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THE COW PEA AND THE VELVET BEAN AS FERTILIZERS.

By J. F. DUGGAR.

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THE COWPEA AND THE VELVET BEAN AS FERTILIZERS.

BY J. F. DUGGAR.

Summary.

This bulletin records the results of more than fifty experiments conducted at Auburn during the past five years, to ascertain the effects of cowpeas and velvet beans in the improvement of the soil. The amount of soil improvement has been determined by the increase in the yields of cotton, corn, oats, wheat and sorghum, grown as first, second, third or fourth crops after the stubble and roots of cowpeas or velvet beans or after vines, stubble and roots of these plants have been plowed under. The basis for determining this increase has been the yield of each crop on plots where no leguminous plant has recently grown.

The fertilizing value of different varieties of cowpeas was found to vary considerably, and is probably in proportion to the luxuriance of growth.

In two tests there was a slightly larger yield of corn from plowing in cowpea vines very late in the fall than from postponing the plowing until April; but it is regarded as generally best to plow in the vines not more than a few weeks before the next crop is planted.

The average for six varieties showed that when cowpeas were at a suitable stage for mowing 36.6 per cent. and in another case 39 per cent. of the dry weight of the plant was available for fertilizing uses in stubble, roots and fallen leaves. In the entire growth of cowpeas on one acre there was contained in one case 53.7 pounds of nitrogen, in another 69.8, and in another 87.2, an average of 70.2 pounds of nitrogen per acre,

which is equivalent to the nitrogen in 1,003 pounds of cotton seed meal.

In the roots, stubble and fallen leaves on an acre there were, respectively, 11.65, 16.2 and 31.4 pounds of nitrogen, an average of 19.75 pounds of nitrogen per acre, which is equivalent to that contained in 282 pounds of cotton seed meal.

The average of three tests shows that 28 per cent. of the total nitrogen was contained in the roots, stubble and fallen leaves after the removal of the hay.

The average increase in the yields of succeeding crops was practically identical whether the fertilizing material was supplied by cowpeas or by velvet beans. Equal areas of these two plants were of practically equal value for soil improvement.

The word vines is here used as synonymous with the entire plant of the velvet bean, and with the entire plant of the cowpea after the pods are picked.

The increase in the yield of seed cotton produced in the year immediately following the plowing in of the vines of cowpeas or velvet beans averaged in four tests 567 pounds per acre, worth (at $6\frac{3}{4}$ cents per pound for lint and $7.50 per ton for seed) $14.17. The increase in the first cotton crop after the use as fertilizers of the vines of the summer legumes was never less than 32 per cent. and averaged 63 per cent.

In one test with corn the increase in the first crop where velvet bean vines had been plowed in was 81 per cent., of 12.3 bushels, worth at least $6.15 per acre. With oats the average increase from the vines of the summer legumes in three tests averaged 17 bushels per acre, and with wheat the corresponding increase in two tests was 5.65 bushels per acre.

The increase in the yield of sorghum hay after cowpea and velvet bean vines averaged 87 per cent., or an

average gain of 2.1 tons of hay per acre, worth, at $6.67 per ton, $14.02.

When the vines of the cowpea or velvet bean were utilized as hay and only the roots and stubble employed as fertilizer the increase in the yield per acre of the crop immediately succeeding the stubble was as follows:

208 pounds of seed cotton, or 18 per cent., worth $5.20.
4.3 bushels of corn, or 32 per cent.;
28 bushels of oats, or 334 per cent.;
6.7 bushels of wheat, or 215 per cent.;
2.08 tons of sorghum hay, or 57 per cent.

The largest *percentage increase* from either the vines or stubble of cowpeas or velvet beans was made by wheat and fall sown oats, probably because these best prevented the washing away or leaching out of the fertilizing material in the stubble or vines of the legumes.

Generally on sandy soil those crops most completely utilize the fertilizing value of the legumes which leave the land unoccupied for the shortest interval. It is generally unadvisable for legumes to immediately succeed legumes in the rotation of crops, for non-leguminous plants like cotton, corn, the small grains, grasses, etc., make better use of the nitrogen of the fertilizing crop.

The *value* of the increased product resulting from the use of the entire legume for fertilizer was greater with cotton and sorghum than with corn, oats or wheat.

These experiments emphasize the importance of such a rotation of crops as will require a large proportion of the cultivated land of every farm to be devoted to some leguminous plant.

Comparing the fertilizing effect of the vines with that of the stubble of the cowpea and the velvet bean, the excess in the next crop in favor of the vines averaged as follows:

6.6 bushels of corn per acre, or.....49 per cent.
.5 ton of sorghum hay, or ..... 9 per cent.
452 pounds of seed cotton per acre, or....40 per cent.

With these three crops the average increase in value per acre was $5.98 greater from vines than from stubble. With oats and wheat the vines of these summer legumes were not superior to the stubble when the small grains were sown immediately after the legumes matured.

The fertilizing effect of the *stubble* of cowpeas or velvet beans was very transitory on sandy land, the average increase in the second crop of corn after the stubble being only 1.34 bushels per acre, or 12 per cent., as compared with the yield of a plot that had not borne legumes.

The fertilizing effect of the *vines* of cowpeas and velvet beans was less transitory than that of the stubble, and the increase was 24 to 54 per cent. in the second crop, 14 per cent. in the third crop (oats), and the favorable effect was even perceptible in the fourth crop (sorghum) grown in the same year as the third. The total increase in value of the four crops occupying certain plots during the three years after the plowing under of the vines of cowpeas and velvet beans was $42.97 per acre, an annual increase of $14.32 per acre.

On the other hand, on very light soil the fertilizing effects of both stubble and vines had practically disappeared within twelve months after the plowing in of the legumes.

Corn as the second crop yielded 14 per cent., or 2.1 bushels more after legume vines than after legume stubble, this representing a value of $1.05. The permanency of effect of legumes in soil improvement seems to be in proportion to the stiffness of the soil and to the mass of vegetable matter afforded by the legume, and the favorable influence of leguminous vines is apparently not less permanent than that of stable manure.

INTRODUCTORY.

The improvement of the soil should be one of the chief aims of every farmer. Every increase in productiveness brings an even more marked increase in profits. Given rich soil, and almost any crop will pay if adapted to the local conditions and markets. Labor spent in the cultivation of corn or cotton on extremely poor soil usually earns scant reward or none.

Fortunately much of the poorest worn land can be brought to a fair degree of productiveness. The means of soil improvement are various. Most thoroughly tested by long experience in Europe and America is that system of farming which depends for soil enrichment on the manure from a large number of livestock maintained on the farm, partly for immediate profit, but largely for use as manufacturers of fertilizers. This system should be much more generally followed in Alabama. However, its introduction will be gradual because of limited capital, inexperience, and the small number and poor quality of the native livestock that must serve as a foundation for stock raising.

Meantime the most immediately available method of increasing the fertility of the soils of the South consists in the free use of that class of leguminous plants, or legumes, which embraces cowpeas, velvet beans, soy beans, beggar weed, peanuts, hairy vetch, crimson clover, and numerous others.

When these plants are grown under suitable conditions specific enlargements occur on their roots and these are called root tubercles, or root nodules. The microscopic organisms which live within these tubercles are able to assimilate the nitrogen of the air that circulates through the upper layers of the soil. This nitrogen while a part of the air was useless to plant life, but

within the tubercles it is changed into available fertilizer and is carried by the sap to every part of the leguminous plant. Hence we may speak of these tubercles as fertilizer factories where nitrogenous fertilizers are manufactured and whence they are sent to every part of the cowpea or velvet bean, or other leguminous plant. The plowing in of the legume gives this nitrogen to the soil for the use of other plants. Nitrogen when purchased in the form of cotton seed meal costs 12 to 15 cents per pound, but when it is furnished by legumes it is many times cheaper, the principal outlay being for seed and labor.

Great as is the need of the South for varied industrial development, the factories most urgently needed and paying largest dividends are those which every farmer can bring into being by the millions on the roots of such legumes as cowpeas, velvet beans, vetch, crimson clover, melilotus, bur clover, and alfalfa.

These crops afford nitrogen and vegetable matter, thus supplying the principal deficiencies of southern soils, and they may be either used directly and exclusively for this purpose, or with greater profit the tops may first be fed to livestock, thus affording a twofold profit in animal products and fertilizer, while the stubble and roots are immediately available for soil improvement.

The stubble alone usually causes a sufficient increase in the yield of the following crop to more than pay the cost of seed, fertilizer, and cultivation of the legume, leaving the food value of the tops as a net gain.

The principal part of this bulletin is occupied with data obtained at Auburn during the past five years and bearing on the extent and permanency of the fertilizing effect of cowpeas and velvet beans.

The following conditions prevailed in all of these tests, unless otherwise specifically stated:

The legumes were grown in drills and cultivated and moderately fertilized with acid phosphate or with phosphate and some potash salt. The crops, corn, cotton, oats, wheat, sorghum, and rye, used to measure the fertilizing effects of the legumes, have received no application of nitrogen, but have been fertilized with phosphate and potash.

The soil in all tests is rather poor to extremely poor deep sandy upland, the white or gray being almost a pure sand and the reddish soil approaching a loam with clayey loam subsoil in the latter case.

The vines or stubble of the legumes have been plowed under just before the planting of the next crop.

The variety of cowpeas employed was the Wonderful or Unknown.

In valuing the crops the endeavor has been made to use conservative average prices, the error, if any, being in putting them too low rather than too high. Lint cotton has been rated at $6\frac{3}{4}$ cents per pound, cotton seed at $7.50 per ton, sorghum hay at $6.67 per ton, corn at 50 cents, oats 40 cents, and wheat 80 cents per bushel. No record is here made of the increase in the yields of grain, straw or corn stover, assmuing that this has been about sufficient to cover the increased cost of harvesting and threshing.

Time to Plow in Cowpea Vines.

On a gray sandy upland soil the vines of drilled cowpeas were plowed under in the late fall of 1898 and 1900, while on other plots plowing was deferred until nearly planting time.

The yields of corn were as follows:

Bushels of corn per acre following cowpea vines plowed under in late fall or early spring.

	Bus. per acre.		
	1899	1901	Av. 2 yr.
Fall plowed	23.8	30.6	27.2
Spring plowed	20.8	29.7	25.3
Difference	3.0	0.9	1.9

The results are slightly in favor of plowing under peavines in the latter part of the fall rather than in spring. As the plots were not strictly uniform, further experiments are needed before definite conclusions can be drawn. It should be said that on July 5, 1899, the foliage of the corn plant was much greener where the vines had been turned under in the fall than on the other plots, though the ears were not discernably different.

It is usually regarded as best to avoid fall plowing on sandy land in the South unless a winter crop is to be grown. On heavy soils where fall plowing may otherwise be desirable, the legumes should first be allowed to mature.

Unless otherwise stated the time of plowing under cowpea and velvet bean vines referred to in this bulletin is a few days or weeks before the planting of the new crop that is to occupy the ground.

Relative Fertilizing Values of Different Varieties of Cowpeas.

Corn was grown in 1898 and 1901 immediately following different varieties of drilled cowpeas which had been picked and in spring the vines plowed under.

Excess of yield of corn in bushels per acre on vine plots as compared in 1898 with no-legumes plot and in 1901 with plot where only pea stubble had been plowed under.

Variety of cowpeas.	1898. Bus.	1901. Bus.
Wonderful (or Unknown)	2.7	0.6
Whippoorwill	2.9	—1.5
Clay	4.3	0.7
Black, from Hastings		—2.9
Red Ripper		5.9
New Era		—3.2
White Giant		0.6
Jones White		1.9
Large White Crowder		5.3
Lady		6.8
Average	3.3	1.4

These figures are given merely as a matter of record, and no conclusions are yet warranted. As a matter of common experience any variety of cowpeas affords in its vines as much or more nitrogen than the following corn crop can utilize. For crops requiring a larger amount of nitrogen or for larger supplies of vegetable matter we may safely value the numerous varieties of cowpeas in proportion to the yeild of hay which they would afford if thus utilized. As noted in Bulletin 118 Wonderful (or Unknown), Clay, and Iron are among the varieties making large yields of hay, and hence of fertilizing material. The Wonderful, by reason of its large yeild, large stems and roots, and varied usefulness, is especially recommended for fertilizing purposes. It is possible, however, that future investigations may show some advantage for varieties that run along the ground and thus by the tangle of runners hold in place on sloping ground in winter a larger proportion of the leaves than is done by an erect variety like Whippoorwill or Wonderful.

Cowpea Vines, Effect on Following Cotton Crop of 1899.

On a reddish loam upland soil of fair quality drilled Wonderful cowpeas and cotton, similarly fertilized were grown in 1898. The peas were picked, yielding 11.8 bushels per acre, and the vines were plowed under the next spring, when both areas were planted with cotton. The corrected yield of cotton in 1899 was 367 pounds, or 32 per cent. greater on the area where the peavines had been plowed in than on the plots where the preceding crop had been cotton.

Cowpea vines, residual fertilizing effect on second crop, viz., oats grown in 1900.—Burt oats were sown in February, 1900, on the same plots as above to test the residual or second-year effects of cowpea vines. On some plots the oats received no nitrogenous fertilizer, on others 76 pounds of nitrate of soda was used per acre.

The yields of oats, in bushels per acre, were as follows:

Fertilizing effects on oats of cowpeas grown two years before.

	After cotton in '98 and '99	After cowpeas in '98 & cotton in '99.	Increase attributable to cowpeas of '98.	
	Bus.	Bus.	Bus.	%
Yield of oats per acre with nitrate of soda..	19.7	25.5	5.8	29
Yield of oats per acre without nitrogenous fertilizer	12.3	22.0	9.7	79

In this case we have an increase of 9.7 bushels, or 79 per cent., as the effect of cowpea vines on oats grown as the second crop after cowpeas. So strong was this

fertilizing effect of cowpeas that it was not entirely obscured even when nitrate of soda was also employed, the increase in the yield of oats under these conditions being 29 per cent.

Cowpeas as fertilizer on lime land.—A co-operative fertilizer experiment was conducted for this Station by Capt. A. A. McGregor on lime land at Town Creek, in North Alabama. In his experiment the cowpea was the legume employed.

In 1898 cowpeas were grown on certain plots and cotton on others. The cowpea vines, on which no fruit had matured, were plowed under in the spring of 1899. Cotton was planted on plots which had borne a crop of cotton in 1898 and on others which had grown cowpeas for fertilizing purposes. All cotton plots referred to in this paragraph were unfertilized in 1899, and the fertilization of cowpeas and cotton in 1898 had been identical, only phosphate having been used with either crop.

The weather was exceedingly unfavorable in 1899, so that the full measure of the fertilizing value of cowpeas was not revealed in this test.

In this case the average increase in the yield of seed cotton, which we may attribute to the cowpea vines is, even under very adverse conditions, 58 per cent., or 125 pounds, worth at $2\frac{1}{2}$ cents per pound, $3.92 per acre. Doubtless later crops have also been benefited by the fertilization with cowpeas.

There is reason to expect a larger increase than the above when cowpeas are plowed under on the lime lands of either the Tennessee Valley or of the Central Prairie Region of Alabama. Especially in the prairie soils the principal need is for vegetable matter to lighten the soil and to add nitrogen, and for these purposes the choice must usually be made between melilotus (the so-called lucern) and cowpeas.

Fertilizing Effects of Vines of Cowpeas and Velvet Beans as Shown by Sorghum in 1897.

In 1897 sorghum was grown on three plots following, respectively, velvet bean vines plowed under, cowpea vines plowed under, and fallow, or clean cultivation without crop in 1896.

In 1897 the yields of sorghum hay per acre were as follows:

	Yield.	Increase	
	Lbs.	Lbs.	%
After fallow	3,792		
After cowpeas, plowed in	7,008	3,216	85
After velvet beans, plowed in	7,064	3,272	86

The effect of the legumes was to nearly double the crop of sorghum hay.

Fertilizing Materials in Leaves, Stems, and Roots of the Cowpea.

In September, 1899, just 81 days after the planting of the seed, samples were taken of six varieties of cowpeas growing in 34-inch drills on poor gray sandy land. The sample in each case comprised the entire growth on a measured area of land, including the roots growing in the upper 6 inches of soil, which stratum contained nearly all the roots.

After curing, the leaves, blooms and pods, coarse stems ,fine stems (including runners, leafstalks, etc.), fallen leaves and leafstalks,and roots with attached stubble about two inches long, were carefully separated. Analyses were made in the chemical department of a composite sample representing all six varieties, the material analyzed being extremely dry. (For analysis of same samples showing food value see Alabama Station Bulletin No. 118, page 37.)

The following table shows what percentage of the total air-dry weight of the plants of each variety was available for fertilizing purposes after the removal of the hay.

Per cent. of the entire weight of the cowpea plant in stubble and roots and in fallen leaves and leaf stalks.

Variety.	Fallen leaves, etc.	Roots and 2-inch stubble.	Total.
	%	%	%
Miller	17.7	25.0	42.7
Whippoorwill	3.7	21.6	25.3
Iron	15.4	19.0	34.4
Wonderful	19.2	20.3	39.5
Jones White	14.3	14.5	28.8
Clay	22.9	26.0	48.9
Average, 6 varieties	**15.5**	**21.1**	**36.6**

The average for the six varieties shows that in each 100 pounds of dry plants there were 15.5 pounds of fallen leaves and leaf stalks, and 21.1 pounds of roots and stubble, making a total of 36.6 pounds, more than one-third of the entire plant being thus left on the ground for fertilizer after the hay was cut.

Analyses of the different parts of the plant made by Prof. C. L. Hare, of the chemical department of this station, are recorded in the following table.

Composition of parts of the air-dry cowpea plant.

	Water.	Nitrogen.	Phosp'ric Acid.	Potash.
	%	%	%	%
Leaves	10.65	3.59	.78	1.49
Fine stems	8.97	1.90	.64	.68
Coarse stems	8.47	1.51	.42	1.49
Fallen leaves and leaf stalks	9.75	1.67	.37	1.09
Roots and 2-inch stubble	5.25	1.38	.26	1.11

Let us direct our attention to the nitrogen, since this is the only one of the three precious elements that the plant obtains (in part) from the air, and the only one in

which the soil is enriched by the growing of cowpeas. The growing leaves in the air-dry condition contain nearly twice as large a percentage of nitrogen as the fine stems, and more than twice as much as the coarse stems and roots and fallen material.

Amounts of air-dry material and nitrogen afforded by different parts of the cowpea plant on one acre (average of six varieties)

	Air dry material.	Nitrogen.
	Lbs.	Lbs.
In leaves retained on vines	501.0	18.00
In fine stems	401.6	7.66
In coarse stems	438.8	6.61
In pods, blooms, etc	325.0	*9.75
In fallen leaves and leaf stalks	357.3	5.97
In roots and 2-inch stubble	411.7	5.68
Total	2435.4	53.67

*Assuming 3% of nitrogen in thoroughly air-dry pods.

The amount of nitrogen stored up by a poor crop of cowpeas growing on an acre, 53.67 pounds, is equivalent to that contained in 767 pounds of cotton seed meal. It should be remembered that an undetermined portion of this nitrogen came from the soil, though on a soil as poor as this the nitrogen derived from the air probably constituted by far the larger portion of the total nitrogen utilized by the plant.

In the stubble, roots, and fallen material there was 11.65 pounds of nitrogen per acre or the same amount as is contained in 162 pounds of cotton seed meal.

Of the total nitrogen in the entire plant 22 per cent. was found in the roots, stubble and fallen material.

An experiment somewhat similar to the preceding was made in 1900, using only a single variety, Wonderful or Unknown. The seed were planted in drills 2½

feet apart on poor gray sandy soil. Four samples were taken from two plots, each sample consisting of the entire growth on an area of four square yards; the roots were obtained by digging and sifting the soil to a depth of six inches, to which stratum all the principal roots were apparently confined.

That the samples were accurately taken is indicated by the close agreement of the duplicate samples; hence only average results are given below. The vines were cut, the fallen leaves and leaf stalks collected, and the roots sifted out on September 5. This was 106 days after the date of planting on one plot and 78 days after planting on the other.

When harvested the more mature sample was slightly past its prime for hay, as shown by the unduly large amount of fallen leaves, while the other sample was too immature and succulent for easy curing.

The yields per acre of extremely dry hay according to the weight of the samples taken after being stored in an office for seven months, were 2,269 pounds on the plot cut at a late stage, and 2,087 pounds of the less mature material. These are equivalent to about $1\frac{1}{4}$ and $1\frac{1}{8}$ tons per acre of cowpea hay with the usual amount of moisture.

Weights (air-dry) per acre of hay, roots, and stubble, and fallen leaves of the cowpea.

	Air dry material, per acre.	
	Ripening stage.	Blooming stage.
	Lbs.	Lbs.
Vines, including stems, leaves, pods, etc	2,269	2,087
Roots, and stubble about 2 in. long...	714	502
Fallen leaves and leaf stalks	1,385	804
Total.....	4,368	3,393

The following table shows what proportion of the entire plant consisted of roots, fallen material, and hay, in the plants harvested when ripening or when in bloom.

	Ripening stage.	Blooming stage.
	%	%
Tops	52	61
Roots and stubble	16	15
Fallen leaves, etc	32	24

When hay was made of cowpeas past their prime there was left on the ground in roots, stubble, and fallen material 48 per cent. of the weight of the plant, and when mowing occurred when the vines were in bloom 39 per cent. of the total weight remained as fertilizer material.

Analyses made by Prof. J. T. Anderson, Associate Chemist of this Station, are recorded below:

Composition of hay, fallen material, and roots and stubble of the cowpea.

	Water.	Nitrogen.	Phosph'ric Acid.	Potash.
In ripening stage:	%	%	%	%
Hay	9.05	2.46	.85	2.14
Fallen leaves and leaf stalks	7.80	1.83	.64	1.45
Roots and stubble	7.77	1.17	.48	1.51
In blooming stage:				
Hay	8.15	2.57	.81	2.86
Fallen leaves, etc.	6.80	1.36	.59	1.15
Roots and stubble	7.00	1.05	.41	2.11

From this table it may be seen that the hay is more than twice as rich as the roots and stubble in nitrogen, and also richer in phosphoric acid and potash.

The amounts of nitrogen contained in the hay, fallen material, and roots and stubble on one acre were as follows:

	Ripening stage. Lbs. nitrogen.	Blooming stage. Lbs. nitrogen.
In hay	55.8	53.6
In fallen leaves, etc	23.1	10.9
In roots and stubble	8.3	5.3
Total per acre	87.2	69.8

The total amounts of nitrogen stored up by the cowpea plant on one acre was in one case 87.2 pounds, in the other 69.8 pounds, equivalent, respectively, to the nitrogen in 1,246 and 997 pounds of cotton seed meal.

Of this amount there was left in and on the soil when mowing occurred late 31.4 pounds of nitrogen; and from the younger plants 16.2 pounds per acre. This is equivalent to the statement that the nitrogen per acre remaining after the vines were removed was equal to the amount contained in 446 or 231 pounds of cotton seed meal.

Of the total nitrogen in the plant, the roots, stubble, and fallen material contained 34 per cent. at the ripening stage, and 23 per cent. at the blooming period.

Considering the three tests together the total amounts of nitrogen per acre of cowpeas was 70.2 pounds in the entire growth, of which the average amount in the stubble was 19.75 pounds, or 28 per cent.

Cowpea Stubble versus Cowpea Vines as Fertilizer for Corn in 1901.

Corn was grown in 1901 on sandy loam land, which, in 1900 had borne a light crop of drilled cowpeas, planted after the removal of the oat crop of 1900.

Three plots were employed. On one the peavines had been cut the previous September, yielding 1,648 pounds of hay per acre. On the other two plots no vines nor peas were harvested but the entire growth, which was

only about half of a normal yield, was plowed under March 14, at which time the stubble plot was also plowed.

On the stubble plot and on one of the others corn was fertilized with 100 pounds of acid phosphate per acre, which fertilizer was omitted from the third plot. The stand was uniform. The yields of corn in bushels per acre were as follows:

	Bus.
Pea stubble and phosphate as fertilizer	11.40
Pea vines and phosphate as fertilizer	20.28
Pea vines as fertilizer, no phosphate	21.74

The yield of corn following pea vines was 78 per cent. greater than the yield on the plot where the stubble only had been plowed under, the increase being 8.88 bushels per acre.

In the presence of a considerable amount of rich vegetable matter furnished by pea vines, phosphate was not needed on this soil where acid phosphate had been applied annually for many years.

In a different field on more permeable gray sandy soil corn grown in 1901 on a plot where the stubble of Wonderful cowpeas had been plowed under for hay yielded 25.3 bushels per acre. The average yield of corn on two adjacent plots—where cowpea vines of the varieties Lady and White Giant, both luxuriant growers, had been plowed under, was 25.9 bushels per acre. Here there was practically no superiority of vines over stubble as a fertilizer for corn.

Note should also be taken of the increase in the corn crop due to plowing in either stubble or vines of a number of varieties as recorded in the table on page 131.

Velvet Bean Stubble and Vines as Fertilizers for Corn in 1901.

The fertilizing effect of velvet bean stubble, of velvet bean vines, and of velvet bean vines in connection with acid phosphate, was tested in 1901 on four plots of very poor, deep white sandy soil. On one plot the preceding crop had been corn. On the other three plots drilled velvet beans planted June 13, after the harvesting of the oat crop, had made only a moderate growth in 1900. On one of these plots the velvet bean vines were cut September 10, 1900, yielding 3,632 pounds of hay per acre.

On the other two plots the vines were left on the land all winter. In the latter part of the winter all four plots were plowed, a disc harrow having first been run over the field while the vines were frozen in order to cut them and thus render it easier to plow them in.

The corn on three of the plots was fertilized with 100 pounds of acid phosphate per acre, but this fertilizer was omitted on one of the plots where velvet bean vines had been plowed in.

Yield of corn in 1901 following corn, velvet bean stubble, or velvet bean vines.

	Bus.
Phosphate (but no legume), as fertilizer.....	13.58
Velvet bean stubble and phosphate as fertilizer..	17.93
Velvet bean vines and phosphate as fertilizer...	25.90
Velvet bean vines (no phosphate), as fertilizer..	21.48

The increased yield per acre, as compared with the yield on the plot on which the previous crop had been corn, was 4.35 bushels, or 32 per cent., with velvet bean stubble, and 12.32 bushels, or 81 per cent., with velvet bean vines.

The increase attributable to 100 pounds of acid phosphate was 4.42 bushels, which made the use of this mineral fertilizer decidedly profitable for corn on very poor white sandy soil, when used in connection with a large mass of rich vegetable matter. On the other hand, on a spot about 100 yards distant, where the soil was less sandy and in better condition, phosphate did not increase the yield of corn when added to pea vines plowed under. (See page 140.)

Immediate Fertilizing Effect on Sorghum of Cowpea and Velvet Bean Vines and of Cowpea and Velvet Bean Stubble.

The soil on which the following experiment was made is a sandy loam, containing many small flint stones, and underlaid by a stiffer subsoil.

In 1898 eight uniform plots were planted, 2 plots with velvet beans, 5 with Wonderful cowpeas (most plots broadcast), and 1 with drilled Orange sorghum. The growth of the several plots was either cured for hay or used as a fertilizer, as indicated in the next table.

March 9, 1899, all plots were plowed and in due time sorghum was planted in drills on all plots, and the two cuttings of this crop at the proper season were cured for hay.

The yields per acre of sorghum hay at two cuttings, the first growth having become too coarse, but the second being of good quality, averaged as follows:

First year effects on sorghum of stubble or vines of cowpeas or velvet beans.

	Yield per acre.	Increase from legumes.
	Tons.	Tons.
Sorghum hay after sorghum stubble..	3.65	
Sorghum hay after cowpea stubble..	5.66	2.01
Sorghum hay after velvet bean stubble	5.80	2.15
Sorghum hay after cowpea vine, pckd	5.72	2.07
Sorghum hay after velvet bean vines	6.76	3.11

As a fertilizer for sorghum velvet bean vines proved superior to cowpea vines, and to velvet bean stubble.

The stubble of cowpeas and of velvet beans was of practically equal fertilizing value.

Residual fertilizing effect of legumes on corn grown as the second crop after cowpea and velvet bean vines and cowpea and velvet bean stubble.

March 17, 1900, the sorghum stubble in the experiment just discussed was turned with a one-horse plow and March 29 corn was planted on all plots.

"Fertilizing effects in 1900 of stubble and vines of cowpeas and velvet beans grown in 1898.

Plot.	Crop in 1898.	Portion used for fertilizer.	Corn per acre in 1900.		
			Yield.	Increase over sorghum plot of 1898.	Increase, vines over stubble.
			Bus.	*Bus.*	*Bus.*
8	Sorghum. .	Stubble.....	24.1	.....	.....
4 & 7	Cowpeas....	Stubble	25.7	1.6	.....
3 & 6	Cowpeas	Vines, after picking	27.7	3.6	2.0
2	Velvet beans.	Stubble.....	23.9	0.2	.....
1	Velvet beans.	Entire growth.....	26.8	2.6	2.4

Let it be noted that the heavy growth of sorghum in 1899 did not utilize all of the fertility derived from the preceding crop of legumes. Although sorghum is a plant that is especially exhaustive to soil fertility, there still remained for the corn crop of 1900 a residue of nitrogen from the cowpea and velvet bean vines of 1898 sufficient to increase the yield of corn to the extent of 3.6 bushels per acre where cowpeas had grown two years before, and 2.6 bushels where velvet beans had grown. This is an average of 3.2 bushels per acre as the residual fertilizing effect of these legumes.

The fertilizing effects of the stubble and roots of these two plants was far more transitory, the first succeeding crop, sorghum, practically exhausting them, leaving sufficient in the soil to increase the corn crop of 1900 by only an inconsiderable amount, viz.: 1.6 bushels and .2 bushel, an average of .9 bushel per acre." (From Bulletin No. 111, Alabama Experiment Station.)

Immediate Fertilizing Effect on Corn in 1900 of Cowpea and Velvet Bean Vines.

This experiment was made on a white, sandy soil, poorer than that used in the last mentioned experiment.

In the late spring and early summer of 1899 velvet beans had been planted in drills on certain plots and beggar weed had been sown broadcast on others. The beggar weed and a portion of the velvet beans was used exclusively for fertilizer. On other plots velvet beans were cut, thus leaving only the stubble as fertilizer for corn.

"These various fertilizing materials were all plowed under March 31, 1900, and Mosby corn planted April 5, using per acre 240 pounds of acid phosphate and 40 pounds of muriate of potash.

Vines versus stubble of velvet beans as fertilizer for corn in 1900.

Plots.	Material used for green manuring.	Yield of corn per acre.	Increase over stubble plot.
		Bus.	Bus.
4 & 9	Stubble of velvet beans	15.6	
3 & 8	Entire growth of velvet beans	27.5	11.9
2 & 7	Entire growth of beggar weeds.....	18.7	3.1

The entire growth of velvet beans afforded a yield of corn greater by 11.9 bushels per acre, or 76 per cent., than the yield where only the stubble was employed as fertilizer." (Alabama Station Bulletin No. 111.)

Residual fertilizing effects of velvet bean vines and stubble on the second crop of corn grown in 1901.

The same poor, white, sandy hilltop was again planted in corn in 1901 without any nitrogenous fertilizer. The yield of corn per acre were 15 bushels where velvet bean vines growing in 1899 had been plowed under and only 11.1 bushels where velvet bean stubble had been turned under at the same time. The residual or second-year fertilizing effect of the vines was greater than that of the stubble by 3.9 bushels per acre, or 33 per cent.

The total fertilizing value of the vines during the two seasons following the date when they were plowed in exceeded that of the stubble to the extent of 59 per cent., or 15.8 bushels of corn per acre. This amount of corn would usually be worth more than the net value of the 2,800 pounds of velvet bean hay obtained from the stubble plot at considerable expense for curing.

In this case it was more profitable to plow under velvet bean vines for fertilizer than to harvest them for hay. Judging from other corresponding tests it would have been still more profitable to have grazed cattle on the vines, either in their green or winter-killed condition.

COWPEA AND VELVET BEAN VINES, IMMEDIATE FERTILIZING EFFECTS ON COTTON GROWN IN 1899.

In 1898 on a reddish loam soil, abounding in flint stones and underlaid by a red loam subsoil there were grown on adjacent plots cowpeas, velvet beans, and cot-

ton, all fertilized alike with acid phosphate and kainit. The cowpeas and velvet beans were planted thickly in drills, using per acre 112 pounds of cowpeas and 120 pounds of velvet beans. The variety of cowpeas used was the Unknown or Wonderful. Both cowpeas and velvet beans were picked and removed from the field, though the latter did not fully mature. The vines were turned under in March, 1899, and all plots were planted to cotton; each plot of cotton was fertilized at the rate of 240 pounds of acid phosphate and 96 pounds of kainit per acre.

The yield of seed cotton per acre in 1899 was 1,533 pounds following cowpeas, 1,373 pounds following velvet beans, and 837 pounds following cotton.

These figures show that the increased yield of seed cotton attributable to manuring with cowpea vines was 696 pounds per acre; the gain apparently due to the fertilization with velvet beans was 546 pounds per acre. In percentages the increase is 83 and 64 per cent., respectively. Valuing seed cotton at $2\frac{1}{2}$ cents per pound (which is equivalent to $6\frac{3}{4}$ cents per pound of lint and $7.50 per ton of seed), the gain with cowpeas and velvet beans is worth, respectively, $17.40 and $13.65 per acre.

Surely it was more profitable to grow cotton every alternate year at the rate of a bale per acre than to grow continuous cotton crops of about one-half bale per acre. Additional proof of this is found in the fact that one of these plots afforded in 1898 a yield of $18\frac{1}{4}$ bushels of cowpeas per acre, besides increasing the cotton crop of the following year to the extent of $17.40 per acre.

Residual fertilizing effects of cowpeas and velvet beans on sorghum, oats, and late sorghum grown as second, third and fourth crops after these legumes.

These same plots were planted with drilled sorghum without any nitrogenous fertilizer in April, 1900; with red oats without nitrogenous fertilizer in November, 1900, and again with drilled sorghum without any nitrogenous fertilizers, July 18, 1901.

Fertilizing effects of cowpeas and velvet bean vines grown in 1898 on sorghum in 1900 and as a second crop in 1901.

Preceding crop.	Sorghum hay per acre, 1900.	Sorghum hay per acre, 1901.	Total increase after legumes.
	Tons.	Tons.	Tons.
Cotton in '98 and '99	5.1	1.0	
Cowpeas in '98 (picked), and cotton in '99	8.1	1.5	3.5
Velvet beans in '98, and cotton in '99	8.2	1.6	3.7

As compared with the plot not recently in legumes the increase of sorghum hay per acre in 1900 from cowpeas grown two years before was 3 tons per acre, or 59 per cent.; from velvet beans two years before the increase in 1900 was 3.1 tons of hay, or 61 per cent.

The increased yield with late sorghum, which was the fourth crop after the plowing in of the vines of the legumes, was, after cowpeas, .5 of a ton, and after velvet beans .6 of a ton. In the two sorghum crops the total increase in yield attributable to legumes was, with cowpeas, 3.5 tons of hay, and with velvet beans 3.7 tons of sorghum per acre.

Now let us go back a few months and note the yield of the oat crop coming between the sorghum crops of 1900 and 1901.

Yield of oats in 1901 grown as the third crop after legumes.

Preceding crops:	Yield, oats per acre.	Increase after legumes.	
	Bus.	Bus.	%
Cotton in '98; cotton in '99; sorghum in 1900	23.3		
Cowpeas in '98; do do	26.5	3.2	14
Velvet beans in '98; do do	37.2	13.9	59

The fertilizing effect of the legumes was apparent in the third crop after the legumes, the increase where cowpeas had once grown being 3.2 bushels of oats per acre, or 14 per cent. The increase where velvet beans had been is suspiciously large, and in subsequent calculations it will be assumed that the increase in the yield on this plot if not influenced by accidental conditions would have been no greater than that on the plot once in cowpeas, viz., 3.2 bushels per acre.

Financial results of using cowpea vines as fertilizers for cotton, sorghum, oats, and late sorghum.

Let us convert these yields of cowpeas, cotton, sorghum, and oats into their money values to learn whether the introduction of cowpeas or velvet beans into the rotation has been profitable.

Value of crops per acre in three years (1) following cotton and (2) following cowpea vines.

	Value of crops per acre in			
	1899.	1900.	1901.	Total for 4 crops in 3 years.
Plot 3—No legume in 5 years:				
In '99, 837 lbs. seed cotton, at 2½c*	$20.92			
In '00, 5.1 tons sorghum hay, at $6.67 per ton		$33.02		$69.93
In 1901, 23.3 bus. oats, at 40c			$9.32	
In 1901, 1 ton sorghum hay			$6.67	
Plot 1, cowpeas in '98, picked and vines plowed under:				
In '99, 1,533 lbs. seed cotton at 2½c	$38.30			
In 1900, 8.1 tons sorghum hay		$54.00		$112.90
In 1901, 26.5 bus. oats, at 40c			$10.60	
In 1901, 1.5 tons sorghum hay			$10.00	
Difference in 3 years				$42.97
Average difference per year peracre				$14.32

*Equal to 6¾ cents per pound of lint, and $7.50 per ton of seed.

The total value of the products grown in three years on an acre was $69.93 on the plot where no legume had been grown for many years and $112.90 per acre on the plot where one crop of cowpeas had been grown once in four years, and where the vines, after the picking of the peas, had been plowed under at the beginning of the three-year period under consideration. The difference in the value of the crops for three years is $42.97; the average annual difference is $14.32 per acre in favor of the plot where cowpeas had been grown

The figures showing the financial advantages of using one crop of velvet beans for fertilizer during the same period so nearly correspond with those for cowpeas that the calculation need not be repeated.

On this land the plowing under of the vines of the cowpeas and velvet beans was exceedingly profitable. The

soil of these plots is a reddish, clayey loam, stiffer and probably more retentive of fertilizer nitrogen and humus than the greater portion of the soil on the Station Farm.

Lest any should misapprehend the lessons of this experiment it is necessary to state that at no time in the three-year period was any nitrogenous fertilizer applied to any crop on any of these plots, but that each crop was supplied with phosphate and potash.

The yearly application of cotton seed meal would have lessened the differences between the plots, as it has done in our unpublished rotation experiments, and would have made the advantage in favor of legumes less striking than in the exhibit above.

Immediate Fertilizing Effects on Cotton of Velvet Bean Vines.

On poor soil at Auburn an effort was made in 1898 and 1899 to ascertain the manurial value of the vines and stubble of velvet beans.

In 1898 cotton was grown on certain plots and velvet beans on others. The fertilization of all plots in 1898 was not identical, but for a given fertilizer applied to cotton there was a plot of velvet beans receiving the same fertilizer. The velvet beans grew in drills 3½ feet apart; the vines formed a dense mat of vegetation, but did not mature seed. In March, 1899, velvet beans and cotton stalks were plowed in and soon afterwards all plots were fertilized alike with a mixture of 240 pounds of acid phosphate and 40 pounds of muriate of potash per acre.

Russell cotton was planted in 3½ feet drills on all plots on April 21. From midsummer forward there was a remarkable difference in the appearance of the two

sets of plots, the cotton plants being much larger, greener, and more luxuriant on the plots where velvet beans had grown the year before.

Av. yield of seed cotton per acre following velvet bean vines	1,578 lbs.
Av. yield of seed cotton per acre following cotton	918 lbs.
Increase from velvet bean vines	660 lbs.

The average increase attributable to velvet beans used as a fertilizer was 660 pounds of seed cotton per acre, a gain of 72 per cent. as compared with the average yield on plots where the preceding crop had been cotton. At $2\frac{1}{2}$ cents per pound of seed cotton (equivalent to $6\frac{3}{4}$ cents per pound for lint and $7.50 per ton for seed) this increase is worth $16.50 per acre.

Residual fertilizing effects on corn of velvet bean vines.

The residual ,or second-year, effects were tested on corn planted on these plots March 29, 1900, without nitrogenous fertilizer.

Where cotton had grown in 1898 the yield of corn in 1900 was 18 bushels per acre; on the next plot, where velvet beans had been grown for fertilizer in 1898, the yield of corn in 1900 was 25.5 bushels. This gain of 7.5 bushels per acre, or 42 per cent., represents the residual or second-year effect of using the entire growth of velvet beans as a fertilizer.

IMMEDIATE AND RESIDUAL EFFECTS OF VELVET BEAN STUBBLE ON COTTON AND CORN.

In the same field the velvet beans on one plot were cut for hay October 12, 1898. The stubble and roots

were plowed in at the same time as the vines on the other plots referred to above.

Cotton on the plot where only roots and stubble were plowed in yielded in 1899 1,126 pounds of seed cotton per acre, an increase when compared with the plots where cotton had grown the previous year of 208 pounds, or 49 per cent.

Comparing velvet bean vines with velvet bean stubble the difference in favor of the vines was 452 pounds of seed cotton per acre in the first crop.

Corn in 1900 on this plot yielded 14 per cent., or 2.6 bushels per acre more than did corn on the nearest plot where in 1898 cotton instead of velvet beans had grown. As the stubble plot was slightly lower down on the hillside we suspect that the increase was partly due to this disturbing condition and not wholly to the residual effects of the velvet bean stubble of 1898.

It was on this stubble plot that in 1898 the velvet bean hay (8,240 pounds per acre) contained 188.7 pounds of nitrogen and the roots and stubble and fallen leaves only 12.5 pounds of nitrogen per acre. (See Alabama Station Bulletin, No. 104, page 336.)

Immediate Fertilizing Effects of Cowpeas on Oats in 1897.

"On sandy soil in 1896 several plots were sown broadcast with the Wonderful variety of cowpeas, and an adjacent plot was sown broadcast with German millet. The German millet was plowed under, as were also the peavines, the peas having been previously picked.

February 18, 1897, Red Rust Proof oats were sown after the above mentioned crops, using in both cases 100 pounds of acid phosphate and 80 pounds of nitrate of soda per acre.

After cowpeas the oat straw grew to be three to four inches taller than on the plot preceded by German millet. The yields were as follows:

Oats following cowpeas and German millet, 1897.

	Yield per acre.	
	Bus. Grain.	Lbs. Straw.
Oats after cowpeas, vines plowed under.....	22.8	788
Oats after German millet, plowed under.....	12.4	559
Difference per acre	10.4	229

In this case cowpeas were more valuable than German millet as fertilizer for the following oat crop, the difference in favor of cowpeas being 10.4 bushels of oats per acre and 229 pounds of straw." (From Bulletin No. 95, Alabama Experiment Station.)

This is an increase of 84 per cent. in grain.

Immediate Fertilizing Effect of Cowpea and Velvet Bean Vines and Stubble on Oats in 1898.

This experiment is descibed in the following quotation from Bulletin No. 95 of this Station:

"May 14, 1897, on poor sandy soil Wonderful cowpeas were sown on two plots, velvet beans on two plots, and German millet on a fifth plot. A sixth plot was prepared and fertilized but left without seed, to grow up in crab grass, poverty weed, etc. Cowpeas and velvet beans were sown in drills two feet apart, German millet broadcast. The millet was cut for hay July 16, yielding 994 pounds per acre. The cowpeas on one plot were picked September 10, yielding 11 bushels per acre.

The velvet beans did not mature seed.

In September, 1897, cowpeas on one plot and velvet

beans on one plot were cut for hay and the stubble plowed under. The vines of cowpeas on one plot and of velvet beans on another were also plowed under on the above mentioned date. Then oats were sown at a uniform rate on all four plots, also on the plot where the German millet stubble had been plowed under and on the one where crab grass and various weeds had just been buried by the plow.

On all plots oats were fertilized with 220 pounds per acre of acid phosphate and 44 pounds of muriate of potash, no nitrogen being supplied except that contained in the remains of preceding crops of cowpeas, velvet beans, etc.

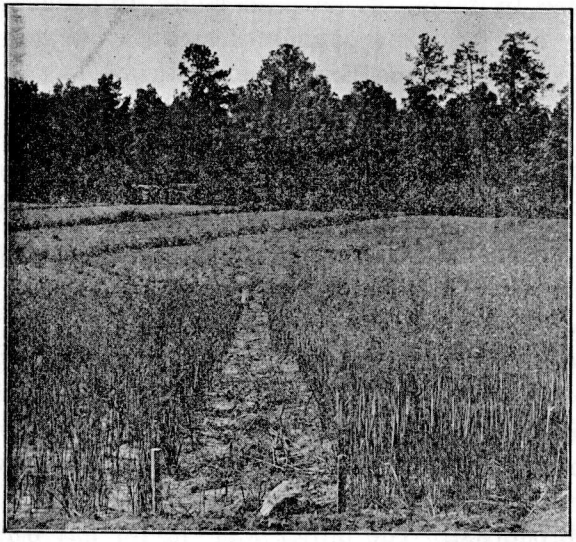

FIGURE 1. Oats following cowpea stubble on the right; on the left oats after crabgrass.

Yield per acre of oats grown immediately after stubble or vines of cowpeas, velvet beans, etc.

Plot No.		Yield per acre.	
		Grain.	Straw.
		Bus.	Lbs.
1	Oats after velvet bean vines	28.6	1206
6	Oats after velvet bean stubble	38.7	1672
	Average after velvet bean vines and stubble	33.6	1439
4	Oats after cowpea vines	28.8	1463
3	Oats after cowpea stubble	34.4	2013
	Average after cowpea vines and stubble	31.6	1738
2	Oats after crab grass and weeds	7.1	231
5	Oats after German millet	9.7	361
	Average, after non-leguminous plants	8.4	296

From early spring there was a marked difference in the appearance of the several plots, the plants being much greener and taller where either the stubble or vines of cowpeas had been plowed under.

When the oats began to tiller, or branch, the difference increased, the plants supplied with nitrogen, through the decay of the stubble or vines of cowpeas and velvet beans, tillering freely and growing much taller than the plants following German millet or crab grass. The difference in the height and thickness of the oats on some of the plots is shown in figures 1 and 2.

May 18, 1898, oats on all plots were cut.

In this experiment the average yield of oats was 33.6 bushels after velvet beans, 31.6 bushels after cowpeas, and only 8.4 bushels after non-leguminous plants (crab grass, weeds and German millet.)

Here is a gain of 24.2 bushels of oats and nearly three-fourths of a ton of straw as a result of growing leguminous or soil-improving plants, instead of non-leguminous plants, during the preceding season.

Undoubtedly this is an extreme, and not an average, case. If cotton seed meal, or other nitrogenous fertilizer, had been used on all the plots of oats, the plants on plots 2 and 5 would have made better growth, and the difference in favor of the leguminous plants would have been reduced.

A gain of five to fifteen bushels of oats per acre as a result of plowing under cowpea stubble or vines would make the growing of cowpeas for fertilizer a profitable operation, and it is far safer to count on such an increase as that obtained in our first experiment (10.4 bushels), rather than to expect such an exceptional increase as that obtained in this last experiment.

An unexpected result of this experiment is the larger crop on the plots where only the stubble was left than on those where the vines of cowpeas and velvet beans were plowed under. The plots were of nearly uniform fertility, as judged by the location and by the uniform growth of cotton on all plots in 1896. While admitting the possibility that the two west plots (plots 3 and 6) were slightly richer than the two on the east (plots 1 and 4), the writer thinks that the difference in yield was almost wholly due (1) to the fact that the vines (especially those of the velvet beans) were not properly buried by the small plow employed, and (2) that the seed bed for oats was more compact where only stubble was plowed under, a point of advantage, doubtless, in such a dry winter as that of 1897-98. It does not follow that the land will be permanently benefitted by cowpea stubble to a greater extent than by cowpea vines. The reverse is probably true." (From Bulletin No. 95, Alabama Experiment Station.)

Residual fertilizing effect on late corn of cowpea and velvet bean vines and stubble.

On June 20, 1898, or a month after the harvesting of the oats in the last mentioned experiment, all six of these plots were planted in corn without nitrogenous fertilization, which crop, as usual with very late corn on poor upland, was a failure.

The yields were as follows:

Yields of late corn grown as the second crop after legumes.

Crop in 1897:	Yield per acre.	Increase after legumes.
	Bus.	
Crab grass, plowed in	4.3	
German millet, stubble plowed in	7.3	
Cowpeas, stubble plowed in	6.2	.4
Velvet beans; stubble plowed in	7.7	1.9
Cowpeas, picked; vines plowed in	6.7	.9
Velvet beans; vines plowed in	7.9	2.1

The fertilizing effects of both stubble and vines of cowpeas was scarcely perceptible in the late corn planted eight months after and harvested thirteen months after the plowing under of the large amounts of nitrogen furnished by the legumes. Apparently the crop failure was not due to deficient rainfall, for this was ample except for about two weeks about the middle of August. The small size of stalks leads to the suspicion that there was a deficiency of nitrogen on all plots. If this nitrogen was lost by being leached out in the draining water this loss must have occurred almost entirely after corn was planted or in July and August; for in 1898 April, May, and June were unusually dry months. On the other hand there was a period of excessive rainfall July 4 to 11 and of still greater excess July 28 to August 6. During this latter

period 7.59 inches of rain fell in a space of ten days.

The experiment seems to teach that on very light, gray, sandy upland, subject also to surface washing, the fertilizing effects of even large amounts of nitrogen furnished by preceding crops of legumes may be removed from the soil within twelve months after the legume has been plowed in. The lesson might also be drawn that on such soils the planting of any non-leguminous crop after small grain is risky, but that if such a crop is employed the seed should be put into the ground as soon as possible after the removal of the grain crop.

An experience like this in which the fertilizing effect of the entire or nearly entire growth of the legume was no greater than that of the stubble on either the first or on the second succeeding crop emphasizes the wisdom of utilizing the vines of cowpeas, etc., for food, leaving only the roots and stubble to fertilize the next crop.

Immediate Fertilizing Effect on Wheat of Cowpea and Velvet Bean Vines and Stubble.

All the plots of the last mentioned experiment were in oats from February to June, 1900.

June 23, 1900, certain plots were planted with drilled cowpeas, certain others with drilled velvet beans, and yet others were merely plowed and fertilized with minerals, as were the legumes.

Of the two plots of cowpeas, one was cut for hay, yielding 2,004 pounds per acre; on the other 7.9 bushels of seed per acre were picked. One plot of velvet beans was cut for hay, while on the other the vines were left on the ground for fertilizer. The cowpea plants, variety Wonderful, were somewhat injured by a fungous disease of the roots; velvet beans, by reason of late date

of planting and deficiency in stand, did not make an entirely satisfactory growth.

November 9 all plots were plowed, turning under either volunteer grass and rag weeds, or cowpea vines, or velvet bean vines, or cowpea stubble, or velvet bean stubble. The plowing was poorly done with a one-horse turn plow and in sowing the wheat a few days later some of the velvet bean vines were pulled up. The wheat received only mineral fertilizers, and, indeed, practically no nitrogen had been applied to these plots for three years.

The yields of wheat in 1900 were as follows:

Bushels of wheat per acre after leguminous and non-leguminous crops:

Crop in 1899.	Yield per acre.	Increase by use of legumes.	
	Bus.	*Bus.*	*%*
Crab grass and weeds; plowed in	3.1		
Cowpeas; stubble plowed in	11.8	8.7	280
Velvet beans; stubble plowed in.....	7.8	4.7	151
Cowpeas, picked; vines plowed in	9.0	5.9	190
Velvet beans; vines plowed in.....	8.5	5.4	174

Both the stubble and the vines of the legumes practically trebled the yield obtained on the plots where no legume had grown. The stubble was at least as effective as the vines, pointing to the greater economy of utilizing the vines for hay or pasturage.

June 19, 1900, all these plots were planted with Mosby corn, fertilized only with phosphate and muriate of potash. The crop was a failure on all plots, the yield of cured fodder corn ranging from 1,540 to 2,200 pounds per acre, the plots where vines had been plowed in the previous fall showing no superiority over the stubble plots, and very little increase as compared with the plot where no legume had grown. It is impossible to ascertain whether the failure with corn was due to the

protracted drought during almost the whole of July or to the leaching out of the nitrogen of the legumes during the last few days in June, when 5.20 inches of rain fell within a period of four days. The latter explanation seems more probable in view of the fairly favorable rainfall after August 1, 1900, and because of similar failure of the late corn crop on the same field in 1898, when there was no long period of drought, but a brief one of even more excessive rainfall.

The history of these six plots for these four years ending with 1900 as just detailed shows very plainly that the fertilizing effects of nitrogen very quickly disappear on this light sandy sloping field, not underlaid by a clay or clayey loam subsoil; and that on such soils the stubble of cowpeas or velvet beans was as efficient as the vines, not only for the immediately succeeding crop, but for later crops as well. This narrative should add force to the recommendation we have so often given that as far as possible the stems, foliage and seed of legumes be utilized as food for animals and only what remains be employed as fertilizer.

Fertilizing Effects of Velvet Beans, and Peanuts; as Compared with Corn, Sweet Potatoes and Chufas.

On a gray sandy upland soil, free from stones and underlaid by a sandy subsoil, various crops were grown in 1899, for the double purpose of comparing them as to the amount of hog food produced and as to their effeet in enriching or depleting the soil. The chufas and a part of the Spanish peanuts were consumed by shoats penned on the field. As the running variety of peanuts failed this season to make any nuts the luxuriant growth of vines was plowed under in the fall, as was also done with the vines of velvet beans and with

cowpea vines after the latter had been picked. Only the ears of corn were removed from the land, and only the roots of sweet potatoes.

Rye, sown broadcast on November 13, 1899, on all plots, was employed as the crop for determining what effect the various summer crops had exerted on the fertility of the soil. The fertilizer for rye consisted of the following amounts per acre:

80 pounds of cotton seed meal.
160 pounds of ammoniated acid phosphate.
64 pounds of muriate of potash.

The effects of the legumes as fertilizers for rye would have been more striking if no cotton seed meal or ammoniated guano had been employed, but the poverty of this sandy soil made some nitrogen indispensible if absolute failure of crop was to be avoided on the plots where sweet potatoes, chufas and corn had grown.

The rye was cut April 13 and April 16, and the green forage at once weighed. No second cutting of rye was made, but the land was turned to other uses.

Yields of rye following sweet potatoes, corn, chufas, peanuts, cowpeas and velvet beans.

Preceding crop.	Yield per acre.	Increase from legumes as compared with sweet potatoes.	
	Lbs.	Lbs.	%
Rye, after sweet potatoes dug (av. 2 plots)..	2360		
Rye, after corn, ears pulled	3440	1080	41
Rye, after chufas, eaten on the land.....	4560	2200	93
Rye, after Spanish peanuts; dug and only nuts removed	3440	1080	41
Rye, after Spanish peanuts; eaten on the land	6640	4280	181
Rye, after Whippoorwill cowpeas, drilled and picked (diseased)	4960	2600	110
Rye, after velvet beans, entire growth plowed in (av. 2 plots)	5720	3360	142
Rye, after velvet beans, nearly mature pods picked, vines plowed in	4720	2360	100
Rye, after running peanuts, entire growth plowed in (av. 2 plots)	5212	2852	121

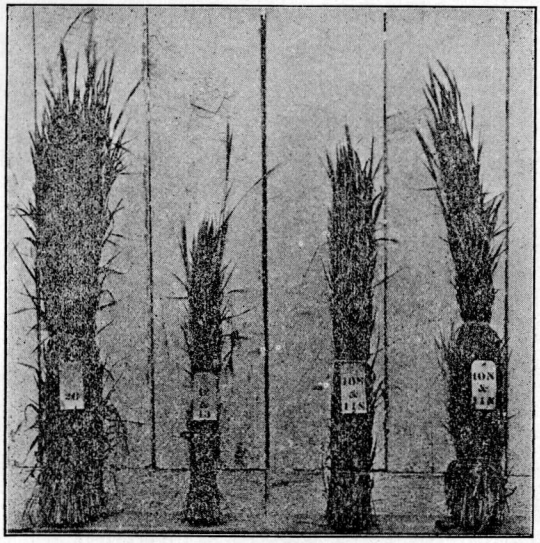

FIGURE 2. Rye from equal areas, following (20 velvet beans: and (12 & 13) sweet potatoes; (10 S & 11 S.) corn; (10 N. & 11 N.) chufas hogged

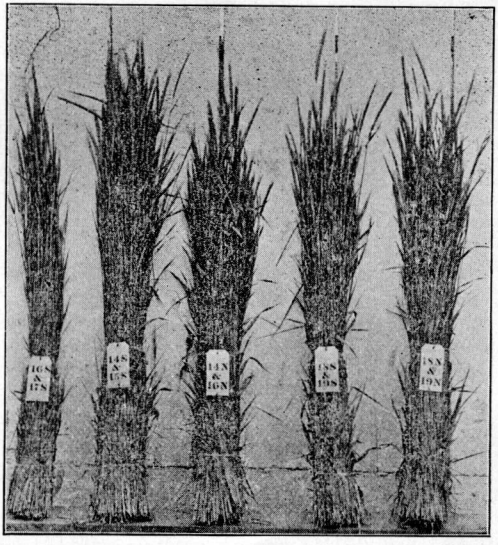

FIGURE 3. Rye from equal areas, following (16 S. & 17 S.) Spanish peanuts, dug; (18 S. & 19 S.) cowpeas; 14 N. & 15 N.) running peanuts.

The legumes increased the yield in every case as compared with sweet potatoes, the excess ranging from 41 to 181 per cent. Among the non-leguminous plants sweet potatoes was most exhausting to the soil, and chufas, when consumed on the land, the least. This agrees with common observation. In this case the exhausting effects of the sweet potatoes were not due to leaching of the disturbed soil, for all plots were plowed soon after the potatoes were dug.

Among the legumes the greatest increase, 181 per cent. was obtained on the plot where Spanish peanuts had been consumed on the land by hogs. Since the yield of peanuts here was not excessive, since the growth of tops was only moderate, and since the vines of Spanish peanuts on an adjoining plot did not greatly increase the yield, we can attribute the increase where hogs had grazed, only to an assumed quicker nutrification of the material that had passed through animals. This view finds further support in the fact that chufas consumed by hogs on the land left the soil in better condition than did either corn or sweet potatoes.

Wherever the entire growth of the several legumes was left on the land, with or without being utilized as hog food, the succeeding yield of rye was more than doubled.

Cotton was grown in 1899 on a plot adjacent to the legumes. The rye following cotton yielded 5,560 pounds per acre, but it is not fair to compare this yield with that following the legumes, because the cotton had been very heavily fertilized, and some of this fertilizer probably remained in the soil to be utilized by the rye.

Fertilizing effects of legumes on sorghum grown as the second crop.

To ascertain what differences still existed in the soil as a result of legumes grown in the summer of 1899, sorghum was sown in drills on this same field June 19, 1900, all plots being uniformly fertilized with acid phosphate. So that sorghum thus becomes the second crop after the various legumes, and is intended to reveal the residual or "left over" effects of the summer crops of 1899.

Residual fertilizing effects on sorguhm, of peanuts, cowpeas and velvet beans.

Preceding crops.		Yield sorghum hay per acre.	Increase from legumes as compar'd with sweet potatoes.
Summer of 1899.	Winter, 1899, 1900.		
		Lbs.	*Lbs.*
Sweet potatoes, dug	Rye	5360	
Corn, ears pulled	Rye	5760	400
Spanish peanuts, dug; nuts removed	Rye	4480	loss.
Spanish peanuts; eaten on land	Rye	4000	loss.
Cowpeas, picked	Rye	5760	400
Velvet beans, all plowed in	Rye	7110	1750
Velvet beans, pods picked	Rye	7600	2240
Running peanuts, all plowed in	Rye	6320	960
Cotton, heavily fertilized	Rye	4000	loss.
Av., potatoes, corn, cotton	Rye	5040	
Av., velvet beans, cowpeas, running peanuts	Rye	6697	1657

Evidently rye had not exhausted all the fertilizing value of the legumes. This second crop was favorably affected by all the legumes except by Spanish peanuts, the benefits of which had disappeared. The average increase on the plots where all the other legumes had grown the preceding summer was 33 per cent. as compared with the yield on the plots where corn, cotton and sweet potatoes had constituted the summer crops in 1899.

Relative Fertilizing Values of the Cowpea and Velvet Bean.

When tested on a number of crops, each grown *immediately after* the legumes, the percentage increase as compared with corresponding plots that had borne no legume was 128 per cent. from peavines, and also 128 per cent. from velvet bean vines. Additional weight is given to these figures since they represent the average of six tests with each plant. Continuing the inquiry as to their comparative value, we find that the second crop after cowpea vines showed an increase of 37 per cent. and the second crop after velvet bean vines an increase of 48 per cent. This is the average result of two comparable tests with each plant.

Comparing these two plants with reference to the fertilizing effect of the stubble on the first crop we find as the average of three tests an increase that is practically the same for the two plants.

Combining the results for the vines of each legume as shown in the first and second succeeding crops with the immediate results from the stubble of each we must conclude that at Auburn the fertilizing values of the cowpea and velvet bean are practically equal. This is true for an acre of each. In the stubble plots the average yield of velvet bean hay has been the greater, that is 4,781 pounds per acre of velvet bean hay against 3,278 pounds of cowpea hay, so that apparently pound for pound the cured tops of cowpeas have been somewhat more effective than the vines of velvet beans. This is in practical accord with the results of chemical analyses made at this station by Dr. Anderson, who analyzed peavine hay and velvet bean hay from plots where the stubble was used as fertilizer. He found 2.29 per cent. nitrogen in velvet bean

vines and 2.46 per cent. of nitrogen in the cowpea vines, both samples containing 9 per cent. moisture. The nitrogen in the two stubbles was practically equal, 1 per cent.

Let us now consider the results as a whole, combining those for the two plants and assuming that the fertilizing value of cowpea vines and of velvet bean vines are equal, and that the stubble of the one plant is as effective as that of the other. In what follows the figures express the average results for cowpeas and velvet beans considered together under the name of summer legumes.

Increase in the First Crop After Plowing in the Vines of Summer Legumes.

With cotton as the first crop the increase in seed cotton per acre at Auburn was respectively 367, 546, 696, and 660 pounds of seed cotton per acre. This is an average increase of 567 pounds, worth at $2\frac{1}{2}$ cents (equal to $6\frac{3}{4}$ cents for lint, $7.50 per ton for seed) $14.17.

The yield of *seed cotton* following the vines of the summer legumes exceeded that on plots where the preceding crop had been cotton to the extent of 32, 64, 83, and 72 per cent. *The average increase in the yield of seed cotton attributable to the vines of the legumes was* 63 *per cent.*

With *corn* as the first crop, the increase per acre attributable to plowing in the entire growth of velvet beans was 81 per cent. or 12.3 bushels, worth, at 50 cents per bushel, $6.15.

With *oats* as the first crop, the effect of the vines of the summer legumes is seen in an increase per acre of 10.4, 20.2, and 20.4 bushels respectively. The average

increase per acre was 17 bushels, worth at 40 cents per bushel, $6.80. *The increase in the first crop of oats after summer legumes was* 84, 240 and 242 per cent., *an average of 189 per cent.*

With *wheat* the increase was 5.4 and 5.9 bushels, an average of 5.65 bushels per acre, worth at 80 cents per bushel, $4.53. *The increment was* 174 and 190 per cent. respectively, an average gain of *182 per cent.*

With *sorghum* grown as the first crop after the plowing under of the vines of cowpeas and velvet beans, the increase in hay per acre was 1.6, 1.6, 2.07, and 3.11 tons, an average gain per acre of 2.1 tons of hay, worth, at $6.67 per ton, $14.02. The percentage gains were 85, 86, 57, and 86, respectively, *an average of 78 per cent.*

Increase in the First Crop After Plowing in the Stubble of Cowpeas and Velvet Beans.

With *cotton* the yield was greater after velvet bean stubble than after cotton to the extent of 18 per cent., or 208 pounds of seed cotton per acre, worth, at $2\frac{1}{2}$ cents per pound, $5.20.

With *corn*, the stubble of velvet beans afforded a gain of 32 per cent. or 4.3 bushels, worth $2.15.

With *oats* grown after the plowing in of the stubble of these summer legumes the increase was 30.3 and 26 bushels, or an average of 28.1 bushels per acre, worth $11.24. This is an average gain of 334 per cent.

With *wheat* following the stubble of cowpeas and velvet beans the increase was 4.7 and 8.7, *an average of* 6.7 *bushels per acre, worth* $5.36. The gain amounted to 151 and 280 per cent. respectively, an average of 215 per cent.

With *sorghum* the yield of hay was increased by the

stubble of the legumes to the extent of 2.01 and 2.15 tons, an average of 2.08 tons of hay per acre, valued at $13.87. *The average increase was* 57 *per cent.*

What Crops Were Most Favorably Affected by the Vines or Stubble of Cowpeas and Velvet Beans.

The data in the following table answer this question.

Increase in first crop attributable to vines or stubble of cowpeas and velvet beans.

Test Crop.	After Legume Vines.			After Legume Stubble.		
	No. of Tests	% Increase	Value of Increase	No. of Tests.	% Increase.	Value of Increase.
Cotton	4	63	$14.17	1	49	$11.30
Corn	1	81	6.15	1	32	2.14
Oats	3	189	6.80	2	334	11.24
Wheat	2	182	4.53	2	215	5.36
Sorghum	4	78	14.02	2	57	13.87

The percentage increase attributable to either the vines or stubble of cowpeas and velvet beans was greater with fall oats and wheat than with cotton, corn or sorghum. In other words, the *crop that was best able to utilize the nitrogen of the legumes was that one which left the land unoccupied for the shortest time between the maturing of the legume and the beginning of the new growth.* Unpublished parallel experiments with hairy vetch employed as fertilizers confirm this latter conclusion. All the facts before us indicate that after the vines or stubble of a legume are plowed under in a sandy soil the seed of the succeeding crop should be planted before the lapse of many weeks. The early occupation of the soil by roots of the young plants will serve to retain much nitrogen, which would be leached out and carried away in the drainage water if the ground should remain unoccupied for several months.

From what has just been said it should not be inferred that we are advocating the sowing of the small grains or of any small seed immediately after plowing in a large mass of vines. Instead, sufficient time should be given for the soil to become somewhat settled by the action of the rain or of harrow, drag, or roller. Small grain and still smaller seed can usually be sown after a shorter interval where the vines of the legume are utilized for hay or pasturage, leaving only the roots and stubble to be incorporated, than where the entire growth of the legume is turned under in the fall for fertilizer.

If plowing under of cowpea vines takes place after Christmas the mass of vegetable matter will have become so diminished and the stems so weak that the delay in sowing to permit of the compacting of the earth around the vegetable matter will be less necessary, or perhaps unadvisable. But this interval may be quite necessary with velvet bean vines at whatever time they are plowed under, for the mass of matter will be considerable and the material is apt to be buried in large wads.

Referring again to the last table, we see that while the small grains gave the largest percentage increase from the use of a preceding summer legume as fertilizer, the value of the increase was greatest with cotton and sorghum hay. In other words, *cotton made more profitable use of either the vines or stubble of the summer legumes on sandy land than did either corn, oats, or wheat.*

Sorghum responded freely to the abundant supply of nitrogen in the legumes, and it may be accepted as a thoroughly tested proposition that on poor or medium soil any hay plant of the grass family will return a large profit for a judicious application of nitrogen,

whether this be in the form of a preceding crop of cowpeas, velvet beans, melilotus, hairy vetch, or crimson clover, or in an application of stable manure, cotton seed, cotton seed meal, or nitrate of soda.

Rotation of Crops the First Step in Soil Improvement.

The general statement may be safely made that any ordinary crop (except peanuts, cowpeas and most other legumes) can usually be produced with far greater profit when it follows some leguminous plant than when its predecessor is some non-leguminous plant, as cotton, corn, the small grains, etc. It may also be added that many, if not most, poor tracts of land can be cultivated in the usual farm crops at a profit only when a legume is occasionally grown to supply the necessary nitrogen, vegetable matter, and improvement in texture and resistance to drought.

A more general use is urged of some rotation that requires all the cultivated upland of the farm to bear cowpeas or other soil-improving plant every second, third or fourth year or oftener. The growing of legumes constitutes the cheapest means of obtaining nitrogenous fertilizers, and on farms where a large proportion of the land is devoted to legumes, the fertilizer bills can be reduced by the discontinuance of purchases of cotton seed meal and by the substitution of high grade acid phosphate for the higher priced ammoniated guanos.

A highly satisfactory rotation for cotton plantations, which has been widely tested, consists of the alternation in the order named of cotton, corn, and any one of the small grains, with cowpeas between the corn rows and also immediately following the small grains. This three-year rotation gives one-third of the land

each year in cotton, the cotton immediately following cowpeas sown after small grain. One-half the total area can be devoted to cotton by a four-year rotation on this plan, as follows: Corn with cowpeas, small grain followed by cowpeas, cotton, and cotton.

The Average Immediate Fertilizing Effects of Vines as Compared with Stubble of Cowpeas and Velvet Beans.

Although in the last table a comparison of the percentage increase after vines with that after stubble is not strictly legitimate since the number of tests was unequal, yet that table throws some light on the matter.

A strictly accurate comparison of the fertilizing effects of vines and stubble as measured by the crop immediately following is shown below; in this table only those experiments are recorded where corresponding vine and stubble plots were under identical conditions of soil, date of planting, etc.

Increased percentage of vine plots over stubble plots.

	No. of tests.	%
With cotton as first crop	1	40
With corn do	4	49
With oats do	2	[31]*
With wheat do	2	[20]*
With sorghum do	2	9

*Yield after legume stubble 31 and 20 per cent. respectively greater than after vines, the latter leaving the land too loose, a condition that could probably have been avoided by better preparation.

In the crop immediately following the legumes the vines afforded the larger yield except when accidental circumstances reversed this result with wheat and oats. This excess in the first crop due to plowing under the

vines was here considerable, but was it sufficient to make this method of disposing of the vines more profitable than to use them for hay?

Of the several factors on which the answer depends, we will first consider the value per acre of the increase in the first crop immediately succeeding the legume, using the values for a unit of each crop heretofore assumed (see p....) and omitting results with small grains, for reasons given in the footnote.

Average superiority of vines over stubble of legumes as shown in first crop.

	No. of tests.	Increase per acre.	Value of increase	% increase
With cotton as first crop.	1	452 lbs. seed cotton	$11.30	40
With corn as first crop	4	6.6 lbs. corn.....	3.30	49
With sorghum as first crop...	2	.5 ton hay.....	3.34	9
Average in favor of vines over stubble	.....	....	**$5.98**	

The average increase of $5.98 in the value of an acre of the first crop in favor of plowing in the vines as compared with utilizing only the stubble for fertilizer is evidently so low as to be much less than the value of the 4,030 pounds of legume hay per acre obtained from the stubble plots, which should be priced at not less than $10 per ton. As a partial offset we must bear in mind that in four of the experiments in plowing under cowpea vines the peas were first picked, the average yield in these tests being 11.1 bushels per acre. There is no such corresponding offset with velvet beans, for the seed usually do not mature in the latitude of Auburn.

If we value cowpeas at 50 cents per bushel, plus the cost of hand-picking, we have a second credit for the vines, the sum being $5.55. Adding this to $5.98, the

extra value of the first crop after vines, as compared with stubble, we have a total credit for the vines when used as fertilizer of $11.53 per acre in comparison with the value of the cowpea and velvet bean hay when utilized as stock food. The average yield of cowpea hay from the stubble plots was 3,278 pounds per acre, and of velvet bean hay 4,781 pounds, or a collective average of 4,030 pounds of legume hay per acre. At $10 per ton, this would be worth $20.15 per acre. Subtracting from this, $9.50 as above, we have $8.47 as the difference in the *first year's profits* in favor of utilizing the vines as hay. However, other factors must be considered before we have satisfactorily determined whether it was most profitable to use the vines after picking the peas or to utilize the tops of both cowpeas and velvet beans for hay; chief among these factors are the relative residual fertilizing values of vines and stubble as shown by differences in the yield of the second and subsequent crops after legumes.

What is the Fertilizing Effect of Vines and Stubble of Cowpeas on the Second Crop After the Legume?

The answer is found in the following table:

	Average increase in second crop after legumes.					
	After vines.			After stubble.		
	No. of tests.	Amt. increase.	% increase.	No. of tests.	Amt. increase.	% Increase.
With corn	5	3.36 bus.	24	5	1.34 bus.	12
With oats	1	7.75 bus.	54			
With sorghum	4	2.15 tons	41			

In the second crop after the legumes there was in every case a considerable increase attributable to the use of the vines as fertilizer.

The fertilizing effect of the stubble as shown by the second crop of corn is much less than the increment due to the vines plowed under many months before.

There is a sixth test with corn not belonging in the preceding table, that gives additional data for a comparison of the second-year effects of vines with stubble. Combining the results of the six tests, we find that the corn grown as the second crop after legumes afforded a larger yield on the vine plots than on the stubble plots to the average extent of 2.1 bushels per acre, or 14 per cent.

The Duration of the Fertilizing Effects of Stubble and Vines of Cowpeas and Velvet Beans.

The stubble of these legumes repeatedly exerted so slight an effect on corn grown as the second crop, (an average of only one and one-third bushels per acre), that we may reasonably conclude that two crops mark the limit to which the benefits of legume stubble extends in cases where the soil is sandy and permeable, as at Auburn. It is quite possible that the advantages from using stubble as fertilizer might have been slightly more enduring in a stiffer soil, but in no case can such a relatively small amount of vegetable matter and nitrogen afforded by the roots and stubble influence the succeeding crops more than a few years.

It is quite a different matter when the vines, representing the entire growth of the legume (except in some cases the pods) are plowed under. We have learned from the data in previous tables that the yield where the vines were used as fertilizer was in the first crop, 63 to 189 per cent. greater than the yield of the corresponding crop immediately preceded by a non-legumenous plant; and that in the second crop the increase

ranged from 24 to 54 per cent. The effect exerted by the vines of the legumes on the third succeeding crop was tested in only one field, the increase in oats as the third crop after cowpea vines being 3.2 bushels per acre, or 14 per cent. With sorghum planted in 1901 as the fourth crop immediately after the oats were cut, there was a perceptible increase on the plots where the vines of cowpeas and velvet beans grown in 1898 had been plowed under; extremely unfavorable conditions and partial failure of late sorghum detract from the reliability of the percentage figures for this, the fourth crop. For three years or four crops the large mass of vines continued to exert some influence. This experiment was conducted on a soil of the stiffest type found on the station farm, which, however, is fairly permeable to water, and which might be described as a reddish loam containing an abundance of large flint stones.

We should expect an equal mass of leguminous vegetation employed as fertilizer on clay or prairie soils to exercise a favorable influence for at least three years, or probably for as long a period as do heavy applications of coarse stable manure. Local experiments to determine the permanency of the action of the legumes are greatly needed, and correspondence is invited from parties wishing to make such tests.

It is our expectation to continue work along the lines indicated in this bulletin, and it is highly desirable that these investigations should be extended to include soils of a character different from that at Auburn, though the means of doing this in a thoroughly satisfactory manner are not now in sight.

In conclusion the writer would reaffirm his previous statement, made in Bulletin No. 107 of this station, as follows:

A Rational System of Fertilization.

Considering permanency of effect, as well as influence on the crop immediately following, the cowpea and other leguminous plants must be ranked as a cheaper source of nitrogen than is any nitrogenous material which may be bought as commercial fertilizers. The aim of the cotton farmer should be to grow such areas of legumes as will enable him to dispense with the purchase of nitrogenous fertilizers for cotton, using the funds thus saved to purchase increased amounts of phosphates or other necessary non-nitrogenous fertilizers. The money that would have been necessary to purchase one pound of nitrogen will buy about three pounds of phosphoric acid, or of potash, which larger purchases of phosphate and potash will enable the farmer to grow heavier crops of legumes. And heavier crops of legumes trap larger amounts of otherwise unavailable atmospheric nitrogen and result in further soil enrichment.

In the writer's opinion *the most promising method of increasing the yield of cotton per acre and the profits of cotton culture is by a more general use of leguminous plants as fertilizers.* These invaluable allies are by some farmers utilized and appreciated, but their use might be increased twentyfold with advantage to the current crop, to the permanent upbuilding of the soil, and to the filling of the farmer's pocket. It is putting the case very mildly to say that the average yield of cotton per acre in Alabama might be increased by at least fifty per cent. through the general use of legumes as fertilizers.

APPENDIX. Condensed statement of effects of using cowpea and velvet bean vines or stubble as fertilizers at Auburn.

Legumes.	Vines or stubble.	Test crop.			Amt. per acre, increase.		Per cent increase.		Superiority of vines over stubble		Yield of legumes per acre.		Field.
		Plant.	1st or 2nd after legumes	Year grown	From vines.	From stubble.	From vines.	From stubble.	Am't per acre.	Per cent.	Lbs. hay.	Bus. cow-peas.	
Cowpea	V. & S.	Corn	1st	'01					8 88	78	1648		D
Cowpea	V. & S.	Corn	1st	'01					.60	2	3920		M
Cowpea	V.	Cotton	1st	'99	367		32					11.8	D
Cowpea	V.	Oats	2nd	'00	5 8*		29*						D
Cowpea	V.	Oats	2nd	'00	9.7		79						D
Cowpea	V.	Sorghum	1st	'97	1.6		86						F
Velvet bean	V.	Sorghum	1st	'97	1.6		85						F
Velvet bean	V.	Corn	1st	'01	12 3		81		5.0	28			D
Velvet bean	S.	Corn	1st	'01		4.3		32			3632		D
Velvet bean	V. & S.	Corn	1st	'00					11 9	76	2800		D
Velvet bean	V. & S.	Corn	2nd	'01					3.9	33			D
Cowpea	V.	Sorghum.	1st	'99	2.1		57		0.1	1		13.6	T
Cowpea	S.	Sorghum.	1st	'99		2 0		55			6400		T
Velvet bean	V.	Sorghum.	1st	'99	3.1		86						T
Velvet bean	S.	Sorghum.	1st	'99		2.2		59			5360		T
Cowpea	V.	Corn	2nd	'00	3.6		15		2.0	8			T
Cowpea	S.	Corn	2nd	'00		1 6		6					T
Velvet bean	V.	Corn	2nd	'00	2.6		11		2 4	10			T
Velvet bean	S.	Corn	2nd	'00		.2		1					T
Velvet bean	V.	Cotton	1st	'99	546		64						T
Cowpea	V.	Cotton	1st	'99	696		83						T
Velvet bean	V.	Sorghum	2nd	'00	3.1		61						T
Cowpea	V.	Sorghum	2nd	'00	3.0		59						T
Velvet bean	V.	Oats	3rd	'01	3 2**		14						T
Cowpea	V.	Oats	3rd	'01	3 2		14						T

Velvet bean	V.	Sorghum.	4th	'01	0.5		60						T.
Cowpeas	V.	Sorghum.	4th	'01	0.5		50						T.
Velvet bean	V.	Cotton.	1st	'99	660		72						T.C.
Velvet bean	S.	Cotton.	1st	'99		208		18	452	40			T.C.
Velvet bean	V.	Corn.	2nd	'00	7.5		42		2.6	10			T.C.
Velvet bean	S.	Corn.	2nd	'00		2 6		14					T.C.
Cowpea	V.	Oats.	1st	'97	10.4		84						M.
Velvet bean	V.	Oats.	1st	'98	20.2		240						F.
Velvet bean	S.	Oats.	1st	'98		30.3		360	¶7 6	¶27	3872		F.
Cowpea	V.	Oats.	1st	'98	20 4		242					11.	F.
Cowpea	S.	Oats.	1st	'98		26 0		309	¶10.1	¶35	2420		F.
Velvet bean	V.	Corn, late	2nd	'98	2 1		36		0 7	9			F.
Velvet bean	S.	Corn. late	2nd	'98		1 9		33					F.
Cowpea	V.	Corn. late	2nd	'98	0 9		16						F.
Cowpea	V.	Corn, late	2nd	'98		0.4		7	¶1.0	¶6			F.
Velvet bean	V.	Wheat.	1st	'00	5.4		174						F.
Velvet bean	S.	Wheat.	1st	'00		4.7		151					F.
Cowpea,	S.	Wheat.	1st	'98	5.9		190					7 9	F.
Cowpea	V.	Wheat.	1st	'00		8.7		280	¶2 8	¶31	2004		F.
Sp. Peanuts	††	Rye	1st	'00	4280		181						F.
do. nuts remv'd		Rye	1st	'00	1080		41						F.
Run'g Peanuts.	All.	Rye	1st	'00	2852		121						F.
Cowpea	V.	Rye	1st	'00	2600		110						F.
Velvet bean	V.	Rye	1st	'00	2360		100						F.
Velvet bean	All.	Rye	1st	'00	3360		142						F.
Sp. Peanuts	V.	Sorghum.	2nd	'01	Loss.		Loss.						F.
Run'g Peanuts.	All.	Sorghum.	2nd	'01	960		16						F.
Cowpeas	V.	Sorghum.	2nd	'01	400		7						F.
Vel. beans (av.)	V.	Sorghum.	2nd	'01	1995		37						F.

* Nitrate of soda used both on non-legume and legume plot.
** Reducing the increase to that on corresponding cowpea plot.
¶ Stubble afforded the larger yield.
†† Peanuts eaten by hogs on land where grown.