the same number of crops of wheat can be i
cluded under each condition. Twelve of the manured cowpea cr
were superior to the unmanured, the average yearly producti
being 1.46 tons per acre for the manured crops and 1.20 tons
the unmanured. In the case of the wheat, while the results fr
10 of the 13 crops were favorable to the manured, the avera
annual acre gain was only 1.6 bushels of grain and .15 ton
straw.

The data are therefore very favorable to the application of
manure prior to the cowpea crop rather than the wheat crop.

NITROGEN RECOVERY

The average nitrogen content of the manure used was fo
to be .73 per cent. The amount of nitrogen furnished annu
by the 4-ton application was therefore 58.4 pounds per acre.
trogen determinations were made frequently in the case of

wheat crops and occasionally for the cowpea crops. The averages found were 2.11 per cent for the wheat grain and .46 per cent for wheat straw, and 2.45 per cent for the cowpea hay. With these figures as the basis, it was calculated that there were removed annually from the manure plots 18.44 pounds per acre more of nitrogen in the grain and straw of the wheat and 18.62 pounds more in the cowpea hay than in the crops grown on plots G5 and G8, which received only phosphate and potash. Both crops considered, there was therefore an apparent recovery of 63.4 per cent of the nitrogen of the manure applied. This is a rather high figure, and it is probable that the actual recovery was somewhat less, as there were larger residues of fallen leaves, roots, and stubble in the case of the manure plots than in the case of plots G5 and G8.

LIMING

As may be seen by inspection of table 1, superior yields on the limed sections are the rule, but are more noticeable for the wheat than for the cowpea crop. The effects of liming will now be discussed more fully in connection with a consideration of the annual fluctuations in yield.

TABLE 5—*Average annual yields from all plots, except H8, of* (1) *cowpea hay and* (2) *wheat, under both limed and unlimed conditions.*

Year	Cowpea hay			Wheat					
				Limed		Unlimed		Average of limed and unlimed	
	Limed	Unlimed	Average of limed and unlimed	Grain	Straw	Grain	Straw	Grain	Straw
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
1905- 6	(1.36)	(1.36)	1.36	(33.1)	(2.04)	(33.1)	(2.04)	33.1	2.04
1906- 7	0.69	0.55	0.62	30.6	1.94	27.8	1.75	29.2	1.85
1907- 8	1.10	1.01	1.06	25.9	1.38	22.2	1.24	24.1	1.31
1908- 9	1.59	1.30	1.45	24.2	1.60	22.8	1.44	23.5	1.52
1909-10	1.51	1.34	1.43	26.1	1.73	22.1	1.48	24.1	1.61
1910-11	1.53	1.36	1.45	24.0	1.33	21.2	1.17	22.6	1.25
1911-12	0.85	0.76	0.81	26.6	1.40	24.0	1.32	25.3	1.36
1912-13	0.70	0.52	0.61	25.3	1.37	22.3	1.30	23.8	1.34
1913-14	0.73	0.69	0.71	23.2	1.22	21.7	1.20	22.5	1.21
1914-15	1.52	1.26	1.39	20.3	0.99	17.4	0.89	18.9	0.94
1915-16	0.79	0.85	0.82	19.6	1.02	19.1	1.03	19.4	1.03
1916-17	1.40	1.39	1.40	20.6	0.56	20.1	0.59	20.4	0.58
1917-18	0.59	0.54	0.57	20.6	1.12	12.6	0.75	16.6	0.94
1918-19	0.65	0.82	0.74	16.7	1.13	16.4	1.17	16.6	1.15
1919-20	1.77	1.47	1.62	19.2	1.16	16.7	1.00	18.0	1.08
1920-21	1.08	1.15	1.12	22.7	1.48	21.8	1.41	22.3	1.45
1921-22	0.71	0.62	0.67	14.5	1.19	13.1	1.11	13.8	1.15
1922-23	0.88	0.84	0.86	16.7	1.20	15.8	1.12	16.3	1.16
1923-24	1.25	1.11	1.18	16.1	1.00	15.1	0.92	15.6	0.96
1924-25	0.57	0.56	0.57	22.5	0.56	18.0	0.48	20.3	0.52
Average	1.06	0.98	1.02	22.4	1.27	20.2	1.17	21.3	1.22

THE EFFECTS OF LIMING ON THE YIELD OF COWPEA

Chart 4 was made from data contained in table 5, and g a graphic comparison between the annual yields of cowpea obtained under limed and unlimed conditions. The yields for e year are averages from 18 plots, or all except H8, without reg to fertilizer treatment. Since there were 4 replications of li and unlimed sections, with 4 or 5 plots in each, the data are c sidered to be especially dependable.

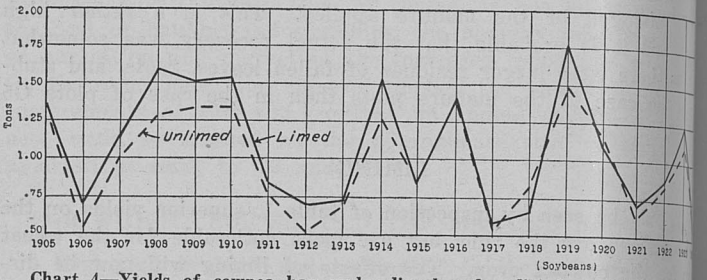


Chart 4—Yields of cowpea hay under limed and unlimed conditions—all pl included except H8—Knoxville

The results may be summarized as follows:

The limed sections produced more than the unlimed for e year of the period 1906-1914. The average annual increase for 9 years was 318 pounds of hay per acre. For the next 3 ye the yields were practically identical. The second application lime was made in the summer of 1917, just prior to the seed of the cowpea crop. For the following 8 crops a light aver increase in hay production was obtained from the limed secti but in 1918 and 1920 the unlimed sections outyielded the li and in 1917 and 1925 the yields were practically identical. In 1 it was found necessary to substitute soybeans for cowpeas. T soybean crop was large and the effects of liming were plainly e dent, both in the appearance of the growing plants and in t yields of hay obtained. With this crop included, the limed secti averaged for the last 7 years 96 pounds more hay per acre th the unlimed; but without it there was on the average for the cowpea crops a negligible difference of only 14 pounds per a in favor of the limed sections. In this connection it should stated that in 1917, the first year after reliming, a poor stand cowpeas was obtained on all the limed sections, due, it appea to the noticeably drier and more flocculated soil condition of th sections. The growth and color of the plants indicated that th would have been no reduction in yield as a result of liming b

there been a good stand. From any point of view, however, it is evident that the second liming produced decidedly less effect on the cowpea crops than the first liming.

EFFECTS OF LIMING ATTRIBUTABLE TO INCREASED AVAILABILITY OF SOIL NITROGEN

Consideration of the effects of liming on the cowpea crops under the various conditions furnishes strong evidence that an in-

TABLE 6—*Average annual yields per acre of crops grown on plots G4, G5, G8, and I4—cowpea crops removed as hay—fertilizer treatments the same as for plots F4, F5, F8, and H4, where cowpea crops were turned under.*

Year	Cowpea hay			Wheat					
	Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed and unlimed	
				Grain	Straw	Grain	Straw	Grain	Straw
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
1905- 6	(1.40)	(1.40)	1.40	(29.4)	(1.48)	(29.4)	(1.48)	29.4	1.48
1905- 6	(1.33)	(1.33)	1.33	(28.9)	(1.50)	(28.9)	(1.50)	28.9	1.50
1906- 7	0.70	0.42	0.56	25.1	1.37	21.4	1.24	23.3	1.31
1907- 8	0.98	0.86	0.92	22.1	1.10	16.2	0.88	19.2	0.99
1908- 9	1.29	1.08	1.19	18.1	1.09	16.8	0.97	17.5	1.03
1909-10	1.22	0.96	1.09	19.2	1.11	13.7	0.87	16.5	0.99
1910-11	1.25	1.12	1.19	15.9	0.75	11.7	0.60	13.8	0.68
1911-12	0.71	0.57	0.64	16.4	0.76	13.8	0.68	15.2	0.72
1912-13	0.48	0.45	0.47	15.9	0.77	14.6	0.74	15.3	0.76
1913-14	0.64	0.54	0.59	17.9	0.88	16.4	0.84	17.2	0.86
1914-15	1.25	0.88	1.07	12.9	0.54	10.7	0.49	11.8	0.51
1915-16	0.63	0.59	0.61	14.2	0.70	14.2	0.70	14.2	0.70
1916-17	0.99	0.90	0.95	16.6	0.41	13.6	0.39	15.1	0.40
1917-18	0.30	0.33	0.32	14.0	0.70	07.4	0.37	10.7	0.53
1918-19	0.47	0.60	0.54	10.3	0.58	10.4	0.65	10.4	0.62
1919-20	1.52	1.03	1.28	11.7	0.73	09.9	0.59	10.8	0.66
1920-21	1.43	1.63	1.53	14.5	0.80	13.4	0.80	14.0	0.80
1921-22	0.51	0.43	0.47	10.9	0.79	09.9	0.73	10.4	0.76
1922-23	0.77	0.66	0.72	10.2	0.67	08.2	0.58	09.2	0.63
1923-24	0.97	0.75	0.86	10.3	0.57	08.8	0.52	09.6	0.54
1924-25	0.43	0.37	0.40	14.0	0.37	08.5	0.32	11.3	0.35
*Average	0.89	0.78	0.84	16.0	0.81	13.4	0.72	14.7	0.77

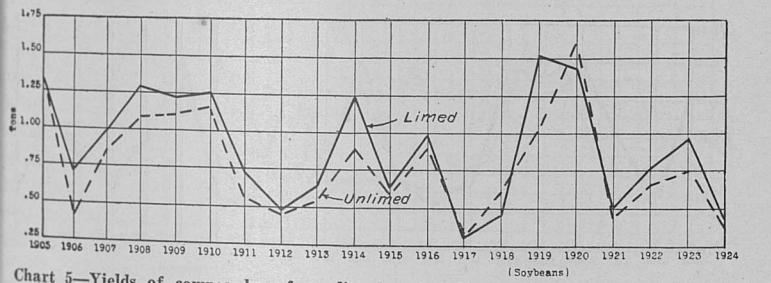


Chart 5—Yields of cowpea hay from limed and unlimed sections of plots G4, G5, G8 and I4 (averaged)—hay crops removed annually—Knoxville

creased supply of available nitrogen was the reason for the g erally increased yields on the limed sections. Chart 5, prepa from table 6, shows the average annual yields from the limed a unlimed sections of the 4 plots G4, G5, G8, and I4, where all c pea crops were removed. Chart 6, prepared from table 7, dep in like manner the yields from the 4 corresponding plots, F4, F8, and H4, where all the cowpea crops were turned under. Fr

TABLE 7—*Average annual yields per acre of crops grown on plots F5, F8, and H4—cowpea crops turned under—fertilizer tr ments the same as for plots G4, G5, G8, and I4, where c pea crops were removed as hay.*

Year	Cowpea hay			Wheat					
	Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed and unlimed	
				Grain	Straw	Grain	Straw	Grain	Straw
	Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	To
1905- 6	(1.32)	(1.32)	1.32	(35.2)	(2.10)	(35.2)	(2.10)	35.2	2
1906- 7	0.62	0.51	0.57	32.0	2.19	28.7	1.78	30.4	1
1907- 8	1.00	1.01	1.01	28.5	1.49	23.6	1.27	26.1	1
1908- 9	1.51	1.42	1.47	26.9	1.76	24.3	1.54	25.6	1
1909-10	1.40	1.26	1.33	27.2	1.85	25.2	1.64	26.2	1
1910-11	1.44	1.30	1.37	28.2	1.59	25.1	1.43	26.7	1
1911-12	0.71	0.73	0.72	29.9	1.49	28.8	1.43	29.4	1
1912-13	0.67	0.53	0.60	26.4	1.43	24.6	1.48	25.5	1
1913-14	0.70	0.68	0.69	25.5	1.36	24.5	1.39	25.0	1
1914-15	1.52	1.35	1.49	21.6	1.09	21.0	1.01	21.3	1
1915-16	0.76	0.88	0.82	21.2	1.09	21.5	1.15	21.4	1
1916-17	1.34	1.46	1.40	18.1	0.53	23.3	0.72	21.2	0
1917-18	0.48	0.55	0.52	22.6	1.20	16.0	0.92	19.3	1
1918-19	0.57	0.79	0.68	18.5	1.22	17.7	1.09	18.1	1
1919-20	1.48	1.30	1.39	20.3	1.18	19.4	1.17	19.9	1
1920-21	0.90	1.03	0.97	23.5	1.43	24.1	1.63	23.8	1
1921-22	0.67	0.59	0.63	15.9	1.27	14.4	1.25	15.2	1
1922-23	0.78	0.84	0.81	18.2	1.28	18.7	1.30	18.5	1
1923-24	1.09	1.10	1.10	17.2	1.02	17.3	1.01	17.3	1
1924-25	0.51	0.54	0.53	22.7	0.57	20.7	0.53	21.7	0
Average	0.97	0.96	0.97	24.0	1.36	22.7	1.29	23.4	1

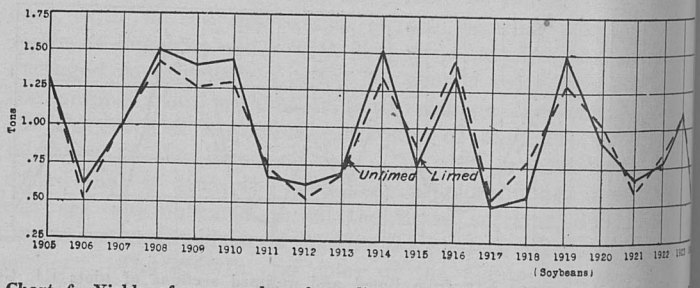


Chart 6—Yields of cowpea hay from limed and unlimed sections of plots F4, F8 and H4 (averaged)—cowpea crops turned under each year—Knoxville

inspection of these two charts it is evident that the effects of liming are much more pronounced where the cowpea crops were removed. In fact, after the eighth season, 1912, there is no practical difference between the yields on the limed and unlimed sections of the plots where the peas were turned under. Chart 7 indicates that liming was of minor importance in the case of the manure plots, the record in this respect closely paralleling that of chart

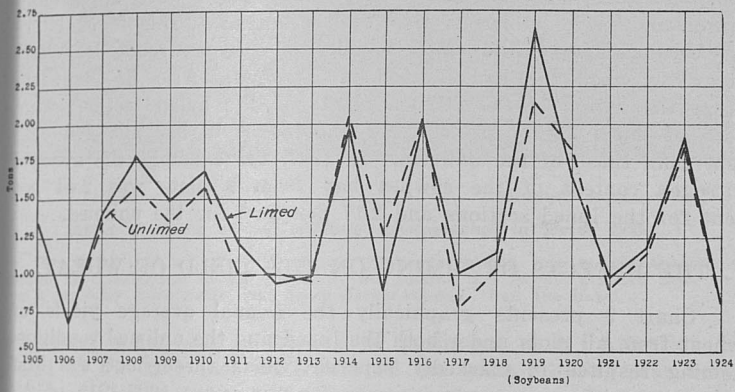


Chart 7—Yields of cowpea hay from limed and unlimed sections of plots receiving 4 tons of manure per acre annually—yields from plots F6 and G6 (averaged)—Knoxville.

6. Chart 8, recording the yields of plot H8, where no wheat was grown and where the cowpea crops were turned under, gives no conclusive evidence that the crops were affected by the limings. As a rule the variations were so small as to be attributable to minor factors which characterize work of this kind. To summarize,

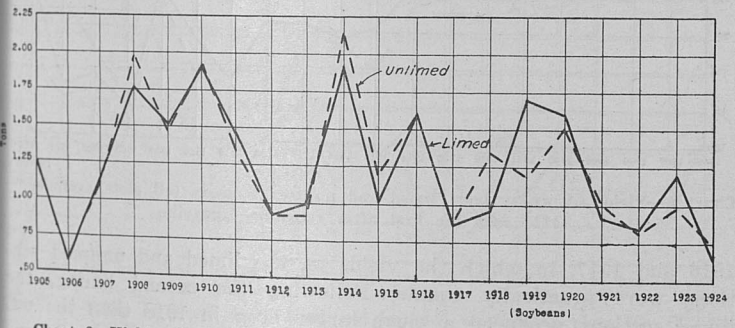


Chart 8—Yields of cowpea hay, plot H8—crops turned under—no wheat grown—liming not effective—Knoxville

liming has evidently increased the cowpea crop most where th was the least replacement of soil nitrogen and was of little co sequence with a good supply of nitrogen.

This evidence is substantiated by the soil nitrogen data, whi will be given later; also by the following observations:

In the early years there was a noticeable difference between t nodule development on the cowpea roots from the limed and u limed sections. In the latter case the nodules were appreciab larger and more numerous than in the former. This is of inte est because sparse and small nodules on cowpea roots are cha acteristic when the soil is rich in nitrogen. Also in the ea years the leaves of the cowpea plants of the limed sections we both of much darker green color and had a higher nitrogen co tent than those of the unlimed. In 1907, for example, the avera nitrogen content of the cowpea hay from 9 plots was 2.44 p cent for the limed sections and 2.17 per cent for the unlimed.

THE EFFECTS OF LIMING ON THE YIELD OF WHEAT

Chart 9 presents graphically the annual average yields o wheat from all plots under both the limed and the unlimed conditi Liming resulted in markedly superior yields throughout the fi 10 years, with an average increase for the years 1907-1915 of 1 bushels of grain per acre. This period was followed by two yea

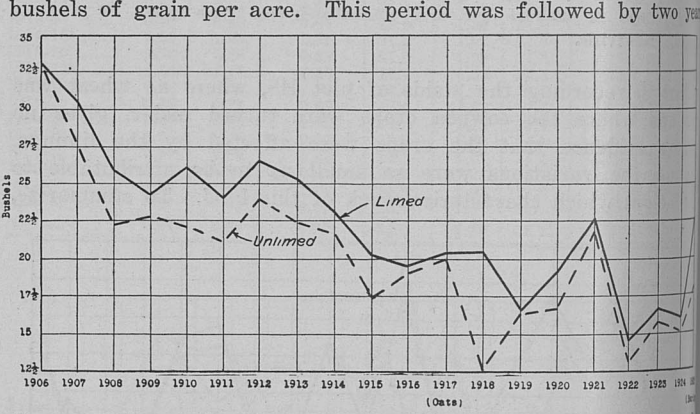


Chart 9—Yields of wheat from limed and unlimed sections (all plots average 1918 crop the first after reliming—Knoxville

1916 and 1917, in which the yields on the limed and unlimed s tions were practically equal. Following the second liming, t limed sections produced a much larger crop in 1918 than the u limed, and for the next 7 years continued to produce, with o exception, consistently larger crops. The average difference

Limed section Unlimed section

Effect of liming on soil moisture (photographed in March 1926)

The division between the limed and unlimed sections was at times sharply defined by a difference in soil moisture; the surface soil of the unlimed area being appreciably more moist, and hence darker-colored, than the limed.

the last 7 years was 1.6 bushels of grain per acre. Attention is called to the fact that the effect of the second liming was conspicuously less than that of the first, as is obvious from chart 9.

If the effects of liming on the yields of wheat where the cowpeas were removed, as shown in chart 10, be compared with those where the cowpea crops were turned under, as shown in chart 11, it is evident that the effects of liming were most pronounced on

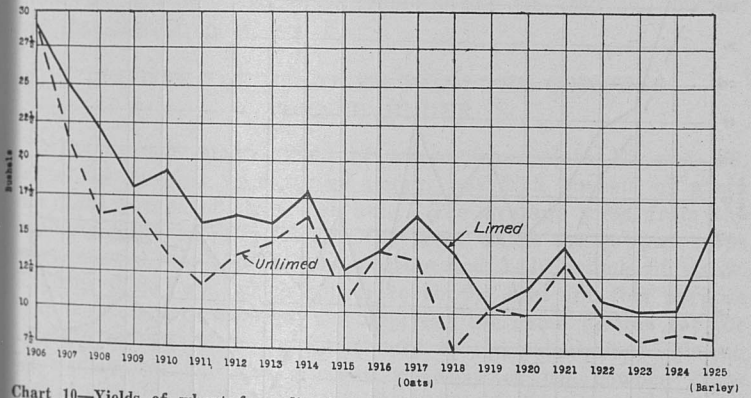


Chart 10—Yields of wheat from limed and unlimed sections of plots G4, G5, G8 and I4 (averaged)—all cowpea crops removed—Knoxville

Note the marked effect of liming throughout the period.

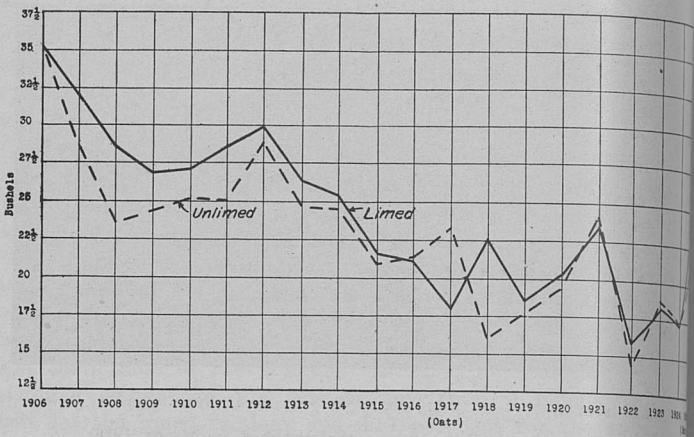


Chart 11—Yields of wheat from limed and unlimed sections of plots F4, F5 and H4 (averaged)—all cowpea crops turned under—Knoxville

those plots where the crops were removed. Until 1914, however, the effects of the first liming are plainly evident on the plots where the cowpea crops were turned under and the second liming was followed by increased yields for each of the 3 years following, after which, or for the last 5 years, the limed and unlimed sections yielded practically alike.

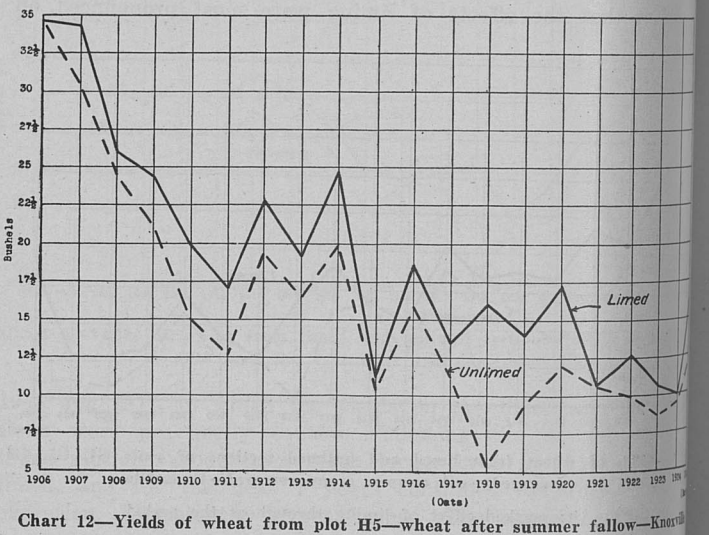


Chart 12—Yields of wheat from plot H5—wheat after summer fallow—Knoxville

INFLUENCE OF THE COWPEA CROPS ON THE YIELDS OF WHEAT

Chart 11 shows that the yields of wheat were not maintained, even where the cowpea crops were turned under, but continued to decline slowly, at least for the first 14 years. The yields on the corresponding plots where the cowpea crops were removed fell very rapidly during the first 6 years, as indicated in chart 10. A less marked downward tendency continued to the close of the period, with an average yield for the 20 years of 8 bushels per acre less than where the cowpea crops were turned under.

There was available only one no-cowpea plot, H5, for comparison with the cowpea plots as to the effects of the cowpeas on the wheat yields. The uniformity of the entire area used in the experiments was considered to be excellent, and plot H5 was as well located as possible in this respect, so that it may be considered as a dependable control. Since this plot received annual applications of phosphate and potash, the crop yields should be compared with those similiarly treated, such as F5 and F8, where the cowpea crops were turned under, and G5 and G8, where the cowpea crops were removed. Chart 3 admits of this comparison when the yields from the limed and unlimed sections are averaged together. The yields from both the limed and unlimed sections of plot H5 are shown in chart 12. It is evident that the yields of this plot fell off rapidly, resembling closely those from G5 and G8, where the cowpea crops were removed. Plot H5 maintained, however, a higher yield for the first 4 years than F5 and F8. On the other hand, the yields for the last 10 years of the 20-year period averaged .7 bushel per acre less than those from G5 and G8, and 10.1 bushels less than those from F5 and F8.

RECOVERY OF NITROGEN FROM THE COWPEAS TURNED UNDER

The average annual yield of wheat from plots F5 and F8, where the cowpeas were turned under, was 25.5 bushels of grain and 2,980 pounds of straw per acre. The average yield from the similarly fertilized plots G5 and G8, from which the cowpea crops were removed, was 15.8 bushels of grain and 1,640 pounds of straw. Utilizing these data, which appear to be the best for this purpose that the experiments afford, and applying the same figures for the nitrogen content of the crops as used in the calculations relating to manure, we find the nitrogen recovery of the cowpea crops turned under to be 32.5 per cent when measured by the wheat crop only. If, as in the calculations relating to the nitrogen recovery from manure, the increased yield of cowpeas be taken into con-

sideration, the per cent of nitrogen recovery is increased to per cent.

SOIL STUDIES

NITROGEN

At the outset of the experiments, and before any crop grown, soil samples were carefully taken from each plot depth of 8 inches. Periodically thereafter samples were taken care from both the limed and unlimed halves. These samples analyzed by the Gunning method for total nitrogen. Precau were taken to make these determinations in as nearly uniform manner as possible; standard acid of constant strength being with 10-gram charges of soil, and blanks run on reagents. In course of this and similar work, however, the fact was establi that it is very difficult, if not impossible, to obtain in practice solutely comparable results between periodical soil samples. samples, for various reasons, may not be representative of the ditions. A constant analytical error affecting the results to a thousandths of a per cent may easily run throughout the series determinations for any year; but this was guarded against as as possible. For the reasons mentioned the comparative res between the plots cropped differently and between the limed unlimed areas are more dependable than the differences appear from one period to another. The writer believes, however, that averages from several plots, as made use of in the discussions, a fair index to the actual changes which took place in the conte of total soil nitrogen.

Table 17 gives in detail the percentages of total nitrogen fo in both the limed and unlimed sections of each plot, at intervals 2 to 3 years throughout the period. Table 8 summarizes the d of table 17 with regard to the disposition of the cowpea cro that is, annual averages are given both for the 13 plots where cowpea crops were turned under and for the 4 unmanured plots wh the cowpea crops were removed. Chart 13 presents graphically data of table 8.

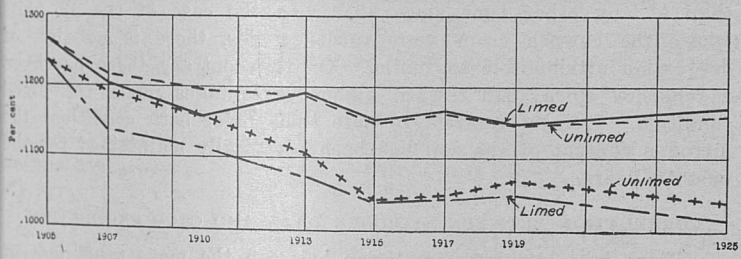
EFFECTS OF GREEN MANURING

As shown in chart 13, there was a positive continued decl in the nitrogen content of the soil for the first 10 years. This true not only where the cowpeas were removed but also wh they were turned under, although the decline under the former co dition was much more marked than under the latter. Since th time a state of equilibrium seems to have been maintained, w an almost constant difference of .012 per cent of nitrogen in fa of the plots where the cowpea crops were turned under. At

TABLE 8—*Effects of liming on the nitrogen content of the soil with regard to the disposal of the cowpea crops—summary of table 17.*

Plots averaged	Disposition of cowpea crops	Year	Nitrogen content of soil		
			Limed	Unlimed	Average
			Per cent	Per cent	Per cent
	Removed	1905	(.1238)	(.1238)	.1238
	"	1907	.1139	.1192	.1165
	"	1910	.1113	.1157	.1135
G4, 5, 8, and I4	"	1913	.1075	.1106	.1090
	"	1915	.1040	.1043	.1042
	"	1917	.1045	.1051	.1048
	"	1919	.1050	.1070	.1060
	"	1925	.1017	.1040	.1029
	Turned under	1905	(.1266)	(.1266)	.1266
	" "	1907	.1204	.1217	.1210
F4, 5 and 8	" "	1910	.1157	.1196	.1177
H4, 6 and 8	" "	1913	.1192	.1191	.1191
I5, 6 and 8	" "	1915	.1154	.1150	.1152
J4, 5, 6 and 8	" "	1917	.1167	.1164	.1166
	" "	1919	.1148	.1147	.1148
	" "	1925	.1169	.1157	.1163

outset the average content of soil nitrogen for the 13 plots where the cowpeas were turned under was .1266 per cent, and at the end of 10 years it was .1152 per cent, showing a loss of practically 9 per cent. In the case of the 4 plots where the cowpeas were removed for hay, the average per cent at the outset was .1236 and at the end of 10 years it was .1042 per cent, showing a loss in this case of 15.7 per cent. When calculated to pounds per acre for



Cowpeas turned under—Limed.

Cowpeas turned under—Unlimed.

Cowpeas removed—Limed.

Cowpeas removed—Unlimed.

Chart 13—Changes in nitrogen content of soil—cowpea-wheat experiments—Knoxville

the depth sampled (8 inches), or 2,000,000 pounds of dry, fine s
the loss of nitrogen for the first 10 years amounts to 228 po
where the cowpeas were turned under and 388 pounds where
were removed.

EFFECTS OF LIMING

Some striking changes took place after the first liming, as
dicated in chart 13. In the case of the 13 plots where the cow
were turned under, the limed sections showed a considerably lo
content of nitrogen for a period of between 5 and 8 years.
maximum difference found was in 1910, when there was nea
.005 per cent, or approximately 100 pounds per acre, less nitro
in the limed sections than in the unlimed. After 1913 there was
appreciable difference between them. In the case of the 4 pl
from which the cowpeas were removed a similar reduction in
trogen content followed liming, but with the difference that
marked reduction continued for a period of at least 8 years, af
which the per cent continued to be slightly in favor of the unli
sections.

The effects of the second liming are little in evidence. In
case of the 4 plots where the cowpea crops were removed there
pears to be some loss of nitrogen attributable to the reliming,
difference between the nitrogen contents of the soil of the lim
and unlimed sections being more favorable to the latter, both
1919 and in 1925, than in either 1915 or 1917. Under both co
ditions the per cent of nitrogen tends downward, being less in 19
than at any other time since 1913. In the case of the 13 pl
where the cowpea crops were turned under, there is no sign
depression attributable to liming. On the contrary there has be
a tendency since 1913 toward higher percentages under the lim
condition. It is of interest to note that under both conditions t
nitrogen content of the soil has been practically maintained for t
past 10 years.

CORRELATION BETWEEN NITROGEN DATA AND CROP PRODUCTION

There is a striking correlation between the more rapid loss
soil nitrogen from the limed sections following the first liming a
the increased crop production of the same sections during the sa
period. Under normal conditions, loss of soil nitrogen may be use
as a measure of its conversion into forms available for plant u
The soil results therefore confirm the crop data in demonstrati
that in these experiments the crop yields were increased by limi
largely, if not almost entirely, because of an increased supply
available soil nitrogen.

LIMINGS NOT INJURIOUS

Attention is also called to the important fact that the limings do not appear to have caused any special waste of soil nitrogen, but rather to have accelerated for a time losses of nearly equal magnitude which took place at a more nearly uniform rate where no liming was done.

HUMUS

CHANGES IN TOTAL HUMUS CONTENT

The determination of the organic carbon of a soil can be made accurately, but there is no accurate method of determining the actual amount of "humus". When, however, the carbon content is multiplied by a suitable factor, a close approximation of the amount of organic matter is obtained. Table 9 gives the humus content, determined in this way at the beginning of the experiments in 1905 and at the end of 20 years, with regard to the effects of various treatments. The table summarizes the results obtained from the individual soil analyses for each of 19 plots.

EFFECTS OF GREEN MANURING

The results given in table 9 show less humus by .11 per cent at the end of the 20-year period where the cowpea crops were turned under annually. When calculated to the 8-inch depth of

TABLE 9—*Changes in the total humus content* (C × 1.724) *of the soil under various conditions at the end of* 20 *years—Knoxville experiments* (*m. f. basis*).

Plots averaged	Disposition of cowpea crops	Humus content in 1905	Humus content in 1925					
			Limed		Unlimed		Average of limed and unlimed	
				Gain (+) or loss (—)		Gain (+) or loss (—)		Gain (+) or loss (—)
		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
G4, 5, 8, I4	Removed	2.34	2.06	—11.97	2.14	—8.55	2.10	—10.26
F4, 5, 8 H4, 6, 8 I5, 6, 8 J4, 5, 6, 8	Turned under	2.45	2.35	—4.08	2.33	—4.90	2.34	—4.49
F6, G6	Removed (Manured)	2.59	2.76	+6.56	2.64	+1.93	2.70	+4.25

sampling, this loss amounts to 2,200 pounds per acre. Where the cowpea crops were removed (plots G4, G5, G8, and I4) the loss was appreciably greater, amounting to .24 per cent, or 4,800 pounds per acre. Two thousand six hundred pounds therefore approximates the amount of humus left from turning under 20 crops of cowpea

hay, averaging 1.1 tons per acre, or a total of 22 tons, furnish nearly 20 tons of actual dry matter. This crop is quickly dec posed in the soil, and although it may supply a current of fr humus, it evidently makes no great contribution to the perma humus supply.

EFFECTS OF FARMYARD MANURE

The manure was rich in both organic matter and nitrogen, a supplied, according to calculation, about one-third more orga matter than the incorporated cowpea crops. The analyses indic that the manure plots are the only ones on which there was increase in humus; the soil content being 2.59 per cent in 1905 a 2.70 per cent in 1925. The calculated gain in humus per acre the depth of plowing was therefore 2,200 pounds.

EFFECTS OF LIMING

The effects of liming on the humus content of the soil at t end of the 20-year period are little in evidence. Where the co pea crops were removed, however, there was a greater loss un the limed than the unlimed condition, the difference being .08 p cent, or 1,600 pounds per acre. On the other hand, where the co pea crops were turned under the limed sections show a slight higher content than the unlimed. The limed sections of the manu plots have an appreciably higher humus content than the unlime but this result must be taken with reservations because there we only two plots concerned in the average and they were adjace It is possible that the limed section had originally a somew higher content than the unlimed. There are also unavoidable e rors in sampling which could easily be accentuated where manu applications have been made.

ACTIVE HUMUS

Table 10 gives the percentages of the more active, or colloid humus in the soil samples, which were taken every 2 or 3 ye for the first 10 years of the experiments. As in table 9, the re sults are averages of separate determinations for each plot. The determinations are made by extracting the humus with dilute a monia after leaching with dilute hydrochloric acid—a method co commonly used, but nearly abandoned of late years, chiefly becau the method gives less accurate results than that for total carb In these experiments there is, however, much similarity in t trend of the results by the two methods. At the end of the year period the soil from the plots where the cowpeas were re moved has lost appreciably the most colloidal humus, and th limed sections have suffered a somewhat greater loss than the u

TABLE 10—*Colloidal humus content of soils under various conditions as determined periodically for the first* 10 *years of the Knoxville experiments* (*m. f. basis*).

Plots averaged	Disposition of cowpea crops	1905	1907		1910		1913		1915	
			Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed
		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
G4, 5, 8, I4	Removed	1.26	1.21	1.29	1.22	1.29	1.20	1.30	1.14	1.20
F4, 5, 8 H4, 6, 8 I5, 6, 8 J4, 5, 6, 8,	Turned under	1.29	1.26	1.29	1.30	1.35	1.28	1.31	1.23	1.23
F6, G6	Removed (Manured)	1.39	1.43	1.44	1.40	1.52	.....	1.58	1.43	1.45

limed. The loss is less where the cowpea crops were turned under, but the content is the same for the limed as the unlimed. The manure plots show a gain, but the difference between the limed and unlimed sections is not positive. In fact, they are closer than duplicate determinations often are from the same soil sample.

Perhaps the most interesting point brought out in this series is the more immediate effect of liming on the humus matter, the effect being similar to that on the soil nitrogen. That is, liming lowered the content of colloidal humus under all conditions during the earlier years. This effect disappears, however, by the tenth year in the case of both the manure plots and the plots where the cowpea crops were turned under. Where the cowpeas were removed the effect is more persistent, being plainly in evidence at the end of the period, although it appears to be of little practical consequence.

RESULTS OBTAINED AT THE JACKSON STATION

Experiments similar to those at Knoxville were conducted for 16 years, 1909-1925, at the West Tennessee Station, at Jackson, with the production of 17 crops of cowpeas and 16 of wheat. The climate of Jackson is better suited to this kind of rotation than the climate of Knoxville, the summer season at the former place being somewhat longer and warmer, and hence more favorable to the cowpea crop and to a late seeding of wheat.

DATES OF PLANTING AND HARVESTING

The dates of planting wheat varied from October 2 to November 12, with October 16 as the average. The dates of harvest varied from June 6 to 19, with June 11 as the average.

The dates of planting the cowpeas varied from June 9 to J 16, with June 21 as the average. The hay crops were cut f August 21 to October 18, with September 9 as the average.

TABLE 11—*Chemical analyses of soils.*

(10-hour digestion with hydrochloric acid, Sp. Gr. 1.115)

Constituent	Knoxville soil	Jackson soil
	Per cent	Per cent
Insoluble residue	82.49	91.45
Potash (K_2O)	0.34	0.20
Lime (CaO)	0.13	0.15
Magnesia (MgO)	0.25	0.32
Manganese oxide (MnO)	0.24	0.17
Ferric oxide (Fe_2O_3)	3.27	1.43
Alumina (Al_2O_3)	6.61	3.41
Phosphoric acid (P_2O_5)	0.14	0.057
Sulphuric acid (SO_3)	0.04	0.04
Volatile matter	5.55	2.52
Humus	1.36	0.68
Total nitrogen	0.128	0.064
Acidity by Veitch method	0.07	0.02
Colloids	21.50	9.40

SOIL AND PLOTS

The soil was a grayish-brown silt loam of good structure, u derlaid by a somewhat heavier reddish-yellow subsoil to a de of about 2 feet, below which was a stratum of sand of unkn depth. The land was uniform and nearly level throughout.

For comparative purposes the chemical analyses of both t Knoxville and Jackson soils are given in table 11 and mechani analyses in table 12. According to the chemical analyses the Ja

TABLE 12—*Mechanical analyses of soils.*

(By method of Bureau of Soils)

Class	Size of particles	Knoxville soil	Jackson soil
	mm	Per cent	Per cent
Gravel	2. -1.	1.14	0.17
Coarse sand	1. - .5	2.37	1.36
Medium sand	.5 - .25	3.32	2.77
Fine sand	.25 - .1	9.15	4.27
Very fine sand	.1 - .05	17.68	5.77
Silt	.05 - .005	47.85	76.00
Clay	.005-0	19.63	9.68

son soil has slightly better supplies of both lime and magn than the Knoxville soil, but the content of potash, phosphoric a nitrogen, and humus is less for each by nearly one-half. The portant differences, as shown in the mechanical analyses, are comparatively high content of silt in the Jackson soil and of b clay and colloids in the Knoxville soil. The latter soil is "hea

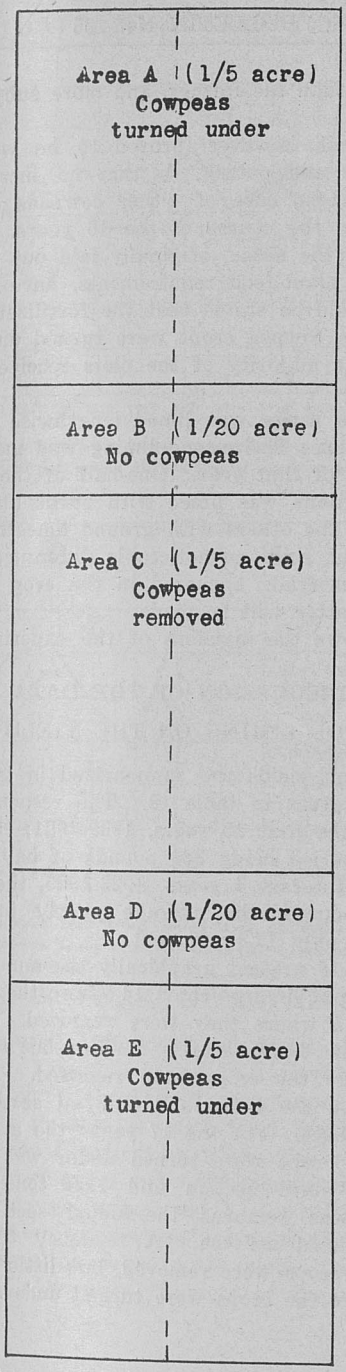


Diagram 2—Experimental range—Jackson

and more granular than the former, and more subject to heaving the winter.

The Jackson soil, however, proved to be well supplied with available phosphate and potash, so that no increased yield from their application in the case of either cowpeas or wheat was at any time evident in the course of the 16 years. For the present purposes, therefore, the areas, originally laid out in 1/40-acre plots to test the special plant-food requirements, have been grouped together. But it should be stated that the fertilizer treatments were the same where the cowpea crops were turned under as where removed, and that the majority of the plots received both phosphate and potash.

One-half of the range was limed lengthwise in 1909, prior to the first cowpea crop. The second liming was made in 1919, prior to the cowpea crop of that year. One-half of the plots under each of the major conditions was limed with burnt lime at the rate of 1 ton per acre and the others with ground limestone at the rate of 2 tons per acre; but since no noticeable difference in the effectiveness of the two materials appeared in the crop yields no further reference to the matter will be made.

Diagram 2 shows the divisions of the experimental range.

DISCUSSION OF THE DATA

THE EFFECTS OF LIMING ON THE YIELD OF COWPEAS

The annual crop yields are summarized in table 13 and given for the individual areas in table 18. The response to liming was especially marked the first 13 years, 1909-1921; the average annual increase for that period being 860 pounds of hay per acre, or 44 per cent. During the last 4 years, 1922-1925, the response to liming was much reduced, the average yearly increase being 36 pounds of hay, or only 17.8 per cent.

Charts 14 and 15 present graphically the annual yields obtained both with and without liming—chart 14 where the crops were turned under and chart 15 where they were removed. The trend of the curves shown in the two charts is similar, but the yields were at a lower level where the crops were removed. The difference between the yields on the limed and unlimed sections is nearly the same in the two cases. For the 17 years the average annual production where the crops were turned under was 1.46 tons of hay per acre on the limed section and 1.08 tons on the unlimed. Where the hay was removed the limed section averaged 1.27 tons and the unlimed .94 ton. A tendency to decreased yields is seen where the crops were removed, but little or no tendency in this direction where the crops were turned under.

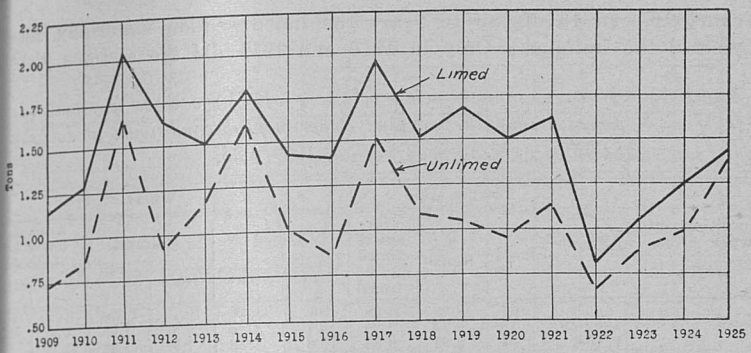


Chart 14—Yields of cowpea hay from limed and unlimed sections of areas A and E (averaged)—cowpea crops turned under each year—Jackson

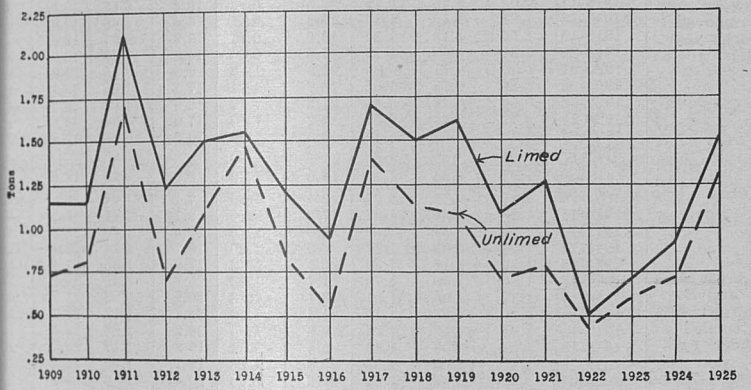


Chart 15—Yields of cowpea hay from limed and unlimed sections of area C—cowpea crops removed annually—Jackson

THE EFFECTS OF LIMING ON THE YIELD OF WHEAT

Table 13 summarizes the yields of wheat obtained both with and without liming. Liming resulted in a markedly superior yield of both grain and straw throughout the period. On the average for the 16 years the increase per acre from liming was 3.5 bushels of grain and 600 pounds of straw where the cowpea crops were removed, 5.8 bushels of grain and 1,000 pounds of straw where the cowpea crops were turned under, and 3.1 bushels of grain and 420 pounds of straw where no cowpeas were grown.

A graphic comparison between the yields from the limed and unlimed sections of the entire 25 plots of the range is given in

chart 16. In 14 of the 16 years the limed section materially o
yielded the unlimed. Only in 1916 and 1919 did the sections y

TABLE 13—*Average annual yields per acre of* (1) *cowpea hay and wheat under the various experimental conditions, at Jack Station, over* 16*-year period,* 1909-1925.

Disposition of cowpea crops	Year	Cowpea Hay			Wheat				
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Aver limed unlim
					Grain	Straw	Grain	Straw	Grain
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.
Area C Cowpea hay removed each year (plots 10-16)	1909-10	1.15	0.73	0.94	13.7	2.16	6.8	1.03	10.3
	1910-11	1.15	0.81	0.98	15.3	1.88	7.5	1.33	11.4
	1911-12	2.11	1.67	1.89	27.8	1.56	21.5	1.35	24.7
	1912-13	1.23	0.70	0.97	19.3	1.04	15.2	0.89	17.3
	1913-14	1.50	1.09	1.30	14.9	0.72	13.2	0.73	14.1
	1914-15	1.55	1.46	1.51	18.2	0.72	18.1	0.86	18.2
	1915-16	1.21	0.83	1.02	07.5	0.52	10.3	0.69	08.9
	1916-17	0.94	0.55	0.75	22.5	0.87	15.4	0.68	19.0
	1917-18	1.68	1.40	1.54	19.4	0.91	16.4	0.69	17.9
	1918-19	1.50	1.13	1.32	14.0	0.71	13.8	0.67	13.9
	1919-20	1.61	1.08	1.35	17.5	0.96	14.5	0.63	16.0
	1920-21	1.09	0.71	0.90	22.9	1.58	16.9	0.98	19.9
	1921-22	1.26	0.78	1.02	18.7	1.31	17.5	1.08	18.1
	1922-23	0.50	0.42	0.46	21.6	1.37	18.9	1.03	20.3
	1923-24	0.72	0.61	0.67	23.2	1.79	17.9	0.96	20.6
	1924-25	0.93	0.72	0.83	19.0	1.09	16.6	0.86	17.8
	1925	1.53	1.26	1.40	.....	.....	.....	.....	.....
	Average	1.27	0.94	1.11	18.5	1.20	15.0	0.90	16.8
Areas A and E Cowpea hay turned under each year (plots 1-7 and 19-25)	1909-10	1.15	0.73	0.94	12.4	1.86	7.1	1.07	9.8
	1910-11	1.28	0.85	1.07	17.2	2.25	9.1	1.41	13.2
	1911-12	2.04	1.67	1.86	29.0	1.70	22.5	1.40	25.8
	1912-13	1.63	0.90	1.27	28.0	1.80	19.7	1.24	23.9
	1913-14	1.50	1.16	1.33	25.0	1.42	17.8	1.05	21.4
	1914-15	1.80	1.60	1.70	31.7	1.62	25.3	1.28	28.5
	1915-16	1.42	1.00	1.21	13.1	1.13	10.2	0.83	11.7
	1916-17	1.40	0.85	1.13	31.4	1.60	24.3	1.12	27.9
	1917-18	1.95	1.52	1.74	30.6	1.60	26.2	1.23	28.4
	1918-19	1.51	1.09	1.30	20.5	1.31	19.8	1.17	20.2
	1919-20	1.67	1.03	1.35	25.8	1.78	18.7	1.06	22.3
	1920-21	1.50	0.95	1.23	29.6	2.48	20.4	1.58	25.0
	1921-22	1.61	1.13	1.37	26.6	2.17	22.3	1.61	24.5
	1922-23	0.80	0.67	0.74	25.2	1.95	19.8	1.38	22.5
	1923-24	1.05	0.88	0.97	31.2	1.96	24.1	1.37	27.7
	1924-25	1.25	0.99	1.12	26.3	1.84	23.3	1.56	24.8
	1925	1.43	1.36	1.40	.....	.....	.....	.....	.....
	Average	1.46	1.08	1.28	25.2	1.77	19.4	1.27	22.3
Areas B and D No cowpeas grown (plots 8, 9 and 17, 18)	1909-10	.....	.....	.....	14.2	2.26	9.6	1.53	11.9
	1910-11	.....	.....	.....	21.1	2.46	11.5	1.87	16.3
	1911-12	.....	.....	.....	21.3	1.16	21.1	1.16	21.2
	1912-13	.....	.....	.....	22.6	1.61	21.4	1.48	22.0
	1913-14	.....	.....	.....	15.7	0.89	15.4	1.00	15.6
	1914-15	.....	.....	.....	20.2	1.01	17.9	0.88	19.1
	1915-16	.....	.....	.....	07.8	0.65	08.0	0.69	07.9
	1916-17	.....	.....	.....	19.4	0.81	12.3	0.59	15.9
	1917-18	.....	.....	.....	19.2	1.03	18.5	0.97	18.9
	1918-19	.....	.....	.....	10.7	0.75	10.6	0.74	10.7
	1919-20	.....	.....	.....	14.4	0.85	11.1	0.72	12.8
	1920-21	.....	.....	.....	17.4	1.13	9.9	0.96	13.7
	1921-22	.....	.....	.....	16.5	1.48	14.3	1.03	15.4
	1922-23	.....	.....	.....	17.8	1.34	13.3	1.06	15.6
	1923-24	.....	.....	.....	21.6	1.51	15.6	1.26	18.6
	1924-25	.....	.....	.....	12.5	1.26	12.9	0.84	12.7
	Average	.....	.....	.....	17.0	1.26	13.9	1.05	15.5

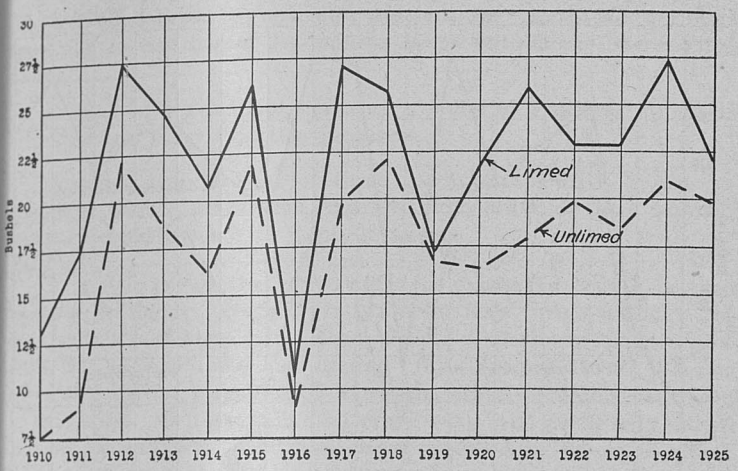


Chart 16—Yields of wheat with and without liming—Jackson

practically alike. The 1916 crop was produced in the most unfavorable of all the seasons. The 1919 crop was the last prior to the reliming of that year. There are indications that the reliming increased the difference between the yields of the two sections, and no positive evidence of declining effectiveness of the liming has appeared, so far as the wheat crop is concerned.

THE INFLUENCE OF THE COWPEA CROP ON THE YIELD OF WHEAT

Table 13 may be referred to again for the influence of the cowpea crop on wheat production under three conditions: (1) Cowpeas removed, (2) cowpeas turned under, and (3) summer fallow. A graphic comparison of the yields under the various conditions is given in chart 17.

On the average for the 16 years the yields of wheat were 1.3 bushels per acre greater and the straw production 200 pounds less on area C, where the cowpea crops were removed as hay, than on areas B and D, where no cowpeas were grown. If, however, the yields for the first 8 years be compared with those for the last 8, much light is thrown on what has taken place, for during the first 8 years the no-cowpea plots outyielded area C by an average of .7 bushel of grain and 420 pounds of straw to the acre, but in the last 8 years area C outyielded the no-cowpea plots by an average of 3.3 bushels of grain, with a straw production only 40 pounds less than that of the no-cowpea plots. The average annual acre

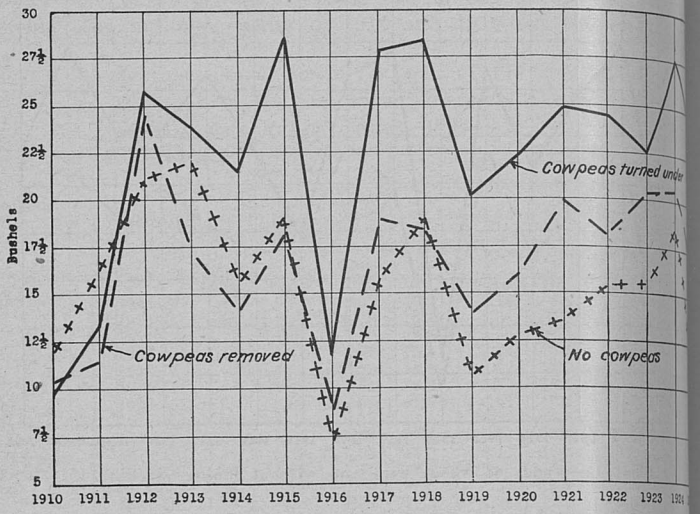


Chart 17—Yields of wheat under various conditions—Jackson

yield of wheat on area C was 16.8 bushels of grain and 1.05 to of straw, or within the range of profitable production.

On areas A and E, where the cowpea crops were turned und the yields of wheat were especially good and the tendency is u ward. For the entire period they produced an annual average 6.8 bushels of grain and 740 pounds of straw per acre more th where no cowpeas were grown. The average yield per acre areas A and E during the first 8 years was 20.3 bushels of gr and 1.43 tons of straw. For the last 8 years the averages we 24.4 bushels of grain and 1.63 tons of straw.

RELIMING AND THE LAW OF DIMINISHING RETURNS

PRELIMINARY CONSIDERATIONS

The following brief preliminary considerations of some we established fundamentals relating to liming may be of assistan in the interpretation of the experimental data and in the estab lishing of principles of wide practical application:

Liming has been found to promote crop production under number of soil conditions, prominent among which are the followi

1. Acid, or "sour", soil.

2. Soil containing injurious metallic salts—a usual result soil acidity.

3. Soil deficient in available calcium for plant-food purposes, especially in the case of leguminous crops with high lime requirements.

4. Soil in which liming induces a material speeding up of nitrification and other oxidation processes.

Although one or other of these conditions is often in the ascendency, their inter-relation and the probability of two or more being concerned should be kept in mind.

It is well known that crops differ to a marked degree in their response to liming. Cotton, for example, may thrive without liming, while alfalfa may fail. Rhode Island Experiment Station Bulletin No. 46, on "Lime and Liming", by Director H. J. Wheeler, gives the relative responses of numerous crops to liming, as found in field trials. In these trilas all crops were well fertilized; nitrate of soda "in generous quantities" being included in the applications. Of the 5 crops used in the cowpea-wheat experiments at Knoxville, 4—barley, wheat, oats, and soybeans—are included by Wheeler among those benefited by liming. Cowpeas he found to be slightly injured. The crops benefited were not found to respond equally to liming. With 1.00 to indicate no response, he gave the standing of the 5 crops as follows:

Barley	2.06
Wheat	1.40
Oats	1.09
Soybeans	1.06
Cowpeas	0.94

As compared with these 5, many other crops were found to be far more largely benefited by liming. Lettuce, for example, was rated at 10.00, and table beets at 5.35. On the other hand, a number of crops, including millet and pumpkins, are mentioned, along with the cowpeas, as being injured by liming.

The low placement of wheat, oats, soybeans, and especially cowpeas, as regards responsiveness to liming is a further confirmation of the proof previously given that an increased supply of available nitrogen offers, in many respects, a satisfactory explanation of the superior yields obtained under liming in the Knoxville experiments. The Knoxville data, on the other hand, do not appear to harmonize with any of the other 3 major conditions mentioned. Assuming the correctness of the conclusion reached, one may well ask what is the outcome of the continued liming of such a soil, so far, of course, as the crops in question are concerned.

THE KNOXVILLE EVIDENCE

In the answer to this question with regard to the Knox evidence, two important conditions may well be considered. is, where either no cowpeas were grown, or, if grown, the cr were removed without return of manure; and the other is, wh the cowpea crops were turned under annually and thus to an preciable extent replenished the soil supply of both nitrogen a organic matter.

In the former case the soil analyses show a continued dr on the original supply of soil nitrogen—a condition which co hardly result in other than a decreasing effectiveness of liming. a matter of fact, the first liming was uniformly effective in t case of the cowpea crop for the suceeding 9 years, but the seco liming was evidently less effective; material increases in yield a pearing in only 4 of the next 7 years. In the case of the wh crops the first liming resulted in materially increased yields f 10 of the first 11 years following, but after the second lim although the yields were favorable to the limed areas, the diff ences between the limed and unlimed areas were too small to of special moment for at least 3 of the 8 years. In short, the e fectiveness of reliming, with little, if any, renewal of the soil su ply of nitrogen, became so reduced for both crops that the prof ableness of a third liming is very doubtful.

Where the cowpea crops were turned under there might be t expectation of a longer-continued effectiveness of lime because the annual incorporation of organic matter. But such was not t outcome. Not only was there a comparatively small increase the yield of cowpea hay from the first liming, but the second li ing produced practically none. Although the first liming resul in consistently increased yields of wheat for at least 7 years, t second liming was materially in evidence for only 1 year. In fa for the last 5 years the differences between the crops produced the limed and unlimed sections were not only very small but wa favorable first to one section and then to the other. Apparen the lime content of the plants turned under was sufficient to su ply that needed in their active nitrification.

THE JACKSON EVIDENCE

The soil at Jackson was initially much poorer in nitrogen th that at Knoxville, but the effect of liming has been considera more pronounced for both the cowpea and the wheat crops. It m be, therefore, that an increased supply of available nitrogen w not the only prominent factor in the case. There is strong ev dence, however, that the effectiveness of liming is dismini

For, although reliming was done only 5 years previous to the last cowpea crop, the differences in yield of cowpea hay between the limed and unlimed sections have been greatly reduced, and are, in fact, relatively small for the last 4 years.

Thus far no such decrease has appeared in the case of the wheat crop. This is not surprising, because at Knoxville the cowpea crop was the first to show no response; superior yields of wheat on the limed sections continuing for several years longer. In this connection it may be recalled that the data relating to wheat at Jackson are of 4 years' shorter duration than those at Knoxville.

The superior wheat crops at Jackson on the limed sections, as compared with the unlimed, can be attributed in part to the much larger cowpea crops, the after-effects of which would be expected to last for more than a single season.

Mention should be made of the fact that there could hardly have been any deficiency of sulphur in either the Knoxville or the Jackson soil. At each place from 50 to 60 pounds of sulphur per acre are yearly brought down by the rainfall. Had the case been otherwise the sulphur factor might have been of importance, because, as found by this Station[3], sulfofication is accelerated in a soil by liming much as is nitrification.

CONCLUSION AND COROLLARIES FROM THE COWPEA-WHEAT EXPERIMENTS

This review of the two series of experiments indicates a very important conclusion; namely, that the effects of liming on the yield of both cowpeas and wheat followed the law of diminishing returns. That is, the first liming acted as a soil stimulant, with marked increases in yield, which continued for a series of years; reliming was followed by a similar reaction, but of decreased intensity; and the unprofitableness of a third liming was indicated.

The following corollaries appear to be justified by the evidence presented, and are in harmony with miscellaneous data secured at various points in the State:

1. For soils rich in nitrogen, liming is not apt to increase the yields of either cowpeas or soybeans. In further support of this statement mention may be made of the fact that soybeans are among the few crops found to do well without liming on the dark-colored, "sour", "natural meadows" of the Cumberland Plateau. This soil is very rich in nitrogen and humus, but exceptionally poor in lime and other mineral elements of plant food.

[3]MacIntire, W. H., Shaw, W. M., and Young, J. B. Influence of calcic and magnesic treatments upon sulphate leachings from soil alone and with additions of ferrous sulphate, pyrite and sulphur. Soil Sci. 16: 3. Sept. 1923.

2. Lack of material response to liming by these cereals a legumes may be expected on soils with a very low content of trogen; the increase in available nitrogen being too small to be consequence.

3. The Knoxville evidence indicates that a natural soil, e where all crops were removed, may be fairly well supplied w nitrogen, much as were the limed sections at the end of the year period, but in such forms or under such conditions that lim results in little increase in the amount available to a grow crop.

APPLICATION OF THE LIMING DATA TO OTHER SOILS IN THE STATE

Tennessee soils vary appreciably in physical character and plant-food supply, according to the geological formations from wh they were derived. There are, however, certain general characte istics common to all, due largely to the fact that the soils we formed under similar climatic conditions. Among the general cha acteristics may be mentioned the rather low content of both lime a nitrogen and the preponderance of loam and silt-loam soils simi to those used in the experiments. The Experiment Station h made trial of liming on numerous types of soil scattered over t State, and the favorable response of such crops as corn, wheat, oa soybeans, and cowpeas is general. There are, therefore, strong i dications that an increase in the supply of available nitrogen is t most prominent cause of the results obtained in all parts of t State.

At this point a word of caution may be necessary in order prevent possible misunderstanding relative to the desirability liming. Even for the crops studied, no good reason is appare why liming should not be practiced as long as the returns w justify the investment. With regard to such important soil-i proving crops as red clover, sweet clover, and alfalfa, liming is necessity to their profitable production over large areas in the Sta and the law of diminishing returns does not appear to apply them except as a minor factor. In support of this statement a tention is called to the marked difference between the response liming of various clovers and of cowpeas, soybeans, or wheat, shown in the following data obtained at the Knoxville Station un der conditions which were practically identical so far as soil, ma urial treatments, and period of time are concerned, as those in t cowpea-wheat rotation:

EXPERIMENTS IN A 5-YEAR ROTATION WITH CLOVER AND GRASS

Experiments were begun in 1905 in a 5-year rotation of corn, soybeans, wheat, and clover and grass, on land adjacent to the cowpea-wheat plots. Seedings were made of crimson clover as a cover crop after corn, but only two harvestable crops were obtained. These were turned under, but all other crops of the rotation were removed. It should be noted that the clover and grass crop stood for 2 years after each seeding, and that the first year's crop was chiefly clover and the second year's chiefly grass. A total of 15 plots of 1/40-acre each were used under various manurial treatments, including liming—one-half of every plot being limed at the same time and rate in 1905 as the cowpea-wheat plots. The second liming was not done until 1919, because the 5-year-rotation plots were in sod at the time of the reliming of the cowpea-wheat plots in 1917.

For the present purpose the record of crop yields will be limited to the averages obtained from 5 plots lying nearest the cowpea-wheat plots, from which they were separated by a 12-ft. driveway.

These 5 plots, in the course of the 20 years, 1905-1925, received nearly the same manurial treatments as the manure plots, F6 and G6, of the cowpea-wheat experiments, except that the manure was not applied annually, but only for the corn and wheat crops—each receiving 9¼ tons of manure per acre. This amounts to an average annual application of 3.7 tons. Table 14 gives all the crop yields obtained under both limed and unlimed conditions. One other crop of wheat was harvested, and one of corn, but unfortunately the yields recorded were from the whole plots and not from the limed and unlimed portions separately. Chart 18 shows the yields of the various clover and grass crops, and may well be compared with chart 7, which shows the yields of the cowpea hay on plots F6 and G6.

DISCUSSION OF THE PLOT DATA

The yield of corn on the limed section was somewhat better than on the unlimed, but apparently the crop was limited in some seasons, as in 1919, by the rainfall rather than by the nitrogen supply. On the average the limed section produced nearly 4 bushels per acre more than the unlimed.

According to the writer's observations, soybeans respond to liming about the same as cowpeas. In this case 3 of the 4 soybean crops did as well on the unlimed as on the limed section. Only

TABLE 14—*Effects of liming on the yields per acre in a rotation of corn, soybeans, wheat, and clover and grass, in parallel experiments with those of the cowpea-wheat rotation at Knoxville Station—all crops removed except two of crimson clover. Manuring and fertilizing similar to that given plots F6 and G6 in cowpea-wheat rotation.*

Year	Limed		Unlimed		Year	Limed	
	Grain	Straw or stover	Grain	Straw or stover			
	Wheat					Clover and grass hay	
	Bu.	Tons	Bu.	Tons		Dominating constituent	Tons
1911	26.9	1.61	25.0	1.62	1907	Alsike clover	2.10
1916	21.9	1.39	22.0	1.38	1908	Grass	3.18
1921	29.0	1.59	24.6	1.41	1910	Crimson clover	1.66
					1912	Red clover	1.66
					1913	Grass	0.62
					1915	Crimson clover	0.65
					1917	Red clover	1.10
					1918	Grass	0.85
					1922	Red clover	2.48
					1923	Grass	0.73
Average	25.9	1.53	23.9	1.47			1.50
	Corn					Soybean hay	
	Bu.	Tons	Bu.	Tons		Dominating constituent	Tons
1909	73.5	1.93	61.4	1.74	1910		2.51
1914	48.8	2.01	49.1	2.15	1915		2.08
1919	51.4	2.74	48.8	2.32	1920		2.74
1924	40.3	1.21	39.5	1.26	1925		0.85
Average	53.5	2.00	49.7	1.87			2.05

in 1920 was there a marked response. This followed the second liming, and the result was similar to that obtained with both cowpeas and soybeans following the reliming in the cowpea-wheat rotation.

It is noticeable that 2 of the 3 wheat crops were nearly as good on the unlimed section as on the limed. Only the third and last crop was decidedly better on the limed section.

The contrast between the effects of liming on the yield of the clovers, on the one hand, and of either cowpeas or soybeans, on the other, is very striking. On manured land, with similar conditions for all crops, the cowpeas showed little effect from liming; and the same is true of soybeans, except for a single season. But the clover and grass crops were nearly doubled by liming, and there is no indication of diminishing returns; the yields on the limed and unlimed sections continued to be far apart throughout the period of the experiments. If it be assumed that the effect of liming

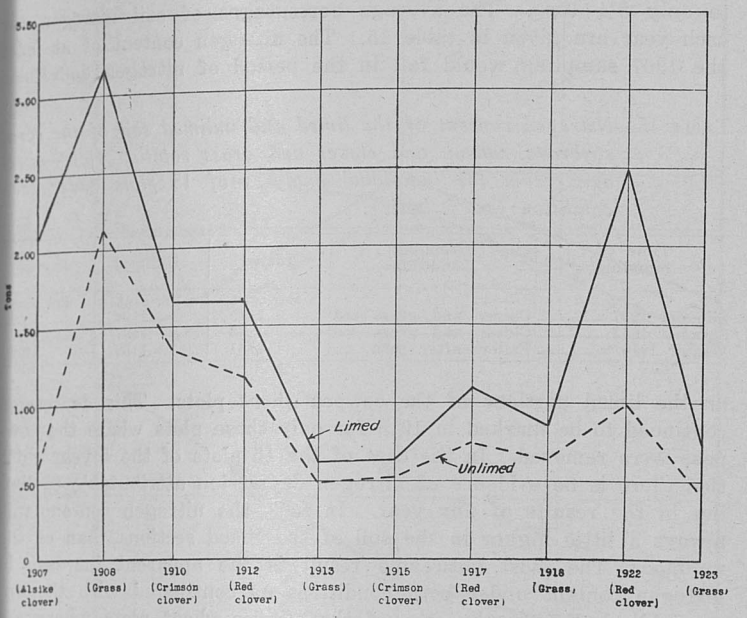


Chart 18—Yields of clover and grass hay in 5-year rotation experiments—Knoxville

the supply of available soil nitrogen was the same in one rotation as in the other, as could reasonably be expected, the conclusion is reached that liming produced larger crops of clover, at least in the latter half of the period, through some important process other than that of increasing the availability of the soil nitrogen—probably by the correction of soil acidity. It is noticeable that the second year's crop, which was chiefly grass, was not benefited by the liming to as great an extent as the first year's crop. The increase obtained may have been largely due to the clover, which furnished the major part of the crop the first year, and may well have been responsible the second year, through the decomposition of its roots and stubble, for supplying the grass with an extra amount of nitrogen.

SOIL NITROGEN DATA

Determinations of the soil nitrogen were not made throughout the period as in the cowpea-wheat experiments, but samples were taken in 1907, in 1913, and again in 1919, from both the limed and the unlimed half of each of the 15 plots. The average annual application of manure for these plots for the 14-year period amounts

to only 3¼ tons. The average percentages of soil nitrogen each year are given in table 15. The nitrogen content of at l the 1907 sampling would fall in the period of nitrogen depres

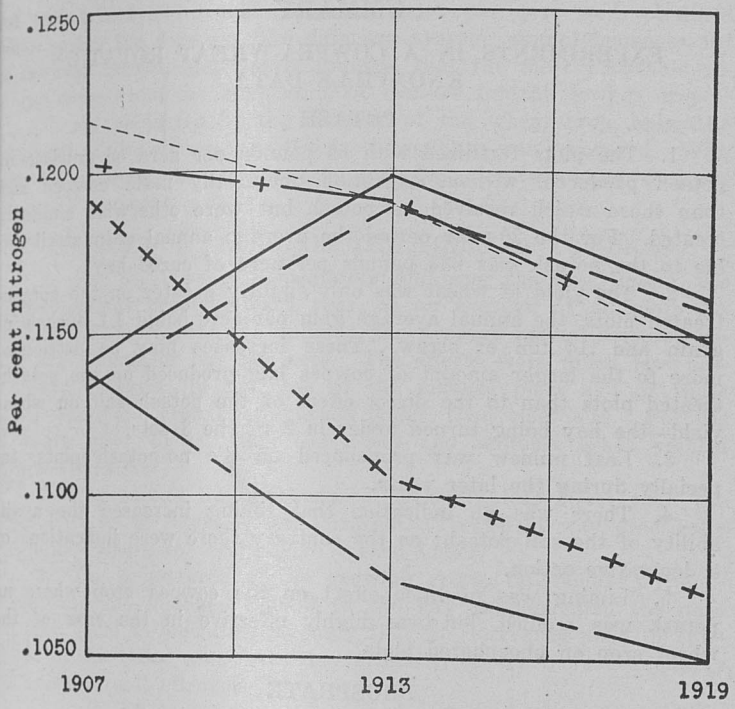
TABLE 15—*Nitrogen content of the limed and unlimed soil of the c soybeans, wheat, and clover and grass rotation plots—a ages from the individual analyses of* 15 *plots under c condition* (*m. f. basis*).

Time of sampling	Cropping condition	Limed	Unlimed	Aver
		Per cent	Per cent	Per c
Summer 1907	Clover and grass sod	.1140	.1134	.1
Summer 1913	Clover and grass sod	.1198	.1187	.1
Winter 1919	Fallow after corn	.1161	.1157	.1

on the limed portions of the cowpea-wheat plots. This depress continued to be marked in 1913 for only those plots where the c peas were removed. In the case of the 15 plots of the 5-year r tion there is no evidence of nitrogen depression attributable to li ing in the results of any year. In fact, the nitrogen content w always a little higher in the soil of the limed sections than of t unlimed. The most noticeable result is the apparent increase nitrogen content under both conditions as contrasted with the p preciable decline in the case of the cowpea-wheat plots where t cowpea crops were turned under, and with the very marked dec in the case of the plots where the cowpea crops were remov This comparison is made in chart 19.

A ROTATION OF COWPEAS AND WHEAT NOT GENERALL PRACTICABLE

With both crops grown annually on the same land, the ro tion of cowpeas and wheat appears to be of practical possibi in this State only under favorable conditions. The important fav able condition at Knoxville was the fertility of the soil. On very p soil it was found, in other trials, especially in the higher porti of the State, that the cowpea crop obtainable after wheat harvest w too small and uncertain, even when well fertilized, to justify this tation. It is therefore recommended for consideration only in the l er and warmer sections, particularly where the conditions are fav able to the cowpea crop. It appeared feasible under the conditions Jackson. If it proves to be so it can be utilized over a large p of West Tennessee, and the soil productivity be maintained a even increased. Attention must always be paid, however, to possible soil need of phosphoric acid and potash, the former particular being deficient over large areas in the State.



5-year rotation—Limed.

5-year rotation—Unlimed.

Cowpea-wheat rotation, cowpeas turned under—Limed.

Cowpea-wheat rotation, cowpeas turned under—Unlimed.

Cowpea-wheat rotation, cowpeas removed—Limed.

Cowpea-wheat rotation, cowpeas removed—Unlimed.

Chart 19—Changes in soil nitrogen content—Knoxville

SUMMARY

EXPERIMENTS IN A COWPEA-WHEAT ROTATION KNOXVILLE DATA

POTASH

1. The plots fertilized with 50 pounds per acre of muriate potash produced, without exception, materially more cowpea than those which received no potash but were otherwise similarly treated. For the 20-year period the average annual gain attributable to the potash was 633 pounds per acre of cured hay.

2. The yield of wheat was only slightly greater on the potash-treated plots, the annual average gain per acre being 1.1 bushels grain and .14 ton of straw. These increases may be attributed more to the larger amount of cowpea hay produced on the potash-treated plots than to the direct effect of the potash salt on the wheat yield—the hay being turned under in 2 of the 3 sets.

3. Leaf mildew was pronounced on the no-potash plots, especially during the later years.

4. There was no indication that liming increased the availability of the soil potash; on the contrary there were indications of a depressive action.

5. Liming was of little effect on the cowpea crop where potash was applied, but was highly effective in the case of the wheat crop on phosphated plots.

PHOSPHATE

1. Phosphate produced little increase of the cowpea crops, the average annual increase per acre being only 87 pounds of hay.

2. The increased yield of wheat attributable to phosphate was appreciable, the annual average for the 20 years being 2 bushels of grain and 160 pounds of straw per acre.

3. The soil was not considered to be sufficiently in need of phosphoric acid to make the comparison between the different phosphates used of any special value.

FARMYARD MANURE

1. Four tons per acre of manure applied annually was highly effective in increasing both the cowpea and the wheat crops. The former were greater than any obtained elsewhere, and the latter unexcelled. Each ton of manure was calculated to be worth more than $5.50.

2. Where the manure was applied at the time of soil preparation for the cowpea crop, 520 pounds per acre more hay was produced than where the application was delayed until the preparation for the wheat crop. Under the latter condition 1.6 bushels more

of wheat and 300 pounds more of straw per acre were obtained than under the former. The data are average annual increases for a 13-year period, and clearly indicate that the most profitable returns came from the application of manure for the cowpea crop.

3. As measured by the increase of the wheat crop, only 31.6 per cent of the nitrogen applied in the manure was recovered. With the increase of the cowpea crop included, the calculated recovery was 63.4 per cent.

EFFECTS OF LIMING ON THE YIELD OF COWPEAS

1. For the 9 years immediately following the first liming, the limed sections produced each year, as an average of all plots excepting H8, more than the unlimed, the average annual increase being 318 pounds of hay per acre. The effects were much less pronounced, however, in the case of the manure plots and of those plots where the crops were turned under, than elsewhere. For the 3 years prior to reliming, the limed and unlimed areas yielded practically alike.

2. The second liming produced decidedly less effect than the first, both as to intensity and duration. The effect was practically negligible where the crops were turned under.

3. The appearance of the growing crops, the nodule development, and the nitrogen content of the hay supplemented the data on crop yield in indicating strongly that the increased yield of cowpeas on the limed areas was due primarily to an increased supply of available soil nitrogen.

EFFECTS OF LIMING ON THE YIELD OF WHEAT

1. As an average of all plots, the first liming resulted in a marked increase in yield of wheat, continuing for the first 10 years, following which were 2 years with practically equal production on the limed and unlimed areas.

2. Where the cowpea crops were turned under the second liming was followed by increased yields on the limed areas for the 3 following years, after which the limed and unlimed areas yielded practically alike. Where the cowpea crops were removed the yields continued favorable to the limed sections.

3. As was the case with the cowpea crops, the effect of liming throughout the 20-year period was more pronounced on the yields of wheat where the cowpea crops were removed, without return of manure, and where no cowpeas were grown, than elsewhere.

INFLUENCE OF THE COWPEA CROP ON THE YIELD OF WHEAT

1. The yields of wheat were not maintained under any of the experimental conditions. Even where the cowpeas were turned un-

der annually the wheat yields continued to decline slowly for first 14 years.

2. The average annual yield where the cowpea crops turned under was 8 bushels per acre greater for the 20-year pe than that from plots similarly fertilized but from which the pea crops were removed.

3. Where no cowpeas were grown and a bare fallow was tained during the summer, the yields were among the best for first 4 years and much better than were obtained under similar tilizing where the cowpea crops were removed. For the las years there was an average annual yield of .7 bushel per acre than where the cowpeas were removed and 10.1 bushels less where the cowpeas were turned under.

4. The calculated recovery of nitrogen from the cowpea c turned under was 32.5 per cent when measured by the increa yield of wheat only, and 42.5 per cent when the increased yield cowpea hay was included.

SOIL STUDIES

NITROGEN

1. The nitrogen content of the soil under all the experime conditions declined appreciably for the first 10 years, after wh there was little change. The averages of 4 plots where the cow were removed were .1236 per cent at the outset and .1042 per at the end of the first 10 years. The corresponding averages the 13 plots where the cowpeas were turned under were .1266 .1152 per cent. At the end of the second 10 years the avera were .1029 per cent where the cowpeas were removed and .1 per cent where they were turned under.

2. For a period of between 5 and 8 years after the first lim the limed areas where the cowpea crops were turned under sho an appreciably lower nitrogen content than the unlimed. A sim but more pronounced result was noticeable for at least 8 y where the cowpea crops were removed.

3. The correlation between the more rapid loss of soil nitro on the limed areas and the increased yields from the same a is striking.

4. The limings caused little or no waste of soil nitrogen, appear to have accelerated for a time losses of nearly equal m nitude which took place at a more nearly uniform rate where liming was done.

TOTAL HUMUS

1. Where the cowpea crops were turned under annually th was a loss of .11 per cent, or 2,200 pounds per acre, of total hu at the end of the 20-year period.

2. Where the cowpea crops were removed annually the loss at the end of the 20-year period was .24 per cent, or 4,800 pounds per acre.

3. The turning under of 20 crops of cowpea hay containing a total of nearly 20 tons of dry substance was calculated to have left a residue of 2,600 pounds of humus.

4. The soil of the manured plots—4 tons per acre for 20 years—showed a gain of .11 per cent of humus, or 2,200 pounds per acre.

5. The effects of liming were not marked, but where the cowpea crops were removed there was at the end of the 20 years .08 per cent, or 1,600 pounds per acre, less humus in the soil of the limed than the unlimed sections. Where the cowpea crops were turned under the limed sections show a slightly higher content by .02 per cent. The results from the limed sections of the manured plots show .12 per cent, or 2,400 pounds per acre, more humus than the unlimed.

ACTIVE OR COLLOIDAL HUMUS

1. Determinations of active, or colloidal, humus were made periodically every 2 or 3 years for the first 10 years.

2. At the end of the 10-year period there was found on the average a loss of .07 per cent of colloidal humus where the cowpea crops were removed, a loss of .05 per cent where the cowpea crops were turned under, and a gain of .03 per cent for the soil of the manured plots.

3. Liming resulted in a lower content of colloidal humus noticeable under all conditions in the earlier years, with the maximum in the neighborhood of the fifth year. At the close of the tenth year no appreciable difference remained except where the cowpea crops were removed, plots G4, G5, G8, and I4; the unlimed soil containing more colloidal humus by .06 per cent, or 1,200 pounds per acre.

JACKSON DATA

EFFECTS OF LIMING ON THE YIELD OF COWPEAS

1. The response to liming was especially marked for the first 13 years, the annual average increase for the period being 860 pounds, or 44.3 per cent, of cured hay per acre. For the next 4 years the average increase was 320 pounds of hay, or only 17.8 per cent.

2. The increases attributable to liming were of similar magnitude, both where the cowpea crops were turned under and where they were removed.

EFFECTS OF LIMING ON THE YIELD OF WHEAT

1. The limed section produced larger wheat crops under the experimental conditions. The average annual increases per were as follows:

3.5 bushels of grain and 600 pounds of straw where the cow crops were removed.

5.8 bushels of grain and 1,000 pounds of straw where the pea crops were turned under.

3.1 bushels of grain and 220 pounds of straw where no cow were grown.

INFLUENCE OF THE COWPEA CROP ON THE YIELD OF WHEAT

1. Where no cowpeas were grown the yields of wheat sh a downward trend, with an average annual yield of 15.5 bush Where the cowpea crops were removed the wheat crops were maintained, with an average annual yield of 16.8 bushels. The av age yield where the cowpeas were turned under was 22.3 bush with a tendency for the yields to increase.

2. Where the cowpea crops were removed the average pr duction of wheat for the first 8 years was .7 bushel less than wh no cowpeas were grown, but for the last 8 years it was 3.3 bush more.

GENERAL CONCLUSIONS FROM THE LIMING DATA OF T COWPEA-WHEAT EXPERIMENTS

1. The principal effect of liming, so far as the crops used the cowpea-wheat experiments are concerned, was that of a stim lant, increasing the amount of soil nitrogen available for crop u That the stimulation follows the law of diminishing returns clearly shown in the Knoxville data, and is supported by the Jo son data, for the cowpea crop.

2. Liming with burnt lime was not found to exert permanen harmful effects on the soil, and is therefore a justifiable practi as long as the crop increases are profitable.

EXPERIMENTS IN A 5-YEAR ROTATION AT KNOXVILL

1. Experiments in a 5-year rotation of corn, soybeans, whe and clover and grass, under both limed and unlimed conditio were conducted at Knoxville for the same period, 1905-1925, u under the same soil conditions, as the cowpea-wheat experimen The manuring and fertilizing were similar to those of the manu plots, F6 and G6, which showed little response to liming.

2. The majority of both the wheat and soybean crops fai to show any increase as the result of liming.

3. On the average, the yield of corn was 4 bushels per acre larger on the limed than on the unlimed section. This was attributed in large part to the greater residues of clover and grass on the limed section.

4. Alsike, red, and crimson clovers all showed marked response to liming, with no indication of decreasing effectiveness of liming throughout the period. The response of crimson clover was less than that of either of the other crops.

5. The increased supply of available nitrogen induced by liming appears to have been a minor factor in the case of the clovers, especially in the later years. Probably soil acidity was the dominant factor.

6. Soil samples were taken at 6-year intervals over the 12-year period from both the limed and unlimed sections of 15 plots. The general conclusions from the nitrogen determinations were as follows:

(1) The per cent of soil nitrogen was larger in 1913 and 1919 than in 1907.

(2) The nitrogen content of the soil was better maintained under the conditions of the 5-year rotation than where the cowpea crops were turned under every year in the cowpea-wheat rotation—the comparison being made over the same interval of time.

(3) The nitrogen contents of the limed sections were each year slightly larger than those of the unlimed.

THE COWPEA-WHEAT ROTATION

A rotation of cowpeas and wheat as carried out in the experiments is not advised for general use in Tennessee, but may be practicable under favorable soil and climatic conditions.

TABLE 16—*Annual yields of* (1) *cowpea hay and* (2) *wheat for individual plots of the cowpea-wheat experiments at Knoxville Station for the 20-year period,* 1905-1925.

Plot and fertilizer treatment	Year	Cowpea hay			Wheat				
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		
					Grain	Straw	Grain	Straw	
		COWPEA HAY REMOVED							
F6 Manure		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	
	1905- 6	(1.24)	(1.24)	1.24	(35.7)	(2.11)	(35.7)	(2.11)	
	1906- 7	0.67	0.67	0.67	30.3	2.01	30.7	1.88	
	1907- 8	1.24	1.30	1.27	23.5	1.30	22.2	1.29	
	1908- 9	1.80	1.62	1.71	24.0	1.48	23.3	1.44	
	1909-10	1.26	1.26	1.26	27.7	1.77	27.3	1.82	
	1910-11	1.89	1.69	1.79	23.7	1.33	27.0	1.63	
	1911-12	1.46	1.15	1.31	32.7	1.74	31.3	1.66	
	1912-13	0.68	1.00	0.84	33.8	2.20	29.8	2.00	
	1913-14	1.04	1.04	1.04	24.0	1.44	24.7	1.42	
	1914-15	2.16	2.36	2.26	23.3	1.18	21.7	1.03	
	1915-16	0.85	1.24	1.05	24.6	1.32	24.0	1.40	
	1916-17	2.27	2.27	2.27	26.8	0.66	25.4	0.68	
	1917-18	0.70	0.54	0.62	24.0	1.36	21.8	1.24	
	1918-19	1.36	1.22	1.29	20.0	1.88	19.7	1.09	
	1919-20	2.69	2.08	2.39	24.0	1.64	23.8	1.48	
	1920-21	1.64	1.84	1.74	26.7	1.80	28.7	1.80	
	1921-22	0.88	0.76	0.82	18.7	1.72	16.0	1.46	
	1922-23	1.10	1.10	1.10	24.0	1.44	23.3	1.38	
	1923-24	1.97	2.00	1.99	22.0	1.42	21.3	1.40	
	1924-25	0.90	0.93	0.92	32.0	0.68	32.0	0.68	
	Average	1.39	1.36	1.38	26.1	1.52	25.5	1.44	
G4 Acid phosphate	1905- 6	(1.36)	(1.36)	1.36	(31.0)	(1.73)	(31.0)	(1.73)	
	1906- 7	0.65	0.35	0.50	29.0	1.62	23.0	1.11	
	1907- 8	1.04	0.89	0.97	25.9	1.30	16.5	.87	
	1908- 9	1.44	0.95	1.19	20.7	1.31	17.4	1.01	
	1909-10	0.87	0.62	0.75	19.6	1.26	14.6	0.93	
	1910-11	1.10	1.10	1.10	17.7	0.81	10.3	0.53	
	1911-12	0.53	0.52	0.53	18.0	0.82	10.7	0.52	
	1912-13	0.32	0.32	0.32	17.8	0.96	15.2	0.76	
	1913-14	0.52	0.40	0.46	22.0	0.94	18.7	0.84	
	1914-15	1.04	0.63	0.84	12.0	0.56	10.7	0.40	
	1915-16	0.41	0.40	0.41	16.0	0.80	13.9	0.68	
	1916-17	0.66	0.69	0.68	21.3	0.32	12.8	0.30	
	1917-18	0.14	0.21	0.18	12.5	0.64	05.3	0.24	
	1918-19	0.30	0.46	0.38	09.3	0.64	12.0	0.64	
	1919-20	1.10	0.59	0.85	10.6	0.72	08.0	0.50	
	1920-21	0.32	0.38	0.35	14.0	0.70	12.0	0.60	
	1921-22	0.44	0.32	0.38	11.3	1.06	10.0	0.74	
	1922-23	0.60	0.53	0.57	10.0	0.70	08.0	0.56	
	1923-24	0.74	0.62	0.68	10.7	0.56	08.0	0.56	
	1924-25	0.32	0.34	0.33	15.3	0.38	07.7	0.29	
	Average	.70	.58	.64	17.2	.89	13.3	.69	
G5 Acid phosphate and muriate of potash	1905- 6	(1.52)	(1.52)	1.52	(30.5)	(1.57)	(30.5)	(1.57)	
	1906- 7	0.80	0.39	0.60	24.7	1.30	20.3	1.30	
	1907- 8	1.25	0.91	1.08	21.9	1.30	16.6	0.87	
	1908- 9	1.42	1.25	1.34	18.1	1.11	17.6	0.98	
	1909-10	1.48	1.17	1.32	21.7	1.15	14.3	0.97	
	1910-11	1.66	1.43	1.55	18.0	0.90	15.0	0.79	
	1911-12	1.05	0.81	0.93	19.0	0.87	17.3	0.80	
	1912-13	0.60	0.52	0.56	17.8	0.80	16.0	0.80	
	1913-14	0.92	0.76	0.84	17.3	0.92	17.3	0.92	
	1914-15	1.80	1.32	1.56	12.4	0.55	11.7	0.57	
	1915-16	0.88	0.80	0.84	15.7	0.68	15.7	0.72	
	1916-17	1.07	1.12	1.09	17.0	0.47	15.1	0.45	
	1917-18	0.38	0.40	0.39	15.4	0.83	06.9	0.43	
	1918-19	0.70	0.78	0.74	10.4	0.62	10.1	0.63	
	1919-20	1.84	1.07	1.46	12.4	0.76	12.2	0.64	
	1920-21	1.01	1.04	1.03	15.7	0.90	14.4	1.00	
	1921-22	0.80	0.48	0.64	11.7	0.78	11.1	0.88	
	1922-23	0.96	0.77	0.87	11.1	0.72	09.7	0.72	
	1923-24	1.26	0.88	1.07	12.3	0.68	11.0	0.66	
	1924-25	0.58	0.39	0.49	14.6	0.42	11.9	0.34	
	Average	1.10	0.89	1.00	16.9	0.87	14.7	0.81	

TABLE 16 (*Continued*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat					
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed and unlimed	
					Grain	Straw	Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
G6 Manure, acid phosphate and muriate of potash	1905- 6	(1.45)	(1.45)	1.45	(38.3)	(1.89)	(38.3)	(1.89)	38.3	1.89
	1906- 7	0.67	0.67	0.67	27.7	1.69	32.3	1.87	30.0	1.78
	1907- 8	1.57	1.43	1.50	24.5	1.30	21.5	1.16	23.0	1.23
	1908- 9	1.75	1.60	1.67	23.0	1.47	21.7	1.27	22.9	1.37
	1909-10	1.69	1.48	1.59	27.3	1.80	26.0	1.80	26.7	1.80
	1910-11	1.47	1.47	1.47	25.0	1.33	21.3	1.06	23.2	1.20
	1911-12	0.94	0.83	0.89	35.3	1.82	30.7	1.76	33.0	1.79
	1912-13	1.20	1.04	1.12	31.2	1.40	25.8	1.60	28.5	1.50
	1913-14	0.92	0.88	0.90	25.3	1.28	22.7	1.32	24.0	1.30
	1914-15	1.81	1.75	1.78	23.3	1.10	24.0	1.12	23.7	1.11
	1915-16	0.92	1.28	1.10	22.6	1.32	21.3	1.24	22.0	1.28
	1916-17	1.76	1.80	1.78	29.9	0.74	27.9	0.72	28.9	0.73
	1917-18	1.34	1.02	1.18	25.3	1.08	19.3	1.04	22.3	1.06
	1918-19	0.93	0.96	0.95	23.0	1.43	21.3	2.00	22.2	1.72
	1919-20	2.59	2.26	2.43	19.8	1.02	17.2	1.00	18.5	1.01
	1920-21	1.64	1.84	1.74	26.7	1.50	24.7	1.40	25.7	1.45
	1921-22	1.08	1.06	1.07	16.7	1.34	16.7	1.22	16.7	1.28
	1922-23	1.26	1.21	1.24	21.3	1.36	18.0	1.18	19.7	1.27
	1923-24	1.86	1.58	1.72	21.3	1.28	20.0	1.28	20.7	1.28
	1924-25	0.74	0.72	0.73	33.3	0.76	28.3	0.71	30.8	0.74
	Average	1.33	1.32	1.35	26.1	1.35	24.0	1.33	25.0	1.34
G8 Rock phosphate and muriate of potash	1905- 6	(1.28)	(1.28)	1.28	(28.3)	(1.39)	(28.3)	(1.39)	28.3	1.39
	1906- 7	0.71	0.51	0.61	21.3	1.20	22.0	1.30	21.7	1.25
	1907- 8	0.88	0.96	0.92	20.5	0.79	16.2	0.87	18.4	0.83
	1908- 9	1.09	1.22	1.16	15.7	0.97	16.0	0.96	15.9	0.97
	1909-10	1.47	1.26	1.36	18.0	1.02	16.7	0.90	17.4	0.96
	1910-11	1.28	1.06	1.17	14.7	0.68	13.3	0.64	14.0	0.66
	1911-12	0.70	0.54	0.62	16.0	0.72	19.3	0.90	17.7	0.81
	1912-13	0.60	0.64	0.62	15.2	0.72	17.2	0.76	16.2	0.74
	1913-14	0.70	0.68	0.69	16.7	0.86	14.7	0.84	15.7	0.85
	1914-15	1.35	1.05	1.20	18.0	0.62	13.3	0.60	15.7	0.61
	1915-16	0.88	0.77	0.83	13.3	0.72	13.3	0.72	13.3	0.72
	1916-17	1.48	1.22	1.35	17.3	0.48	17.3	0.48	17.3	0.48
	1917-18	0.52	0.50	0.51	17.8	0.76	12.5	0.56	15.2	0.66
	1918-19	0.63	0.82	0.73	12.0	0.72	13.7	0.87	12.9	0.80
	1919-20	2.19	1.43	1.81	13.2	0.72	11.8	0.70	12.5	0.71
	1920-21	1.29	1.44	1.37	16.7	1.00	18.0	1.10	17.4	1.05
	1921-22	0.68	0.64	0.66	10.7	0.72	10.7	0.72	10.7	0.72
	1922-23	1.01	0.85	0.93	11.3	0.70	09.3	0.60	10.3	0.65
	1923-24	1.36	1.01	1.19	10.0	0.56	10.7	0.52	10.4	0.54
	1924-25	0.56	0.44	0.50	14.7	0.36	11.3	0.36	13.0	0.36
	Average	1.04	0.92	0.98	16.1	0.79	15.3	0.79	15.7	0.79
I4 None	1905- 6	(1.15)	(1.15)	1.15	(25.9)	(1.32)	(25.9)	(1.32)	25.9	1.32
	1906- 7	0.63	0.42	0.53	25.3	1.36	20.3	1.15	22.8	1.26
	1907- 8	0.75	0.68	0.72	19.9	1.00	15.5	0.90	17.7	0.95
	1908- 9	1.20	0.90	1.05	17.7	0.96	16.3	0.92	17.0	0.94
	1909-10	1.04	0.77	0.90	17.3	1.00	09.3	0.68	13.3	0.84
	1910-11	0.97	0.90	0.94	13.0	0.59	08.0	0.44	10.5	0.52
	1911-12	0.54	0.42	0.48	12.7	0.62	08.0	0.48	10.4	0.55
	1912-13	0.36	0.32	0.34	12.9	0.60	10.1	0.65	11.5	0.63
	1913-14	0.40	0.32	0.36	15.6	0.78	15.0	0.76	15.3	0.77
	1914-15	0.79	0.51	0.65	09.1	0.41	07.1	0.39	08.1	0.40
	1915-16	0.36	0.39	0.38	11.7	0.58	13.7	0.66	12.7	0.62
	1916-17	0.73	0.57	0.65	10.7	0.35	09.1	0.31	09.9	0.33
	1917-18	0.17	0.22	0.20	10.1	0.55	04.8	0.23	07.5	0.39
	1918-19	0.26	0.35	0.31	09.4	0.33	05.7	0.44	07.6	0.39
	1919-20	0.96	1.11	1.04	10.4	0.70	07.6	0.50	09.0	0.60
	1920-21	0.24	0.40	0.32	11.7	0.60	09.1	0.50	10.4	0.55
	1921-22	0.12	0.28	0.20	09.7	0.60	07.7	0.58	08.7	0.59
	1922-23	0.51	0.50	0.51	08.4	0.56	05.7	0.44	07.1	0.50
	1923-24	0.52	0.48	0.50	08.3	0.48	05.6	0.32	07.0	0.40
	1924-25	0.27	0.32	0.30	11.3	0.32	03.0	0.28	07.2	0.30
	Average	0.60	0.55	0.58	13.6	0.69	10.4	0.60	12.0	0.64

TABLE 16 (*Continued*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat				
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		
					Grain	Straw	Grain	Straw	C
		COWPEA HAY TURNED UNDER							
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	
F4 Acid phosphate	1905- 6	(1.23)	(1.23)	1.23	(34.5)	(2.01)	(34.5)	(2.01)	
	1906- 7	0.59	0.41	0.50	34.0	2.18	25.0	1.12	
	1907- 8	1.13	1.11	1.12	30.5	1.53	21.2	1.08	
	1908- 9	1.45	1.19	1.32	28.4	1.88	22.3	1.34	
	1909-10	1.27	1.17	1.22	31.0	2.00	24.6	1.55	
	1910-11	1.39	1.33	1.36	27.7	1.61	24.0	1.28	
	1911-12	0.83	0.77	0.80	30.7	1.40	25.7	1.19	
	1912-13	0.44	0.60	0.52	25.8	1.20	20.6	1.20	
	1913-14	0.70	0.60	0.65	25.3	1.36	24.0	1.36	
	1914-15	1.82	1.42	1.62	22.0	0.98	19.3	0.94	
	1915-16	0.72	0.77	0.75	20.0	1.00	20.6	1.08	
	1916-17	0.99	1.04	1.02	17.3	0.48	20.7	0.50	
	1917-18	0.34	0.49	0.42	22.6	0.92	15.1	0.74	
	1918-19	0.44	0.51	0.48	15.7	1.01	13.0	0.77	
	1919-20	1.11	1.02	1.07	18.4	1.18	14.6	0.86	
	1920-21	0.76	0.68	0.72	23.3	1.20	21.2	1.30	
	1921-22	0.64	0.48	0.56	16.0	1.20	13.3	1.08	
	1922-23	0.71	0.79	0.75	17.3	1.04	14.0	1.02	
	1923-24	0.96	0.80	0.88	16.7	0.98	15.3	0.82	
	1924-25	0.51	0.43	0.47	20.3	0.55	16.3	0.49	
	Average	0.90	0.84	0.87	23.9	1.29	20.3	1.08	
F5 Acid phosphate and muriate of potash	1905- 6	(1.43)	(1.43)	1.43	(36.7)	(1.99)	(36.7)	(1.99)	
	1906- 7	0.64	0.47	0.56	30.1	1.86	27.8	1.65	
	1907- 8	1.08	0.88	0.98	27.5	1.37	22.2	1.13	
	1908- 9	1.66	1.37	1.52	27.1	1.72	25.3	1.57	
	1909-10	1.68	1.25	1.46	28.7	1.98	26.3	1.67	
	1910-11	1.84	1.57	1.71	26.3	1.65	27.7	1.63	
	1911-12	0.82	0.78	0.80	31.7	1.61	30.7	1.56	
	1912-13	0.96	0.60	0.78	27.5	1.58	26.9	1.64	
	1913-14	0.96	0.88	0.92	28.3	1.52	25.0	1.58	
	1914-15	1.95	1.78	1.87	23.1	1.15	25.1	1.21	
	1915-16	0.84	1.08	0.96	21.1	1.10	21.8	1.18	
	1916-17	1.42	1.75	1.59	19.2	0.61	21.7	0.90	
	1917-18	0.72	0.62	0.67	24.3	1.31	15.4	0.95	
	1918-19	0.71	1.02	0.87	20.7	1.43	18.7	1.01	
	1919-20	1.77	1.53	1.65	22.6	1.04	21.6	1.18	
	1920-21	1.18	1.30	1.24	27.1	1.60	27.9	1.60	
	1921-22	0.76	0.58	0.67	16.4	1.40	16.4	1.32	
	1922-23	0.99	0.88	0.94	17.1	1.22	21.7	1.40	
	1923-24	1.32	1.14	1.23	15.6	1.06	17.0	1.06	
	1924-25	0.57	0.61	0.59	22.4	0.55	22.7	0.54	
	Average.	1.17	1.08	1.12	24.7	1.39	23.9	1.34	
F8 Rock phosphate and muriate of potash	1905- 6	(1.42)	(1.42)	1.42	(34.8)	(2.30)	(34.8)	(2.30)	
	1906- 7	0.70	0.67	0.69	32.0	2.76	34.0	2.72	
	1907- 8	0.92	1.16	1.04	30.5	1.73	27.9	1.72	
	1908- 9	1.43	1.62	1.53	27.3	1.78	28.0	1.83	
	1909-10	1.50	1.51	1.51	27.7	1.87	28.3	1.83	
	1910-11	1.33	1.36	1.35	32.0	1.64	25.7	1.59	
	1911-12	0.54	0.60	0.57	32.0	1.72	32.0	1.84	
	1912-13	0.76	0.52	0.64	32.0	1.84	28.6	1.84	
	1913-14	0.64	0.72	0.68	25.3	1.40	25.3	1.44	
	1914-15	1.27	1.18	1.23	24.0	1.36	21.3	1.04	
	1915-16	0.88	0.88	0.88	23.2	1.36	21.9	1.28	
	1916-17	1.87	1.91	1.89	21.3	0.56	32.6	1.02	
	1917-18	0.59	0.67	0.63	27.1	1.64	22.6	1.32	
	1918-19	0.74	1.01	0.88	25.7	1.63	25.7	1.63	
	1919-20	2.06	1.34	1.70	25.2	1.64	22.6	1.52	
	1920-21	1.29	1.44	1.37	25.7	1.90	25.7	2.30	
	1921-22	0.76	0.76	0.76	18.0	1.46	16.0	1.48	
	1922-23	0.85	0.90	0.88	23.3	1.50	24.0	1.72	
	1923-24	1.45	1.54	1.50	21.3	1.20	20.0	1.24	
	1924-25	0.64	0.70	0.67	31.0	0.71	30.3	0.69	
	Average	1.08	1.10	1.09	27.0	1.60	26.4	1.62	

TABLE 16 (*Continued*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat					
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed and unlimed	
					Grain	Straw	Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
H4 No fertilizer	1905- 6	(1.21)	(1.21)	1.21	(34.6)	(2.08)	(34.6)	(2.08)	34.6	2.08
	1906- 7	0.53	0.50	0.52	31.8	1.95	28.1	1.62	30.0	1.79
	1907- 8	0.86	0.89	0.88	25.5	1.32	22.9	1.15	24.2	1.24
	1908- 9	1.48	1.50	1.49	24.6	1.67	21.6	1.40	23.1	1.54
	1909-10	1.13	1.09	1.11	21.3	1.54	21.7	1.51	21.5	1.53
	1910-11	1.20	1.23	1.22	26.7	1.44	23.0	1.23	24.9	1.34
	1911-12	0.66	0.76	0.71	25.3	1.24	26.7	1.12	26.0	1.18
	1912-13	0.52	0.40	0.46	20.3	1.08	22.1	1.24	21.2	1.16
	1913-14	0.48	0.52	0.50	23.0	1.16	23.6	1.18	23.3	1.17
	1914-15	1.03	1.03	1.03	17.1	0.85	18.4	0.85	17.8	0.85
	1915-16	0.60	0.77	0.69	20.5	0.90	21.8	1.06	21.2	0.98
	1916-17	1.06	1.12	1.09	14.5	0.47	18.3	0.47	16.4	0.47
	1917-18	0.26	0.40	0.33	16.3	0.91	10.8	0.67	13.6	0.79
	1918-19	0.37	0.61	0.49	11.7	0.82	13.4	0.93	12.6	0.88
	1919-20	0.96	1.32	1.14	15.0	0.84	18.8	1.10	16.9	0.97
	1920-21	0.37	0.68	0.53	17.7	1.00	21.7	1.30	19.7	1.15
	1921-22	0.52	0.52	0.52	13.1	1.02	11.7	1.10	12.4	1.06
	1922-23	0.56	0.79	0.68	15.1	1.36	15.1	1.04	15.1	1.23
	1923-24	0.64	0.90	0.77	15.0	0.84	17.0	0.90	16.5	0.87
	1924-25	0.32	0.40	0.36	16.9	0.45	13.3	0.46	15.1	0.46
	Average	0.74	0.83	0.79	20.3	1.15	20.2	1.12	20.3	1.14
H6 Bone meal and muriate of potash	1905- 6	(1.27)	(1.27)	1.27	(34.0)	(1.99)	(34.0)	(1.99)	34.0	1.99
	1906- 7	0.59	0.48	.53	28.0	1.88	28.3	1.67	28.2	1.78
	1907- 8	1.19	0.86	1.03	27.7	1.35	21.3	1.33	24.5	1.34
	1908- 9	1.55	1.01	1.28	25.3	1.68	25.7	1.67	25.5	1.68
	1909-10	1.64	1.17	1.40	30.0	2.02	21.3	1.48	25.7	1.75
	1910-11	1.59	1.10	1.35	26.7	1.40	24.7	1.24	25.7	1.32
	1911-12	0.82	0.70	0.76	29.3	1.68	26.7	1.60	28.0	1.64
	1912-13	0.84	0.36	0.60	31.2	1.76	25.8	1.36	28.5	1.56
	1913-14	1.00	0.80	0.90	25.3	1.30	23.3	1.34	24.3	1.32
	1914-15	1.92	1.02	1.47	24.7	1.38	21.3	1.08	23.0	1.23
	1915-16	0.88	0.80	0.84	24.0	1.28	23.2	1.16	23.6	1.22
	1916-17	1.67	1.39	1.53	24.1	0.56	21.3	0.56	22.7	0.56
	1917-18	0.80	0.54	0.67	24.0	1.28	12.0	0.84	18.0	1.06
	1918-19	0.69	0.93	0.81	20.0	1.48	20.7	1.46	20.4	1.47
	1919-20	1.73	1.40	1.57	22.6	1.16	17.2	0.92	19.9	1.04
	1920-21	1.32	1.34	1.33	34.0	2.40	24.0	1.50	29.0	1.95
	1921-22	0.72	0.60	0.66	17.3	1.48	13.3	1.20	15.3	1.34
	1922-23	1.01	0.79	0.90	20.0	1.44	18.0	1.30	19.0	1.37
	1923-24	1.34	1.00	1.17	20.0	1.20	16.0	1.20	17.0	1.20
	1924-25	0.65	0.62	0.64	30.0	0.62	16.7	0.42	23.4	0.52
	Average	1.16	0.91	1.04	25.9	1.46	21.7	1.27	23.8	1.37
H8 Acid phosphate and muriate of potash	1905	(1.24)	(1.24)	1.24						
	1906	0.59	0.58	0.58						
	1907	1.16	1.13	1.15						
	1908	1.77	1.98	1.88						
	1909	1.51	1.45	1.48						
	1910	1.90	1.93	1.92						
	1911	1.44	1.33	1.39						
	1912	0.92	0.92	0.92						
	1913	1.00	0.92	0.96						
	1914	1.92	2.15	2.04						
	1915	1.02	1.20	1.11						
	1916	1.60	1.61	1.61	(No wheat grown)					
	1917	0.87	0.88	0.88						
	1918	0.97	1.34	1.16						
	1919	1.70	1.19	1.45						
	1920	1.61	1.51	1.56						
	1921	0.92	1.00	0.96						
	1922	0.85	0.82	0.84						
	1923	1.20	0.98	1.09						
	1924	0.65	0.73	0.74						
	Average	1.24	1.24	1.24						

TABLE 16 (*Continued*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat			
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed	
					Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons
	1905- 6	(1.62)	(1.62)	1.62	(41.3)	(2.87)	(41.3)	(2.87)
	1906- 7	0.84	0.55	0.70	34.3	1.96	26.7	1.56
	1907- 8	1.33	0.91	1.12	27.9	1.69	27.0	1.40
	1908- 9	1.48	1.39	1.43	27.7	1.82	25.7	1.64
	1909-10	1.68	1.66	1.67	28.0	2.04	25.7	1.39
	1910-11	1.76	1.54	1.65	27.7	1.57	26.3	1.43
	1911-12	0.95	0.90	0.93	30.3	1.49	26.0	1.46
	1912-13	0.92	0.56	0.74	29.2	1.28	24.6	1.58
	1913-14	0.76	0.72	0.74	26.7	1.44	25.3	1.40
I5	1914-15	1.61	1.37	1.49	25.3	1.16	20.7	1.02
Acid phosphate	1915-16	0.92	0.96	0.94	21.9	1.08	21.3	1.12
and muriate	1916-17	1.40	1.57	1.49	42.8	0.68	40.0	0.64
of potash	1917-18	0.76	0.58	0.67	24.5	1.40	12.0	0.84
	1918-19	0.69	0.92	0.81	17.7	1.37	17.3	1.32
	1919-20	2.52	2.21	2.37	21.2	1.18	17.2	1.00
	1920-21	1.13	1.32	1.23	26.0	1.70	23.3	1.40
	1921-22	0.80	0.60	0.70	14.0	1.22	14.0	1.22
	1922-23	0.84	0.77	0.80	16.0	1.32	17.3	1.28
	1923-24	1.20	1.09	1.15	18.0	1.14	16.7	1.06
	1924-25	0.56	0.60	0.58	24.7	0.62	16.0	0.52
	Average	1.19	1.09	1.14	26.3	1.45	23.2	1.31
	1905- 6	(1.44)	(1.44)	1.44	(33.3)	(1.99)	(33.3)	(1.99)
	1906- 7	0.65	0.51	0.58	30.3	1.89	30.0	1.81
	1907- 8	0.92	0.75	0.84	28.0	1.56	23.2	1.30
	1908- 9	1.48	0.96	1.22	25.0	1.65	25.3	1.64
	1909-10	1.75	1.62	1.68	32.3	2.25	22.7	1.42
	1910-11	1.84	1.25	1.55	29.3	1.60	24.7	1.26
	1911-12	0.87	0.63	0.75	31.3	1.78	23.3	1.30
	1912-13	0.80	0.32	0.56	32.6	1.80	25.8	1.36
	1913-14	0.80	0.68	0.74	28.0	1.36	25.3	1.28
	1914-15	1.62	1.17	1.40	23.3	1.10	24.0	1.12
I6	1915-16	0.84	0.80	0.82	23.2	1.28	21.3	1.16
Thomas slag	1916-17	1.66	1.46	1.50	26.7	0.72	22.8	0.56
and muriate	1917-18	0.64	0.56	0.60	25.5	1.40	15.1	0.76
of potash	1918-19	0.65	0.85	0.75	18.3	1.33	17.3	1.44
	1919-20	1.95	1.72	1.84	23.8	1.38	20.0	1.10
	1920-21	1.15	1.20	1.18	24.7	2.30	24.7	1.50
	1921-22	0.72	0.64	0.68	15.3	1.30	13.3	1.12
	1922-23	0.93	0.73	0.83	22.7	1.60	19.3	1.30
	1923-24	1.44	1.14	1.29	18.0	1.18	19.3	1.02
	1924-25	0.63	0.60	0.62	27.3	0.68	22.0	0.58
	Average	1.14	0.95	1.05	25.9	1.51	22.6	1.25
	1905- 6	(1.23)	(1.23)	1.23	(28.2)	(1.66)	(28.2)	(1.66)
	1906- 7	0.64	0.53	0.59	34.3	2.05	29.3	1.76
	1907- 8	1.03	0.91	0.97	24.5	1.39	21.9	1.26
	1908- 9	1.44	1.39	1.42	25.0	1.65	23.3	1.50
	1909-10	1.60	1.44	1.52	27.3	1.74	25.0	1.63
	1910-11	1.58	1.59	1.59	25.0	1.55	23.0	1.35
	1911-12	0.93	0.84	0.89	30.0	1.74	28.0	1.80
	1912-13	0.72	0.40	0.56	26.6	1.56	25.8	1.44
	1913-14	0.84	0.80	0.82	21.3	1.16	20.7	1.08
	1914-15	1.36	1.15	1.26	24.7	1.26	14.0	1.10
I8	1915-16	0.77	0.76	0.77	19.2	1.04	17.9	1.00
Rock phosphate	1916-17	1.64	1.26	1.45	25.4	0.64	22.8	0.70
and muriate	1917-18	0.80	0.56	0.68	20.5	1.80	13.5	0.88
of potash	1918-19	0.76	0.88	0.82	17.3	1.28	23.0	1.43
	1919-20	1.80	1.66	1.73	22.2	1.38	21.2	1.18
	1920-21	1.58	1.30	1.44	28.0	1.90	28.7	1.90
	1921-22	0.44	0.64	0.54	15.3	1.42	14.7	1.28
	1922-23	0.95	0.78	0.87	18.7	1.74	15.3	1.30
	1923-24	1.52	1.18	1.35	18.7	1.20	16.0	1.04
	1924-25	0.58	0.52	0.55	24.7	0.70	20.7	0.50
	Average	1.11	.99	1.05	23.8	1.44	21.7	1.29

TABLE 16 (*Continued*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat					
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Average of limed and unlimed	
					Grain	Straw	Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
J4 Bone meal and muriate of potash	1905- 6	(1.48)	(1.48)	1.48	(31.4)	(3.12)	(31.4)	(3.12)	31.4	3.12
	1906- 7	0.96	0.89	0.93	37.3	2.72	30.3	1.97	33.8	2.35
	1907- 8	1.40	1.24	1.32	27.0	1.69	28.0	1.64	27.5	1.67
	1908- 9	1.59	1.43	1.51	28.4	2.00	25.4	1.77	26.9	1.89
	1909-10	1.76	1.64	1.70	31.0	2.15	27.3	1.92	29.2	2.04
	1910-11	1.65	1.56	1.61	26.3	1.69	24.7	1.46	25.5	1.58
	1911-12	0.99	0.92	0.96	29.3	1.48	29.3	1.52	29.3	1.50
	1912-13	0.76	0.48	0.62	24.0	1.36	25.8	1.32	24.9	1.34
	1913-14	0.60	0.64	0.62	22.0	1.26	23.3	1.26	22.7	1.26
	1914-15	1.57	1.29	1.43	23.3	1.22	20.7	1.04	22.0	1.13
	1915-16	0.72	0.88	0.80	18.6	0.96	20.0	1.08	19.3	1.02
	1916-17	1.23	1.26	1.25	16.0	0.56	18.8	0.64	17.4	0.60
	1917-18	0.54	0.62	0.58	22.6	1.12	13.8	0.84	18.2	0.98
	1918-19	0.55	0.70	0.63	17.0	0.93	18.3	1.13	17.7	1.03
	1919-20	1.51	1.18	1.35	19.8	1.38	15.8	0.92	17.8	1.15
	1920-21	1.20	1.13	1.17	25.3	1.60	24.0	1.40	24.7	1.50
	1921-22	0.92	0.68	0.80	14.0	0.94	14.7	1.16	14.4	1.27
	1922-23	0.91	0.96	0.94	10.7	0.96	15.3	1.18	13.0	1.07
	1923-24	1.05	0.92	0.99	.....	.....	05.3	0.24	.....	.....
	1924-25	0.61	0.64	0.63	18.0	0.50	17.3	0.40	17.7	0.45
	Average	1.10	1.03	1.07	23.3	1.45	21.5	1.30	22.8	1.42
J5 Rock phosphate and muriate of potash	1905- 6	(1.40)	(1.40)	1.40	(32.9)	(2.13)	(32.9)	(2.13)	32.9	2.13
	1906- 7	0.75	0.53	0.64	33.4	1.60	28.4	1.75	30.9	1.68
	1907- 8	1.07	1.00	1.04	27.5	1.42	24.5	1.31	26.0	1.37
	1908- 9	1.49	1.13	1.31	24.7	1.73	26.0	1.71	25.2	1.72
	1909-10	1.87	1.49	1.68	30.3	2.15	23.0	1.92	26.7	2.04
	1910-11	1.68	1.62	1.65	27.0	1.63	25.3	1.32	26.2	1.48
	1911-12	0.93	0.87	0.90	28.7	1.66	22.7	1.52	25.7	1.59
	1912-13	0.72	0.52	0.62	30.2	1.61	26.3	1.40	28.3	1.51
	1913-14	0.64	0.70	0.67	24.7	1.34	22.7	1.24	23.7	1.29
	1914-15	1.60	1.29	1.45	22.7	1.12	20.7	1.06	21.7	1.09
	1915-16	0.84	0.96	0.90	20.6	1.16	21.9	1.16	21.3	1.16
	1916-17	1.38	1.53	1.46	25.4	0.60	22.8	0.68	24.1	0.64
	1917-18	0.76	0.60	0.68	24.5	1.45	13.5	0.88	19.0	1.17
	1918-19	0.60	0.95	0.78	18.7	1.32	20.0	1.48	19.4	1.40
	1919-20	1.79	1.46	1.63	22.6	1.32	18.6	1.12	20.6	1.22
	1920-21	1.11	1.26	1.19	29.3	1.80	26.7	1.60	28.0	1.70
	1921-22	0.76	0.60	0.68	16.7	1.34	15.3	1.26	16.0	1.30
	1922-23	0.94	0.92	0.93	21.3	1.44	20.0	1.40	20.7	1.42
	1923-24	1.35	1.20	1.28	.....	.....	18.0	1.14	.....	.....
	1924-25	0.70	0.67	0.69	28.3	0.63	23.0	0.51	25.7	0.56
	Average	1.12	1.04	1.08	25.2	1.44	22.6	1.33	24.3	1.39
J6 Thomas slag and muriate of potash	1905- 6	(1.54)	(1.54)	1.54	(38.9)	(3.03)	(38.9)	(3.03)	38.9	3.03
	1906- 7	0.73	0.78	0.76	32.7	2.38	34.7	2.44	33.7	2.41
	1907- 8	1.26	1.32	1.29	30.7	1.64	29.5	1.64	30.1	1.64
	1908- 9	1.59	1.61	1.60	28.0	2.16	29.0	1.97	28.5	2.07
	1909-10	1.71	1.68	1.69	30.0	2.10	27.3	1.98	28.7	2.04
	1910-11	1.71	1.18	1.45	29.0	1.57	26.7	1.40	27.9	1.49
	1911-12	0.97	0.79	0.88	27.3	1.90	26.0	1.54	26.7	1.72
	1912-13	0.68	0.36	0.52	31.2	1.80	22.6	1.40	26.9	1.60
	1913-14	0.60	0.60	0.60	23.3	1.26	21.3	1.16	22.3	1.21
	1914-15	1.27	1.12	1.20	23.3	0.94	20.7	0.98	22.0	0.96
	1915-16	0.84	0.84	0.84	21.3	1.16	17.9	1.04	19.6	1.10
	1916-17	1.35	1.48	1.42	21.3	0.60	20.1	0.56	20.7	0.58
	1917-18	0.54	0.50	0.52	18.6	0.92	10.6	0.72	14.6	0.82
	1918-19	0.56	0.85	0.71	21.3	1.24	16.0	1.36	18.7	1.30
	1919-20	1.60	1.01	1.31	22.6	1.48	17.2	1.00	19.9	1.24
	1920-21	1.00	0.99	1.00	24.7	2.00	20.7	1.40	22.7	1.70
	1921-22	0.72	0.72	0.72	14.0	1.30	11.3	1.12	12.7	1.21
	1922 23	0.81	0.80	0.81	19.3	1.38	17.3	1.28	18.3	1.33
	1923-24	1.30	1.04	1.17	18.0	1.30	14.7	0.84	16.4	1.07
	1924-25	0.52	0.53	0.53	21.7	0.63	14.7	0.52	18.2	0.58
	Average	1.07	0.99	1.03	24.9	1.54	21.9	1.37	23.4	1.46

TABLE 16 (*Concluded*)

Plot and fertilizer treatment	Year	Cowpea hay			Wheat				
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		Av.
					Grain	Straw	Grain	Straw	Gr.
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.
	1905- 6	(1.28)	(1.28)	1.28	(27.8)	(1.77)	(27.8)	(1.77)	27.
	1906- 7	0.73	0.59	0.66	30.0	1.98	26.7	2.00	28.
	1907- 8	1.01	0.94	0.98	23.5	1.42	19.2	1.34	21.
	1908- 9	1.45	1.24	1.35	24.0	1.60	21.7	1.35	22.
	1909-10	1.71	1.76	1.73	27.7	2.01	24.0	1.68	25.
	1910-11	1.52	1.55	1.54	23.0	1.31	20.3	1.11	21.
	1911-12	0.84	0.85	0.85	22.7	1.24	21.7	1.39	22.
	1912-13	0.80	0.44	0.62	21.2	1.36	20.6	1.32	20.
	1913-14	0.64	0.65	0.65	21.3	1.20	18.7	1.04	20.
	1914-15	1.45	1.27	1.36	22.0	1.06	13.3	0.84	17.
	1915-16	1.00	1.00	1.00	18.6	0.72	17.9	1.08	18.
	1916-17	1.73	1.65	1.69	22.0	0.64	20.7	0.66	21.
	1917-18	0.58	0.70	0.64	20.0	1.24	09.3	0.76	14.
	1918-19	0.80	0.95	0.88	14.3	1.09	17.3	1.72	15.
J8 Muriate of potash	1919-20	1.76	2.08	1.92	21.2	1.36	19.8	1.40	20.
	1920-21	1.48	1.52	1.50	23.3	1.70	27.3	2.30	25.
	1921-22	1.06	0.76	0.91	14.7	1.42	12.7	1.28	13.
	1922-23	0.94	1.07	1.01	19.3	1.58	19.3	1.50	19.
	1923-24	1.32	1.42	1.37	17.3	1.08	18.7	1.08	18.
	1924-25	0.51	0.64	0.58	25.0	0.61	22.0	0.58	24.
	Average	1.13	1.12	1.13	21.9	1.32	20.0	1.31	21.
		NO COWPEAS GROWN							
	1906	.....	.....	.....	(34.6)	(1.38)	(34.6)	(1.38)	34.
	1907	.....	.....	.....	34.3	2.37	30.7	2.52	32.
	1908	.....	.....	.....	25.9	1.38	24.5	1.31	25.
	1909	.....	.....	.....	24.3	1.84	21.3	1.45	22.
	1910	.....	.....	.....	19.7	1.17	15.0	1.23	17.
	1911	.....	.....	.....	17.0	0.93	12.7	0.78	14.
	1912	.....	.....	.....	23.0	1.11	19.3	1.06	21.
	1913	.....	.....	.....	19.2	1.12	16.6	0.92	17.
	1914	.....	.....	.....	24.7	1.14	20.0	1.30	22.
	1915	.....	.....	.....	11.3	0.54	10.7	0.40	11.
H5 Acid phosphate and muriate of potash	1916	.....	.....	.....	18.6	1.00	16.0	0.80	17.
	1917	.....	.....	.....	13.4	0.40	11.3	0.34	12.
	1918	.....	.....	.....	16.0	0.72	05.5	0.32	16.
	1919	.....	.....	.....	14.0	0.94	09.3	0.88	11.
	1920	.....	.....	.....	17.2	1.12	12.0	0.85	14.
	1921	.....	.....	.....	10.7	0.60	10.7	0.60	10.
	1922	.....	.....	.....	12.7	0.98	10.0	0.78	11.
	1923	.....	.....	.....	10.7	0.82	08.7	0.66	09.
	1924	.....	.....	.....	10.0	0.82	09.3	0.60	09.
	1925	.....	.....	.....	16.3	0.43	12.0	0.36	14.
	Average	.....	.....	.....	18.7	1.04	15.5	0.93	17.

Average annual equivalents of fertilizer materials applied in the 20-year p... 1905-1925, calculated to acre basis:

Plots F4 and G4: ..... 150 lbs. acid phosphate (16 per cent available P...

Plots F5, G5, H8 and I5: ..... { 150 lbs. acid phosphate; 50 lbs. muriate of potash (50 per cent K_2O)

Plot F6: ..... 4 tons farmyard manure

Plot G6: ..... { 4 tons farmyard manure; 50 lbs. acid phosphate; 12½ lbs. muriate of potash

Plots F8, G8, I8 and J4: ..... { 285 lbs. rock phosphate (29.5 per cent total P_2O_5); 50 lbs. muriate of potash

Plots H4 and I4: ..... None

Plots H6 and J4: ..... { 100 lbs. bone meal (25.4 per cent total P_2O_5); 50 lbs. muriate of potash

Plots I6 and J6: ..... { 140 lbs. Thomas slag meal (18 per cent total P...; 50 lbs. muriate of potash

Plot J8: ..... 50 lbs. muriate of potash

TABLE 17—*Nitrogen content of both the limed and unlimed soil of the individual plots where the cowpea crops were* (1) *removed and* (2) *turned under annually—Knoxville experiments.*

(All samples taken to a depth of 8 inches. Results on m. f. basis of the fine earth of less than ½ mm.)

Plot	Year	Nitrogen content			Plot	Year	Nitrogen content		
		Limed	Unlimed	Average			Limed	Unlimed	Average
COWPEAS REMOVED									
G4		Per cent	Per cent	Per cent	G5		Per cent	Per cent	Per cent
	1905	*(.1314)	(.1314)	.1314		1905	(.1300)	(.1300)	.1300
	1907	.1254	.1198	.1226		1907	.1172	.1269	.1221
	1910	.1191	.1191	.1191		1910	.1153	.1209	.1181
	1913	.1130	.1085	.1108		1913	.1158	.1172	.1165
	1915	.1084	.1061	.1072		1915	.1102	.1088	.1095
	1917	.1081	.1056	.1068		1917	.1094	.1097	.1096
	1919	.1105	.1071	.1088		1919	.1112	.1105	.1108
	1922	†				1922			
	1925	.1045	.1032	.1039		1925	.1076	.1088	.1082
G8	1905	(.1101)	(.1101)	.1101	I4	1905	(.1236)	(.1236)	.1236
	1907	.1019	.1098	.1059		1907	.1111	.1202	.1157
	1910	.1027	.1052	.1040		1910	.1080	.1175	.1128
	1913	.0994	.1055	.1024		1913	.1017	.1112	.1064
	1915	.0972	.0974	.0973		1915	.1001	.1049	.1025
	1917	.1012	.1025	.1018		1917	.0991	.1027	.1009
	1919	.1010	.1044	.1027		1919	.0973	.1059	.1016
	1922					1922			
	1925	.0986	.1022	.1004		1925	.0961	.1017	.0989
COWPEAS TURNED UNDER									
F4	1905	(.1293)	(.1293)	.1293	F5	1905	(.1329)	(.1329)	.1329
	1907	.1212	.1202	.1207		1907	.1226	.1313	.1269
	1910	.1179	.1165	.1172		1910	.1223	.1290	.1256
	1913	.1226	.1172	.1199		1913	.1229	.1290	.1260
	1915	.1183	.1150	.1166		1915	.1208	.1278	.1243
	1917	.1150	.1183	.1166		1917	.1271	.1246	.1259
	1919	.1142	.1129	.1136		1919	.1228	.1244	.1236
	1922					1922			
	1925	.1134	.1137	.1136		1925	.1230	.1271	.1251
F8	1905	(.1321)	(.1321)	.1321	H4	1905	(.1284)	(.1284)	.1284
	1907	.1280	.1273	.1277		1907	.1171	.1235	.1203
	1910	.1209	.1317	.1263		1910	.1113	.1158	.1135
	1913	.1297	.1298	.1297		1913	.1133	.1211	.1172
	1915	.1227	.1230	.1229		1915	.1090	.1169	.1130
	1917	.1282	.1239	.1260		1917	.1099	.1176	.1138
	1919	.1269	.1203	.1236		1919	.1081	.1165	.1123
	1922					1922			
	1925	.1264	.1195	.1230		1925	.1088	.1174	.1131
H6	1905	(.1178)	(.1178)	.1178	H8	1905	(.1037)	(.1037)	.1037
	1907	.1198	.1204	.1201		1907	.0977	.1027	.1002
	1910	.1136	.1166	.1151		1910	.0946	.1006	.0976
	1913	.1158	.1150	.1154		1913	.0974	.0971	.0973
	1915	.1170	.1100	.1135		1915	.0901	.0942	.0921
	1917	.1165	.1158	.1162		1917	.0942	.0959	.0950
	1919	.1157	.1130	.1143		1919	.0947	.0995	.0971
	1922					1922			
	1925	.1264	.1195	.1230		1925	.0986	.0991	.0989
I5	1905	(.1330)	(.1330)	.1330	I6	1905	(.1290)	(.1290)	.1290
	1907	.1280	.1255	.1167		1907	.1232	.1177	.1204
	1910	.1219	.1261	.1240		1910	.1197	.1202	.1200
	1913	.1281	.1236	.1258		1913	.1183	.1216	.1200
	1915	.1238	.1191	.1214		1915	.1211	.1147	.1179
	1917	.1236	.1211	.1224		1917	.1190	.1168	.1179
	1919	.1193	.1208	.1201		1919	.1157	.1137	.1147
	1922					1922			
	1925	.1210	.1215	.1213		1925	.1154	.1168	.1161

TABLE 17 (*Concluded*)

Plot	Year	Nitrogen content			Plot	Year	Nitrogen content	
		Limed	Unlimed	Average			Limed	Unlimed
		Per cent	Per cent	Per cent			Per cent	Per cent
I8	1905	(.1082)	(.1082)	.1082	J4	1905	(.1321)	(.1321)
	1907	.1098	.1069	.1084		1907	.1219	.1329
	1910	.1027	.1092	.1060		1910	.1149	.1250
	1913	.1068	.1077	.1072		1913	.1211	.1217
	1915	.1058	.1018	.1038		1915	.1124	.1191
	1917	.1058	.1056	.1057		1917	.1142	.1198
	1919	.1041	.1033	.1037		1919	.1117	.1165
	1922	.....	.....	.....		1922	.....	.....
	1925	.1091	.0961	.1026		1925	.1129	.1159
J5	1905	(.1346)	(.1346)	.1346	J6	1905	(.1422)	(.1422)
	1907	.1310	.1291	.1300		1907	.1278	.1269
	1910	.1241	.1250	.1246		1910	.1236	.1241
	1913	.1281	.1263	.1272		1913	.1271	.1259
	1915	.1235	.1215	.1225		1915	.1234	.1213
	1917	.1224	.1231	.1228		1917	.1221	.1200
	1919	.1223	.1208	.1216		1919	.1226	.1165
	1922	.....	.....	.....		1922	.....	.....
	1925	.1235	.1215	.1225		1925	.1215	.1196
J8	1905	(.1219)	(.1219)	.1219				
	1907	.1170	.1183	.1177				
	1910	.1163	.1148	.1155				
	1913	.1188	.1120	.1154				
	1915	.1129	.1105	.1117				
	1917	.1175	.1106	.1140				
	1919	.1137	.1132	.1135				
	1922	.....	.....	.....				
	1925	.1200	.1169	.1185				

*In 1905, sample taken to represent plot; i. e., samples of limed and limed halves not taken separately.

†In 1922, samples taken as usual through oversight were retained of questionable value by long storage in paper bags.

TABLE 18—*Annual yields per acre of* (1) *cowpea hay and* (2) *wheat for the various areas of the cowpea-wheat experiments at the Jackson Station for the* 16-*year period* 1909-1925.

Disposition of cowpea crop	Year	Cowpea hay			Wheat					
					Limed		Unlimed		Average of limed and unlimed	
		Limed	Unlimed	Average of limed and unlimed	Grain	Straw	Grain	Straw	Grain	Straw
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons
Area C Cowpea hay removed each year (Plots 10-16)	1909-10	1.15	0.73	0.94	13.7	2.16	06.8	1.03	10.3	1.60
	1910-11	1.15	0.81	0.98	15.3	1.88	07.5	1.33	11.4	1.61
	1911-12	2.11	1.67	1.89	27.8	1.56	21.5	1.35	24.7	1.46
	1912-13	1.23	0.70	0.97	19.3	1.04	15.2	0.89	17.3	0.97
	1913-14	1.50	1.09	1.30	14.9	0.72	13.2	0.73	14.1	0.73
	1914-15	1.55	1.46	1.51	18.2	0.72	18.1	0.86	18.2	0.79
	1915-16	1.21	0.83	1.02	07.5	0.52	10.3	0.69	08.9	0.61
	1916-17	0.94	0.55	0.75	22.5	0.87	15.4	0.68	19.0	0.78
	1917-18	1.68	1.40	1.54	19.4	0.91	16.4	0.69	17.9	0.80
	1918-19	1.50	1.13	1.32	14.0	0.71	13.8	0.67	13.9	0.69
	1919-20	1.61	1.08	1.35	17.5	0.96	14.5	0.63	16.0	0.80
	1920-21	1.09	0.71	0.90	22.9	1.58	16.9	0.98	19.9	1.28
	1921-22	1.26	0.78	1.02	18.7	1.31	17.5	1.08	18.1	1.20
	1922-23	0.50	0.42	0.46	21.6	1.37	18.9	1.03	20.3	1.20
	1923-24	0.72	0.61	0.67	23.2	1.79	17.9	0.96	20.6	1.38
	1924-25	0.93	0.72	0.83	19.0	1.09	16.6	0.86	17.8	0.98
	1925	1.53	1.26	1.40	.....	.....	.....	.....	.....	.....
	Average	1.27	0.94	1.11	18.5	1.20	15.0	0.90	16.8	1.05
Area A Cowpea hay turned under each year (Plots 1-7)	1909-10	1.15	0.73	0.94	12.0	1.81	06.9	1.04	09.5	1.43
	1910-11	1.25	0.83	1.04	16.2	2.25	10.2	1.54	13.2	1.90
	1911-12	2.05	1.60	1.83	30.0	1.74	24.0	1.43	27.0	1.59
	1912-13	1.55	0.88	1.22	27.0	1.80	19.0	1.21	23.0	1.51
	1913-14	1.46	1.13	1.30	24.0	1.34	17.2	0.96	20.6	1.15
	1914-15	1.80	1.60	1.70	30.4	1.74	26.3	1.41	28.4	1.58
	1915-16	1.59	0.96	1.28	13.4	1.13	11.1	0.88	12.3	1.01
	1916-17	1.23	0.85	1.04	32.3	1.63	24.3	1.13	28.3	1.38
	1917-18	1.88	1.22	1.55	32.2	1.67	26.4	1.22	29.3	1.45
	1918-19	1.33	1.28	1.56	21.1	1.40	18.2	1.07	18.7	1.24
	1919-20	1.92	1.02	1.47	25.9	1.86	19.3	1.12	22.6	1.49
	1920-21	1.50	0.90	1.20	27.3	2.39	18.3	1.59	23.3	1.99
	1921-22	1.52	1.05	1.29	28.4	2.16	22.7	1.72	25.6	1.94
	1922-23	0.81	0.66	0.74	23.7	2.10	19.4	1.40	21.6	1.75
	1923-24	1.01	0.81	0.91	30.5	1.86	23.9	1.37	27.2	1.62
	1924-25	1.30	1.05	1.18	25.7	1.82	21.8	1.57	23.8	1.70
	1925	1.42	1.29	1.36	.....	.....	.....	.....	.....	.....
	Average	1.49	1.05	1.27	25.0	1.79	19.3	1.29	22.2	1.54
Area E Cowpea hay turned under each year (Plots 19-25)	1909-10	1.15	0.73	0.94	12.7	1.90	07.3	1.10	10.0	1.50
	1910-11	1.31	0.86	1.09	18.1	2.25	7.9	1.27	13.0	1.76
	1911-12	2.02	1.74	1.88	27.9	1.65	21.0	1.37	24.5	1.51
	1912-13	1.70	0.91	1.31	28.9	1.80	20.3	1.27	24.6	1.54
	1913-14	1.53	1.18	1.36	25.9	1.50	18.3	1.14	22.1	1.32
	1914-15	1.80	1.60	1.70	32.9	1.50	24.3	1.14	28.6	1.32
	1915-16	1.34	1.03	1.19	12.8	1.13	09.3	0.77	11.1	0.95
	1916-17	1.56	0.84	1.20	30.5	1.57	24.2	1.10	27.4	1.34
	1917-18	2.01	1.81	1.91	29.0	1.53	26.0	1.24	27.5	1.39
	1918-19	1.52	1.09	1.31	19.8	1.21	21.3	1.26	20.6	1.24
	1919-20	1.41	1.04	1.23	25.7	1.69	18.0	1.00	21.9	1.35
	1920-21	1.49	1.00	1.25	31.9	2.56	22.4	1.56	27.2	2.06
	1921-22	1.70	1.21	1.46	24.7	2.17	21.8	1.49	23.3	1.83
	1922-23	0.79	0.68	0.74	26.7	1.80	20.1	1.35	23.4	1.58
	1923-24	1.08	0.94	1.01	31.8	2.05	24.2	1.37	28.0	1.71
	1924-25	1.20	0.92	1.06	26.9	1.86	24.8	1.54	25.9	1.70
	1925	1.44	1.42	1.43	.....	.....	.....	.....	.....	.....
	Average	1.47	1.12	1.30	25.4	1.76	19.5	1.25	22.4	1.51

TABLE 18 (*Concluded*)

Disposition of cowpea crop	Year	Cowpea hay			Wheat				
		Limed	Unlimed	Average of limed and unlimed	Limed		Unlimed		
					Grain	Straw	Grain	Straw	
		Tons	Tons	Tons	Bu.	Tons	Bu.	Tons	
Area B No cowpeas grown (Plots 8 and 9)	1909-10				14.8	2.22	7.2	1.08	
	1910-11				20.7	2.64	13.0	2.18	
	1911-12				25.7	1.25	19.0	1.22	
	1912-13				23.2	1.76	21.3	1.54	
	1913-14				16.0	0.88	16.7	1.10	
	1914-15				22.3	1.08	19.0	0.98	
	1915-16				10.0	0.78	8.0	0.70	
	1916-17				23.0	1.01	14.3	0.71	
	1917-18				19.7	0.95	17.7	0.84	
	1918-19				12.7	0.92	12.0	0.84	
	1919-20				16.3	0.93	13.0	0.79	
	1920-21				18.7	1.48	10.7	1.04	
	1921-22				17.2	1.49	13.7	0.98	
	1922-23				20.7	1.47	15.4	1.14	
	1923-24				23.3	1.68	16.0	1.27	
	1924-25				14.7	0.88	14.7	0.88	
	Average				18.6	1.34	14.5	1.08	
Area D No cowpeas grown (Plots 17 and 18)	1909-10				13.6	2.29	12.0	1.97	
	1910-11				21.5	2.28	10.0	1.55	
	1911-12				16.9	1.07	23.2	1.09	
	1912-13				21.9	1.46	21.4	1.41	
	1913-14				15.3	0.90	14.1	0.90	
	1914-15				18.1	0.93	16.7	0.77	
	1915-16				5.6	0.51	7.9	0.68	
	1916-17				15.7	0.61	10.2	0.47	
	1917-18				18.6	1.10	19.3	1.10	
	1918-19				8.7	0.58	9.1	0.63	
	1919-20				12.4	0.77	9.1	0.65	
	1920-21				16.1	0.78	9.1	0.87	
	1921-22				15.7	1.46	14.9	1.07	
	1922-23				14.9	1.20	11.1	0.97	
	1923-24				19.8	1.33	15.2	1.24	
	1924-25				10.3	1.64	11.1	0.80	
	Average				15.3	1.18	13.4	1.01	

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