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THE USE OF WINTER LEGUMES IN THE SOUTHEASTERN STATES

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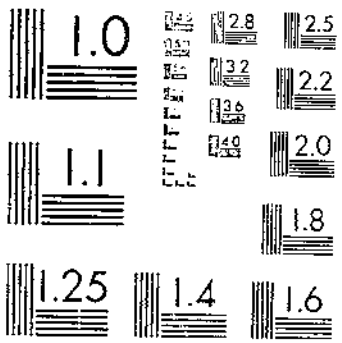

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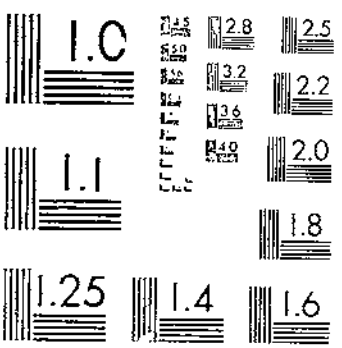

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TECHNICAL BULLETIN No. 367 June, 1933

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C.

THE USE OF WINTER LEGUMES IN THE SOUTHEASTERN STATES

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INTRODUCTION

The primary purpose of planting winter legumes in the South is to enrich the land; they are plowed down in the spring to fertilize corn, cotton, and other crops. The secondary use of winter legumes is for hay and grazing and the prevention of soil erosion.

"Winter legumes" usually mean those legumes that are planted in the fall and that ripen about the same time as winter wheat or oats. In the Southeast, hairy vetch (*Vicia villosa*) has led all other winter legumes, with Austrian winter peas (*Pisum arvense*) a good second. Crimson clover (*Trifolium incarnatum*) stands third in importance in that area and southern bur clover (*Medicago arabica*) stands fourth. Sour clover (*Melilotus indica*), which is used as a winter legume in Louisiana and Arizona, volunteers naturally in the black lands of Alabama and Mississippi.

The need for improved methods of building up and maintaining the soil fertility of the Southern States is evidenced by the fact

[1] The writers wish to acknowledge their indebtedness to Director M. J. Funchess and to J. F. Bailey, J. T. Williamson, J. M. Robinson, and F. S. Arant of the Alabama Agricultural Experiment Station; to J. R. Fain, Paul Tabor, and E. D. Alexander of the Georgia State College of Agriculture; to H. P. Bledsoe of the Georgia Experiment Station; to T. S. Buie of the South Carolina Agricultural Experiment Station; to J. F. Jackson, agricultural agent of the Central of Georgia Railway Co. and his field assistants, G. E. McWhorter, J. G. Liddell, and J. A. Winslow; and to all county agricultural agents in the counties visited and to farmers who gave freely of knowledge gained through their experience.

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that in many fields corn yields are only 8 or 10 bushels an acre and cotton yields are frequently below 100 pounds an acre. Such low yields make it necessary to put an undesirably large part of the farm in corn or to buy a considerable part of the feed. Through the use of winter legumes it seems feasible and economical to increase the yields until the same quantity of corn can be produced on one half to two thirds of the acreage, thus releasing land and labor for other crops. It appears that the low average yield of corn in South Carolina can be nearly doubled on the same acreage and, after meeting the feed requirements of a 2-mule farm, leave from 200 to 300 bushels to sell or to feed to an increased number of hogs or cows. Similar opportunities exist in other Southern States. In North Carolina, the 5-year average (1926–30) yield of corn was 21 bushels per acre; in South Carolina, 15 bushels; in Georgia, 13 bushels; and in Alabama, 14 bushels.

Large quantities of nitrogenous fertilizer to be used on cotton are bought by farmers each year in North Carolina, South Carolina, Georgia, and Alabama. This means a large cash outlay, a part of which might be eliminated through the use of more winter legumes.

Using winter legumes to improve soils and increase the yields of subsequent crops is not a new practice, but only recently has the real worth of these legumes for this purpose become generally known. This bulletin describes the actual experience of farmers who have used these legumes in increasing soil productivity, and indicates the costs of using winter legumes and the benefits received from their use under actual farming conditions.

METHOD OF STUDY AND APPLICATION OF RESULTS

The data used in this bulletin were obtained from farmers who grew winter legumes for fertilizing cotton and corn. Of the usable estimates of acreage and yield, 125 were made in 1929 for crops of cotton and corn grown after winter legumes in 1928 and earlier, and 375 were made in 1930 for crops harvested in 1929 and earlier. In addition, 31 estimates for corn crops and 14 estimates for cotton crops were obtained for periods of 3 to 5 years.

Some reference is made to the experiments with winter legumes as fertilizers at a number of experiment stations, but since such tests were made on particular soils under particular climatic conditions it seemed desirable to supplement them with the experience of farmers who live on a great variety of soils and under varied climatic conditions.

Both large and small farms were visited and estimates were obtained from areas as small as 1 acre and as large as 100 acres. As a number of farmers grew both vetch and winter peas, and in some instances had two or more tracts of the same legume growing under different conditions, the five hundred 1-year estimates were furnished by 300 farmers.

Most of the data were estimates of the number of acres of corn and cotton and the yield per acre. The acreage and production of corn and cotton following winter legumes were stated by the farmer. Then for the same year and for adjacent land, or land of the same natural fertility, the yield of these crops without winter legumes was given. The latter crops are called "check" crops. Their yields were compared with or checked against the yield of the same crops following the legumes.

There were 264 estimates for corn and cotton after vetch, 193 after Austrian winter peas, 32 after crimson clover, and 11 after southern bur clover. The size of the vetch fields and winter-pea fields aver-

aged, in each case, a little more than 12 acres. The crimson-clover and bur-clover fields averaged approximately 7 acres each.

TABLE 1.—*Number of fields, total acreage, and average number of acres per field of corn and cotton grown after specified kind of winter legume*

Item	Fields [1]		Average size of field
	Number	*Acres*	*Acres*
Corn after vetch	202	2,393	11.8
Cotton after vetch	62	818	13.2
Total or average	264	3,211	12.2
Corn after Austrian winter peas	129	1,568	12.2
Cotton after Austrian winter peas	64	922	14.4
Total or average	193	2,490	12.9
Corn after crimson clover	18	151	8.4
Cotton after crimson clover	14	93	6.6
Total or average	32	244	7.6
Corn after bur clover	4	33	8.2
Cotton after bur clover	7	44	6.3
Total or average	11	77	7.0
Total corn	353	4,145	11.7
Total cotton	147	1,877	12.8
Grand total or average	500	6,022	12.0

Estimates of yields obtained on farms in the various States were: North Carolina, 4 estimates for corn after crimson clover; South Carolina, 17 estimates of crops after vetch, 8 after winter peas, 20 after crimson clover, and 10 after bur clover; Georgia, 113 after vetch, 79 after winter peas, 8 after crimson clover, and 1 after bur clover; Alabama, 131 after vetch and 106 after winter peas. South Carolina, Georgia, and Alabama probably represent the greatest concentration of winter legumes.

[1] The word field in this case is used for the tract of land growing the legume.

After winter legumes the cornfields averaged 11.7 acres and the cotton fields 12.8 acres. In all the size groups shown in table 2 except in that ranging from 21 to 50 acres, the acreage per field for cotton and for corn was practically the same, indicating uniformity of conditions. Even in the excepted group the acreage per field for corn and for cotton differed by only about 10 percent.

TABLE 2.—*Number of estimates and total acres of winter legumes classified according to the number of acres per estimate*

CORN AFTER WINTER LEGUMES

Item	Item specified when size of field was—					Total
	1 to 5 acres	6 to 10 acres	11 to 20 acres	21 to 50 acres	51 to 100 acres	
Estimates—number	136	112	55	43	7	353
Legumes—acres	459	905	852	1,409	520	4,145
Acres per estimate	3.4	8.1	15.5	32.8	74.3	11.7

COTTON AFTER WINTER LEGUMES

Estimates—number	59	34	31	18	5	147
Legumes—acres	202	201	474	535	375	1,877
Acres per estimate	3.4	8.6	15.3	29.7	75.0	12.8

COTTON AND CORN AFTER WINTER LEGUMES

Estimates—number	195	146	86	61	12	500
Legumes—acres	661	1,106	1,326	1,944	895	6,022
Acres per estimate	3.4	8.2	15.4	31.9	74.6	12.0

The vetch and winter-pea fields were larger than the fields of crimson clover and bur clover (table 1), probably because they were on larger farms. The two clovers were restricted to the piedmont and richer soils, whereas the vetch and winter peas grew in both the piedmont and the Coastal Plain. In the Coastal Plain the farms were much larger.

The relative acreages of the various winter legumes, as found in this study, agree in a general way with the relative importance of the legumes in the States and parts of States visited. The results of this study are useful to farmers in all farming sections of the States in which data were collected and to farmers in other Southern States that have a humid climate. Farmers in Mississippi, Arkansas, and north Florida are using winter legumes in increasing quantities and with good results. In Louisiana, the annual yellow sweetclover (*Melilotus indica*) is being used successfully as a winter legume.

The word vetch is here used to include hairy vetch (*Vicia villosa*), smooth vetch (*V. villosa* variety), and Monantha vetch. "Winter pea" means Austrian winter pea (*Pisum arvense*) and "bur clover" means southern bur clover (*Medicago arabica*). Hairy vetch has predominated in this area heretofore, but in the spring of 1930 the writers found a much larger acreage of smooth vetch than of hairy vetch in the States visited. Smooth vetch is a variety of hairy vetch that has little pubescence or few hairs; it is fully as desirable for this area as hairy vetch and is considered superior by some farmers. Monantha vetch is used only in the southern parts of the area because it will not stand very low temperatures.

INCREASED YIELD FROM USE OF WINTER LEGUMES

CORN

Agronomists and experienced farmers have generally agreed that winter legumes, when plowed down in the spring for corn, increase the yield of corn. The real question has been, How much are yields increased by the use of winter legumes under actual farming conditions, and to what extent do farmers benefit by their use after deducting all expenses incident thereto? The answer to the first part of the question will be found in table 3.

TABLE 3.—*Average yield of corn and cotton when grown with and without winter legumes preceding*

Legume	Acreage studied	Average yield of corn per acre				Acreage studied	Average yield of lint cotton per acre			
		After winter legume	Not after winter legume	Increase per acre			After winter legume	Not after winter legume	Increase per acre	
	Acres	*Bushels*	*Bushels*	*Bushels*	*Percent*	*Acres*	*Pounds*	*Pounds*	*Pounds*	*Percent*
Vetch	2,303	33.3	19.6	13.7	70	818	389	280	109	39
Austrian winter peas	1,568	34.8	20.4	14.4	71	922	356	271	85	31
Crimson clover	151	43.5	24.4	19.1	78	93	538	384	154	40
Bur clover	33	23.5	15.0	8.5	57	44	391	293	98	33
Total and weighted averages	4,145	34.1	20.0	14.1	70	1,877	381	281	100	35

The increase in yield of corn from 20 bushels per acre to 34.1 bushels (an increase of 14.1 bushels per acre) amounts to 70 percent. It would have been a little more than this, probably, if as large a quantity of nitrate of soda had been used on the corn grown after legumes as was used on that grown without a preceding crop of legumes. The increase varied somewhat with the kind of legume plowed under. The use of crimson clover gave the largest increase in corn yield and bur clover gave the least, with yields from the use of vetch and winter peas coming between. It is perhaps unsafe to say that crimson clover is a better fertilizer than the other winter legumes even though the figures seem to show it. Its acreage was relatively limited and its geographic location was confined mostly to the northern parts of South Carolina and Georgia. It would be popular on the piedmont soils, to which it is adapted, if dependable stands could be secured. Further efforts should be made to see whether skill in getting stands can be improved.

Acreage of bur clover was also small and there is chance for a larger error in the indicated corn yields than in the yields of corn grown after vetch and winter peas.

The difference between vetch and winter peas in increasing yields is probably not great. On the farms studied corn did better after winter peas and cotton after vetch, but it is doubtful whether the differences are significant.

The increases indicated in table 3 mean that many farmers can produce as much corn as they are now producing on a little more than one half the present acreage, or nearly twice as much as they are now producing on the present acreage. They can easily produce all the corn needed for home requirements on their present acreage and thereby reduce the feed bills to a nominal amount.

Use of these legumes does not necessarily involve change in the type of farming. It involves no change in the quantity or kind of labor employed except that the larger harvest will require a little more labor. No change in power or implements is involved except that larger teams and plows would help in some instances.

Estimates were made of the yield of crops for each year from 1925 to 1929, inclusive (table 4). The yield of corn varied from year to year; but, in general, the yields after winter legumes and the yields not after winter legumes varied together, indicating that the seasons affected each in a similar way. The yields were lowest in 1925 and highest in 1926 (fig. 1).

TABLE. 4.—*Average yield of corn and cotton per acre after winter legumes and without winter legumes, 1925–29*

Year grown	Corn				Lint cotton			
	Acreage studied	Yield after legumes	Yield not after legumes	Increase in yield	Acreage studied	Yield after legumes	Yield not after legumes	Increase in yield
	Acres	*Bushels*	*Bushels*	*Bushels*	*Acres*	*Pounds*	*Pounds*	*Pounds*
1925 [1]	204	32.2	16.6	15.6	31	341	298	43
1926	552	39.6	21.9	17.7	43	454	283	171
1927	390	34.0	19.0	15.0	122	334	246	88
1928	802	30.5	20.4	10.1	383	434	310	124
1929	2,197	32.0	19.8	12.2	1,298	368	276	92
Total and weighted average	4,145	34.1	20.0	14.1	1,877	381	281	100

[1] 3 estimates for corn and 1 for cotton grown in 1924 are included in the 1925 figures.

Not every farm obtained an increase in yield from the use of winter legumes. There were failures as well as successes and various degrees

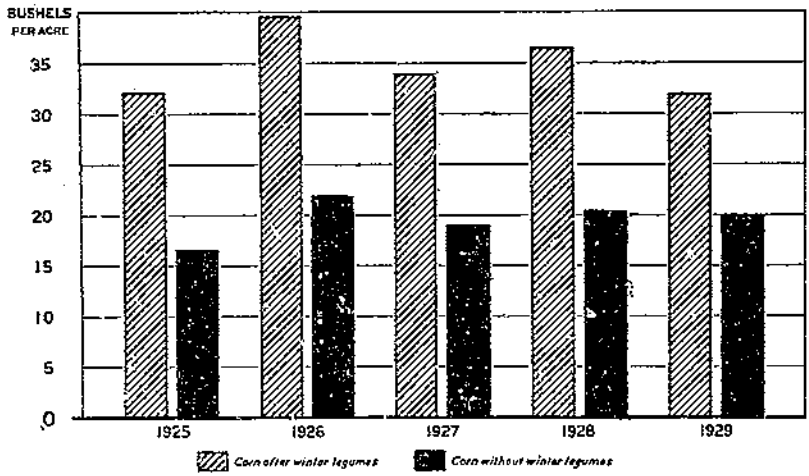

FIGURE 1.—YIELD OF CORN GROWN AFTER WINTER LEGUMES AND WITHOUT WINTER LEGUMES.

The year of the largest yield of corn after winter legumes and without winter legumes was in 1926 and the next largest was in 1928. Increases in yields varied from year to year, but were profitable in all years.

of each. Variations in increase or decrease in yield are shown in table 10 (p. 16) and discussed in the text at that point.

In addition to the 353 fields of corn for which estimates were made, each for a specified year, there were 31 fields totaling 919 acres for

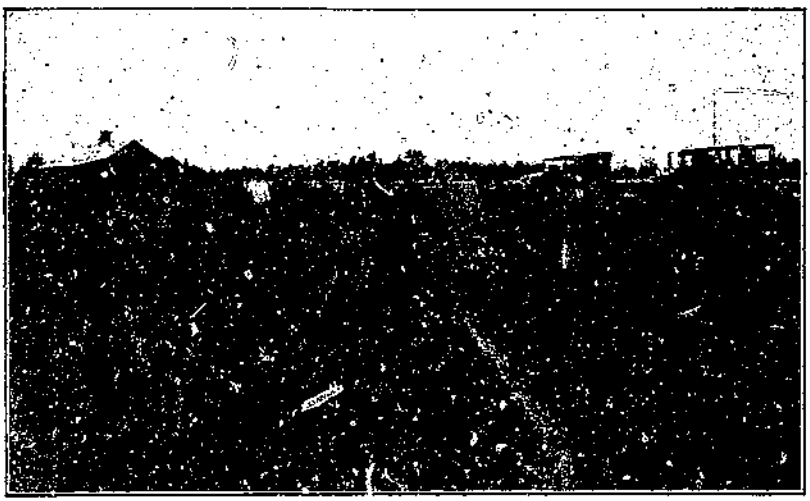

FIGURE 2.—Hairy vetch on a farm near Trenton, S. C., May 3, 1929. A crop of corn following this vetch yielded 105 bushels an acre. The corn was fertilized with 400 pounds of nitrate of soda and 100 pounds of potash manure salts an acre. The vetch was not fertilized, but the land had been well farmed in previous years.

which the estimates represented average results for periods of 3 to 5 years. The average yields for these crops were 35 bushels per acre after legumes and 19 bushels not after them—a gain of 16 bushels per

acre. Here, again, the experience of the farmers points to a tremendous gain in corn yield through the use of winter legumes.

As farmers have longer experience with winter legumes they will learn how to handle these crops, and will get better results; but even

FIGURE 2.—Corn after winter peas and not after winter peas near Ozark, Ala. Corn after winter peas, on right, yielded 50 bushels an acre. Corn not after winter peas, on left, yielded 28 bushels an acre. Corn on right was not fertilized directly, but 400 pounds of superphosphate per acre had been applied to the winter peas the preceding fall. On left, 300 pounds of nitrate of soda per acre were applied to the corn.

with the limited experience these men had they obtained increases that are of much significance (figs. 2 and 3).

TABLE 5.—*Average yield of corn grown after vetch and winter peas, by date of planting*

Date of planting corn	Winter legumes		Corn yields per acre		Increase in corn yield per acre
	Fields	Acreage	After legumes	Not after legumes	
	Number	*Acres*	*Bushels*	*Bushels*	*Bushels*
Mar. 20 to Apr. 5	17	181	30	17	13
Apr. 6 to 30	56	670	37	21	16
May 1 to 10	67	729	35	19	16
May 11 to 31	77	935	31	17	14
June 1 to 28	28	350	38	22	16

Estimates of corn yields after vetch and winter peas according to the date of planting are given in table 5 for five different periods of planting. After eliminating farms on which the dates of planting differed, following legumes and not following legumes, 245 farms remained.

The increased yield of corn due to the use of winter legumes averaged 16 bushels per acre for plantings from April 6 to May 10 and this was a larger increase than for earlier or later plantings except that for the latest planting dates—June 1 to 28—it was also 16 bushels increase per acre. On 123 acres on 8 farms of this group the yield of corn averaged 52 bushels per acre after the winter legumes and 36

bushels per acre without the legumes. Such high yields on so many acres can be explained only on the assumption of a superior quality of land; it was a mere accident that these farms fell into the last group.

COTTON

Increase in yields of cotton grown after winter legumes is smaller on a percentage basis than the increase of corn, but compares well in value per acre. The average increase for the total acreage studied was 100 pounds of lint cotton per acre, or one fifth of a bale (table 3). This increase per acre is more than the entire production per acre of much land as it is now being farmed.

Crimson clover gave the largest increase in yield of cotton but its use is restricted to the piedmont soils. Expressed as a percentage of the yield of cotton without winter legumes, the yield after crimson clover was increased 40 percent; after vetch, 39 percent; after bur

FIGURE 4.—Austrian winter peas on a farm near Madison, Ga., being plowed down with a tractor.

clover, 33 percent; and after winter peas, 31 percent. The expenses in connection with winter peas were smaller than those connected with vetch and the net profit was greater. Winter peas are grown mostly in the southern part of the area, in the Coastal Plain, where there was less expense in preparing the land for planting (fig. 4).

Yields of cotton for 5 consecutive years, after legumes and without them, are shown in table 4 and figure 5. The relation between the bars representing yield of cotton grown after winter legumes and that grown without them is not so uniform as for corn (fig. 1). This lack of uniform relationship occurs for 1925 and 1926 and may be explained largely by the smaller number of estimates for these years and by abnormal yields on some of the farms. For the years 1927, 1928, and 1929, the bars (fig. 5) have a rather uniform correlation, indicating that the seasons affected the yield of cotton grown after winter legumes about the same as they did the cotton grown without them.

Fourteen farmers gave estimates of the average yield of cotton grown after winter legumes for periods of 3 to 5 years. The average of these 14 estimates was 404 pounds of lint cotton per acre when

grown after winter legumes and 260 pounds when grown without them, an increase of 144 pounds, or 55 percent.

RESIDUAL EFFECT OF USING WINTER LEGUMES

In the clover and alfalfa area it has been the experience of farmers that the effect of plowing down these crops or even plowing under the stubble and roots, is to increase the yields of corn, potatoes, etc., above the yield obtained without legumes and that this effect continues in diminishing degree for 2 or 3 years or even longer.

At the Central Experimental Farms, Ottawa, Canada, red clover was grown on plots in 1900. The yields of corn on the check plots the first year afterward (1901), and of oats the second year afterward (1902), were greatly increased. The third year afterward (1903),

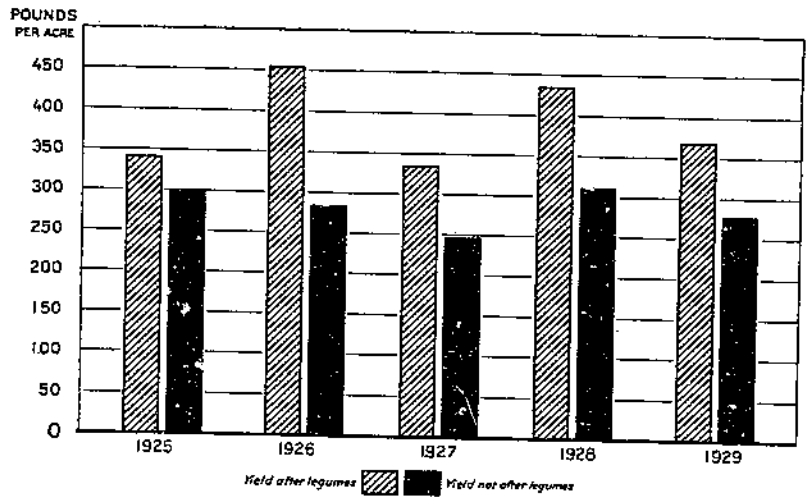

FIGURE 5.—YIELD OF LINT COTTON GROWN AFTER WINTER LEGUMES AND WITHOUT WINTER LEGUMES.

The increase in the yield of cotton resulting from fertilizing with winter legumes was very small in 1925 and very large in 1926, due to an abnormally low yield on 1 farm out of 3 in 1925 and to abnormally high yields on 3 farms out of 8 in 1926. For later years a larger number of farms were averaged and the increases in yield were more regular.

the yield of potatoes was increased from 175 bushels per acre to 195 bushels, the yield of carrots from 20.32 tons per acre to 31.48 tons, and the yield of sugar beets from 8.6 tons to 22.3 tons per acre.

At the Alabama Canebrake Station, plots of crimson clover and bur clover were turned under in 1907 and cotton was planted on these plots in 1907, 1908, and 1909, but no clover was grown after 1907. An adjacent plot was fertilized annually with 200 pounds cottonseed meal per acre and 200 pounds of superphosphate per acre; a check plot received no treatment. The total yield of seed cotton per acre in 3 years was 2,356 pounds on the check plot; 2,646 pounds on the fertilized plot; 2,842 pounds on the crimson-clover plot; and 2,856 pounds on the bur-clover plot, the clover plots having received no fertilizer.

At the Mississippi (Delta) experiment station, unpublished data show that the yield of cotton has been increased by use of various

winter legumes to the extent of 200 to 400 pounds of seed cotton per acre the second year after the legume was plowed under, these results being an average of trials over 4 years.

Further evidence of the residual effect of winter legumes is found in the use of Monantha vetch at the Alabama experiment station in 1925, 1926, and 1927, in relation to the yield of corn in 1928. Data relating to these experiments will be found in table 6. Corn followed vetch in each of the first 3 years and its yield was increased by the vetch. In early January of the fourth year (1928) the vetch was frozen and the residual effect in 1928, therefore, came from what remained of the influence of vetch over and above what the corn had used during the first 3 years. How long this effect would have lasted if no more winter legumes had been plowed under is not known. The experiment was not designed to show the residual effect of vetch on subsequent crop yields but because the vetch accidentally froze that effect could be measured.

Even when the vetch was turned under as early as March 25 (for the first 3 years), when the average green weight per acre was only 4,629 pounds, the residual effect in 1928 was nearly 10 bushels of corn per acre over the no-nitrate plot, and 4.3 bushels per acre over that produced by 100 pounds of nitrate of soda per acre applied in 1928 and whatever nitrate may have been left over from previous years (table 6).

TABLE 6.—*Residual effect of vetch turned under in 1925, 1926, and 1927 on the corn yield of 1928 at the Alabama Agricultural Experiment Station* [1]

Plot No.	Date of—		Nitrate of soda per acre	Average weight of green vetch per acre for 1925, 1926, and 1927 [2]	Yield of corn per acre in 1928	Increase per acre over yield without nitrate of soda
	Turning vetch	Planting corn				
			Pounds	*Pounds*	*Bushels*	*Bushels*
1 and 5		Apr. 5			6.1	
2		do	100		11.7	5.6
3		do	200		22.6	16.5
4	Mar. 25	do		4,629	16.0	9.9
5 and 9		do			9.4	
6		Apr. 20	200		22.0	12.6
7		do	300		26.3	16.9
8	Apr. 5	do		8,147	28.9	19.5
9 and 13		Apr. 5			12.9	
10		May 1	200		25.0	12.1
11		do	400		30.8	23.9
12	Apr. 15	do		12,014	34.6	21.7

[1] BAILEY, R. Y., WILLIAMSON, J. T., and DUGGAR, J. F. EXPERIMENTS WITH LEGUMES. Ala. Agr. Expt. Sta. Bul. 232, table 6. 1930.

[2] Corn was planted after vetch in each of these years, but in January 1928, the Monantha vetch on plots 4, 8, and 12 was killed; hence there was no vetch to turn under in 1928, but nitrate of soda was applied as in previous years. All plots were fertilized alike with superphosphate and potash.

Better residual effects were obtained when the vetch was turned under later, the quantity of nitrogen and organic matter being greater then. For the second date of turning the vetch (Apr. 5) and for the corn planting (Apr. 20) the residual effect was greater than from the use of 300 pounds of nitrate of soda per acre; the yield was 28.9 bushels compared with 26.3 bushels.

A clear instance of the residual effect of winter peas on oats is shown in figure 6. Cotton had preceded the oats on the entire field; winter peas had preceded the cotton on one side of the field but not on the other. Oats from the two parts of the field were not thrashed separately, but the owner estimated the yields at 10 bushels and 30 bushels per acre and the authors estimated them at 10 and 25 bushels, respectively.

COST OF USING WINTER LEGUMES

Several cost items in the growing of crops are the same regardless of whether the crops follow winter legumes. The work of breaking the land is the same except in cases of very heavy legume growth. The work of cultivating the crop is the same in either case. The labor of

FIGURE 6.—Oats on a farm near Lafayette, Ala. Cotton preceded oats on the entire field. Winter peas preceded cotton on the right but not on the left.

harvesting the subsequent crop is different only to the extent of harvesting the increased yield.

The first part of table 7 gives figures on the cost of starting winter legumes in the fall. The second part of the table gives figures that show the cost of growing and harvesting the increase in yield of the subsequent crop, due to the use of winter legumes. All of the costs in the fall, in starting the legume, are charged to the subsequent crop. In the following year, the additional cost on the cotton or corn crop because of the winter legume, consists of the extra work of plowing down the legume as compared with plowing the bare soil; the extra labor of harvesting and hauling the increased yield; and, in the case of cotton, the extra cost of ginning and wrapping the increased yield. These costs are designated as costs in starting the legume and "extra costs" on the subsequent crop.

TABLE 7.—*Extra cost per acre to produce corn and cotton after winter legumes*[1]

COST FOR STARTING LEGUMES AT HIGH PRICES[2]

Item	For corn			For cotton		
	Cash cost	Non-cash cost	Total cost	Cash cost	Non-cash cost	Total cost
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Seed and inoculation	2.90		2.90	3.12		3.12
Man labor		0.67	.67		0.60	.60
Horse labor		.80	.80		.67	.67
Implement and machinery charge		.27	.27		.18	.18
Fertilizer	.81		.81	.50		.50
Total	3.77	1.74	5.51	3.62	1.45	5.07
EXTRA COST ON SUBSEQUENT CROP						
Man labor gathering extra yield		.35	.35	.45	[3] 2.50	2.95
Ginning and wrapping extra yield				1.04		1.04
Horse labor gathering extra corn		.35	.35			
Wagon charge gathering extra corn		.05	.05			
Hauling extra cotton to gin					.60	.60
Extra work plowing down legume		.25	.25		.30	.30
Total		1.00	1.00	1.49	3.40	4.89
Grand total	3.77	2.74	6.51	5.11	4.85	9.96
Credit for fertilizer	.90		.90	1.31		1.31
Credit for labor applying fertilizer		.07	.07		.04	.04
Total credit	.90	.07	.97	1.31	.04	1.35
Net cost at high prices [4]	2.87	2.67	5.54	3.80	4.81	8.61
Net cost at low prices [4]	1.88	1.48	3.36	2.39	2.52	4.91

[1] 4,145 acres of corn and 1,877 acres of cotton were studied.
[2] Figures in last line of table show net cost at low prices.
[3] This amount is about 85 percent of the total of $2.95 on the assumption that 85 percent of the cotton was picked by the families and only 15 percent was picked by hired labor.
[4] Prices used in calculating costs: High prices: Man and horse labor, 15 cents an hour; legume seed, $3 an acre; ginning and wrapping $5 a bale; fertilizers, prices of 1927, 1928, 1929. Low prices: Man and horse labor, 7½ cents an hour; legume seed $2 an acre; ginning and wrapping, $3.50 a bale; fertilizers, 85 percent of prices of 1927, 1928, and 1929.

As computed in this study, cash costs for starting the winter legume and the extra costs for growing and harvesting the additional yields of cotton and corn resulting from the use of the legume, are for legume seed, inoculation, fertilizer, cotton ginning and wrapping, and the part of the labor that is hired. The noncash costs are for the labor that was not paid for in cash, mule work, and implement and machinery charges. Labor on the small farms is usually done by the farmer and members of his family; labor on the plantations is done by the share cropper and family. In the latter case there was probably a little labor for which cash was paid that was not so classified in making the computations, but it is a small item and is covered in the total cost. It is estimated that the farm operators and their families, plus the share croppers and their families, picked 85 percent of the cotton crop, hence only 15 percent of the picking charge is a cash cost. A small part of the implement and machinery charge for operating the farm is cash but the implements were used chiefly on other enterprises and the cash part of such cost for winter legumes is negligible.

Costs for starting winter legumes in the fall amounted to $5.51 per acre of corn and $5.07 per acre of cotton. In the following season, the

extra cost of growing and harvesting the corn crop was only $1 per acre whereas for cotton it was $4.89 per acre, nearly all of which was for picking, ginning, wrapping, and hauling the increase in yield due to the use of the legumes.

The total extra cost was $6.51 per acre of corn and $9.96 per acre of cotton. Of these totals $3.77 was the cash cost for corn and $5.11 the cash cost for cotton. But certain expenses for fertilizer must be deducted from the total costs to obtain the net cost of using winter legumes, because less fertilizer was used on the corn and cotton that followed the legumes than was used on these crops when grown without winter legumes. These deductions are shown in the lower part of table 7 and are referred to as "credits." The average fertilizer application per acre to corn following legumes was 10 pounds of nitrate of soda and 49 pounds of other fertilizer, whereas on corn not following legumes it was 36 pounds of nitrate of soda and 66 pounds of other fertilizer. On cotton following legumes the average application per acre was 43 pounds of nitrate of soda and 419 pounds of other fertilizer; on cotton not following legumes it was 85 pounds of nitrate of soda and 427 pounds of other fertilizer.

The cost of the extra fertilizer for the corn not following legumes, plus the labor of applying it, was 97 cents an acre; for cotton it was $1.35 an acre (table 7). Deducting these items from the total extra cost of the crops after the legumes, leaves a net extra cost of $5.54 an acre for corn and $8.61 an acre for cotton in comparison with cost of the same crops not following legumes, these figures being according to high prices. (See footnote 4, table 7.)

There is not much opportunity to reduce these costs. It would be convenient and helpful if farmers could raise their own legume seed but that does not seem practicable in the case of vetch and winter peas which are the most popular winter legumes. The extra cost of plowing under the legumes in certain cases can be reduced or eliminated by the proper implements and by good management, but it is a small cost on the average because it has been eliminated already in a majority of cases.

PROFITS FROM USE OF WINTER LEGUMES

CORN

That the use of winter legumes as fertilizer increases the yield of the crops that follow in the rotation is well known, but the amount of the increase, the cost in cash outlay, the labor of men and teams involved, and the degree of wear on implements are items regarding which there is limited information. The value of the increase in yield minus the expenses for legume seed, fertilizer, labor, etc. (table 7), is the profit or net gain from the use of winter legumes as fertilizers.

The increase in yield of corn averaged about 14 bushels per acre for all farms and was valued at $1 a bushel, at high prices, and at 50 cents a bushel, at low prices (table 8). These are much above Corn Belt prices for the reason that the South produces a deficiency of corn whereas the Corn Belt produces a surplus. To the value of the increase in yield of corn is added an average pasture value of 63 cents an acre and 30 cents an acre at high and low prices, respectively. This added amount is small because the acreage pastured was small, and the whole acreage was averaged to obtain the result.

TABLE 8.—*Average increase in yield, cost, and net gain per acre from the use of winter legumes for corn and cotton*

Item	Corn [1]		Cotton [2]	
	At high prices	At low prices	At high prices	At low prices
	Dollars	*Dollars*	*Dollars*	*Dollars*
Value of increase in yield [3]	14.10	7.05	18.00	7.00
Value of legume pasture and hay	.63	.30	.30	.15
Total	14.73	7.35	18.30	7.15
Net cash cost [4]	2.87	1.88	3.80	2.39
Net noncash cost [4]	2.67	1.48	4.81	2.52
Total net cost	5.54	3.36	8.61	4.91
Net gain, all costs considered	9.19	3.99	9.69	2.24
Net gain, only cash costs considered	11.86	5.47	14.50	4.76

[1] 4,145 acres with increase in yield per acre of 14.1 bushels.
[2] 1,877 acres with increase in yield per acre of 100 pounds lint.
[3] Corn is valued at $1 a bushel, high-prices and 50 cents a bushel, low-prices. Cotton is valued at $90 a bale, cottonseed included, at high-prices, which is approximately 15 cents per pound of lint; and $30 per ton of seed and $35 a bale, at low-prices, which is approximately 6 cents per pound of lint and $10 per ton of seed.
[4] Taken from the last 2 lines of table 7.

On the basis of high prices the net cost of $5.54 an acre deducted from the extra value of $14.73 an acre leaves a net gain of $9.19 an acre, but when cash costs only are considered the net gain is $11.86 per acre.

On the basis of low prices the net cost of $3.36 an acre, deducted from the extra value of $7.35 an acre, leaves a net gain of $3.99 an acre, but when cash cost ($1.88 an acre) only are considered, the net gain is $5.47 an acre.

On the basis of low prices for corn, labor, and materials the net gain is reduced but is still substantial. Therefore, at any probable price of corn for a period of years, a safe average profit from the use of winter legumes is likely.

The meaning of this to southern agriculture is evident. Low yields of corn will give way to medium and high yields as farmers use winter legumes. It may be that no increase of acreage will be necessary to make the South self supporting in regard to corn if winter legumes are generally used as fertilizers.

It may be asked whether the increased yields are greater in the lower Southeast than in the upper Southeast. To determine this the latitude of 33°, which is that of middle Georgia and Alabama, was made the dividing line between the upper and the lower South, in carrying on this study.

The results of this inquiry are embodied in table 9 and are confined to the effects of growing vetch and winter peas, because these legumes were found both north and south of this latitude, whereas crimson clover and bur clover were found only north of the line. The figures show somewhat better results south of the line than north of it. Whether this difference is related to the kind of soil or to the date of plowing under the legume and planting the subsequent crop is uncertain. South of the line, in the Coastal Plain, the soils are mostly sandy, whereas north of it they are mostly clay and silt loam. The net gain per acre south of the line was $2.33 greater for corn and $3.26 greater for cotton than the net gain north of the line, on the basis of high prices.

TABLE 9.—*Average increase yield and net gain per acre from the use of vetch and winter peas for corn and cotton, north and south of latitude 33°*

Item	Corn		Cotton	
	North of 33°	South of 33°	North of 33°	South of 33°
Acres.....number	1,301	2,660	725	1,015
Increase in yield per acre.....bushels	12.6	14.7		
Increase in yield per acre.....pounds of lint			91	101
Net gain per acre, all costs considered [1].....dollars	7.34	9.67	7.32	10.58
Difference in favor of crops south of latitude 33 [2].....do		2.33		3.26

[1] High prices used for this table. See notes, tables 7 and 8.

COTTON

The method of calculating the net gain of cotton following winter legumes is the same as that for corn. Details of the expenses are found in table 7 and are summarized in table 8 for the purpose of calculating the net gain.

For this purpose cotton is valued at $90 a bale, cottonseed included, at high prices, and at $35 a bale at low prices. The increased yield of 100 pounds of lint cotton per acre, plus the cottonseed, was worth, at high prices, $18. To this sum 30 cents an acre was added as the value of the legumes eaten by livestock. Thus, with an increased value of $18.30 an acre and an increased cost of $8.61 per acre, there is left $9.69 as the net gain, all costs considered; or $14.50 an acre with cash costs only considered.

At $35 per 500-pound bale of cotton, including seed, the net gain per acre dropped to $2.24 an acre, all costs considered, and to $4.76 an acre with cash costs only considered.

On the basis of high prices (table 8) the net gain per acre is a little greater for cotton than for corn but for low prices the monetary advantage rests with corn.

The yield of lint cotton was 10 pounds per acre greater south of 33° than north of 33°; on the basis of high prices the net gain was $3.26 per acre greater south of 33° than north of it. The monetary gain is due partly to increased yield and partly to decreased cost.

VARIATIONS IN PROFIT

It is not expected that plowing under winter legumes will always increase yields. No practice, new or old, brings perfect results every time. Table 10 shows that on 62 acres of corn grown after winter legumes, the yield was 7.3 bushels per acre less than of corn grown not after legumes, and on 357 acres there was no increase in yield due to the use of winter legumes. These acreages, taken together, constitute only 10 percent of the total acreage of corn included in this study. On the other 90 percent there was a profit or net gain ranging from $1.54 an acre on the third group of farms shown in table 10 to $29.52 on the last group, based on high prices. At low prices the net gain ranged from 50 cents an acre on the third group of farms to $13.41 on the last group, but on the first two groups there was a monetary loss (fig. 7).

TABLE 10.—*Average yield and net gain per acre of corn grown after winter legumes, by specified increases in yield, based on high and low prices*

Increase in yield (bushels)	Acreage studied	Yield per acre			High prices [1]			Low prices [2]		
		After legumes	Not after legumes	Increase	Value of increase per acre	Total extra cost per acre	Net gain per acre	Value of increase per acre	Total extra cost per acre	Net gain per acre
	Acres	*Bushels*	*Bushels*	*Bushels*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Decreases	62	15.1	22.4	[3] −7.3	[3] −7.30	3.40	[3] −10.70	[3] −3.62	2.30	[3] −5.92
No increase	357	19.2	19.2	0	4.75	3.65	[3] −2.90	.38	2.05	[3] −1.67
1 to 5	408	21.8	17.0	4.8	5.55	4.01	1.54	2.77	2.27	.50
5½ to 10	908	28.9	19.8	9.1	9.41	5.26	4.15	4.72	3.05	1.67
10½ to 15	1,071	35.0	20.3	14.7	15.21	6.27	8.94	7.64	3.98	3.66
15½ to 20	559	38.3	19.2	19.1	19.22	5.96	13.26	9.43	3.68	5.75
20½ to 25	427	46.4	22.7	23.7	24.02	5.08	18.94	11.98	2.92	9.06
25½ to 30	132	54.2	25.3	28.9	31.63	6.04	25.59	15.82	3.54	12.28
Over 30	221	56.8	18.6	38.2	38.77	9.25	29.52	19.38	5.97	13.41
Total and weighted average	4,145	34.1	20.0	14.1	14.73	5.54	9.19	7.35	3.36	3.99

[1] Prices used in calculating costs and net gains. High prices: Corn, $1 a bushel; man labor and horse work 15 cents an hour; legume seed, $3 an acre; fertilizers, prices of 1927, 1928, and 1929.
[2] Prices used in calculating costs and net gains. Low prices: Corn, $0.50 a bushel; man labor and horse work 7½ cents an hour; legume seed, $2 an acre; fertilizers, 85 percent of prices of 1927, 1928, and 1929.
[3] Decrease.
[4] Credits from grazing and from legume hay harvested account for a slight gain in value per acre even when there was no increase in the yield of corn.

Causes of these variations in yield are numerous. A comparable table could be made on the results obtained on crops from the use of

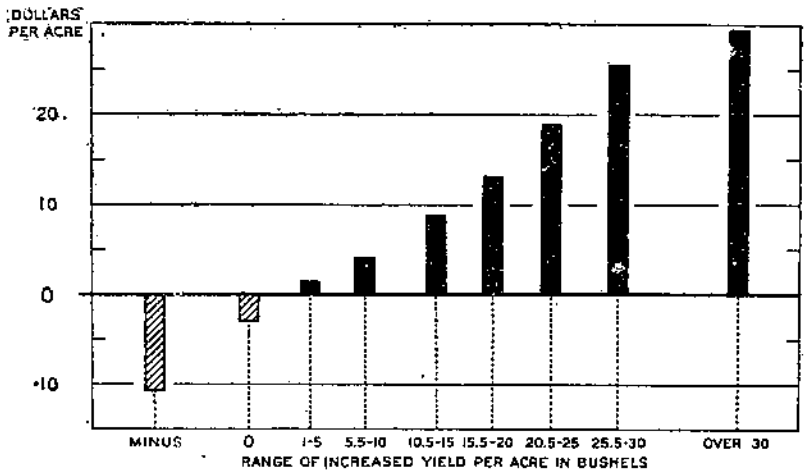

FIGURE 7.—NET MONEY GAIN PER ACRE ON CORN GROWN AFTER WINTER LEGUMES ACCORDING TO THE INCREASED YIELD.

With corn worth 50 cents to $1 a bushel it takes an increased yield of about 5 bushels an acre to pay the cost of the winter legume.

fertilizers. Differences are found in soils, methods of preparation and planting, time of preparation and planting, seasons, and extent of damage by insects and diseases.

The interviewed farmers said more about damage from insects than about damage from other causes. Concerning insects that damaged the stand of young corn following winter legumes much was said about "bud worms", but since this name is applied to the larvae of several insects it was not easy to identify the species meant.

It is known, however, that one of the insects that often does serious damage of this kind is the southern corn rootworm (*Diabrotica 12-punctata Fab.*). In the spring of 1929 the writers inspected plots of corn following winter legumes on the grounds of the Alabama Agricultural Experiment Station and saw stands of corn that had been made very imperfect by this insect. This use of these plots constituted an experiment to determine the extent of infestation of this insect according to dates of plowing under the legume and dates of planting corn thereafter. According to these experiments the technic of outwitting the southern corn rootworm appears to consist of (1) plowing the land on which winter legumes are growing somewhat later than March—say April 15 in the latitude of Auburn, Ala.; (2) covering the legume completely with the plow, followed by the disk harrow; and (3) waiting about 3 weeks before planting corn, although 2 weeks may be long enough in many cases. In late seasons the turning and planting date should be somewhat later.[2]

Another insect that has damaged vetch, the crops planted thereafter, and the crops in the vicinity, is the so-called "vetch worm", which is the same as the corn ear worm (*Heliothis obsoleta*), and is sometimes called the army worm. Several farmers referred to these "worms" as having damaged their crops. The writers saw one field of vetch that had been completely defoliated by the corn ear worm which then spread to an adjacent field of young cotton and injured the stand. At another place the writers saw corn ear worms in a peach orchard in which vetch was the winter cover crop, eating the vetch foliage, and even eating holes in young peaches on the trees.

This sounds more alarming than it really is. Vetch is large enough to use as a fertilizer before the corn ear worm hatches, hence a simple method of control when the crop is to be used as a fertilizer is to plow it under before the "worms" appear. Close daily examination of the vetch after it reaches the early hay stage of growth would reveal the tiny worms, if present, before they are large enough to do serious damage. The corn ear worm does not injure the vetch every year; it depends largely upon the weather. It is most likely to appear after a period of cool, moist weather.[3]

The writers heard no complaint about injury to winter peas and to Monantha vetch by the corn ear worm. In the peach orchard referred to, scattering plants of winter peas were mixed with the vetch but no injury was done to them.

Concerning variations in the increase in yield of cotton following winter legumes there were 55 acres out of a total of 1,877 acres on which the yield after winter legumes was 122 pounds of lint per acre compared with 298 pounds per acre not after them, or a decrease of 176 pounds per acre; and on 284 additional acres there was neither increase nor decrease. There was, of course, a net money loss from the use of winter legumes on these two groups of farms according to high prices as shown in table 11, and on three groups according to low prices (table 11 and fig. 8).

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[1] For further information about the southern corn rootworm, see the following publications:
LUGINBILL, P. THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT. U.S.Dept.Agr. Farmers' Bul. 950, 12 p., illus. 1918.
ARANT, F. S. BIOLOGY AND CONTROL OF THE SOUTHERN CORN ROOTWORM. Ala. Agr. Expt. Sta. Bul. 230, 46 p., illus. 1929.

[2] Further information about "vetch worms" will be found in the following publications: LUGINBILL, P. CORN EARWORM AS AN ENEMY OF VETCH. U.S.Dept.Agr. Farmers' Bul. 1206, 19 p., illus. 1921.

TABLE 11.—*Average yield and net gain per acre of cotton grown after winter legumes, by specified increases in yield, based on high and low prices*

Increase in yield (pounds of lint)	Acreage studied	Yield of lint per acre			High prices [1]			Low prices [2]		
		After legumes	Not after legumes	Increase	Value of increase per acre [3]	Total extra cost per acre	Net gain per acre	Value of increase per acre [3]	Total extra cost per acre	Net gain per acre
	Acres	*Pounds*	*Pounds*	*Pounds*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Decreases	55	122	298	[4]—176	[4]—25.62	[4]—4.77	[4]—20.85	[4]—9.29	[4]—2.55	[4]—6.74
No increase	284	306	306	0	.32	3.19	[4]—2.87	.18	1.69	[4]—1.53
1 to 50	195	315	282	33	6.50	5.68	.82	2.59	2.95	[4]—.36
51 to 100	487	377	291	86	15.85	6.77	9.08	5.97	3.79	2.13
101 to 150	470	405	270	135	24.35	11.61	12.74	9.47	6.57	2.90
151 to 200	210	492	306	186	33.46	13.19	20.27	13.04	8.13	4.91
201 to 250	121	473	240	233	41.85	14.58	27.27	16.26	8.19	8.07
Over 250	55	593	272	321	57.70	20.65	37.05	22.44	12.22	10.22
Total and weighted average	1,877	381	281	100	18.30	8.61	9.69	7.15	4.91	2.24

[1] Prices used in calculating cost and net gain. High prices: Cotton, $90 a bale including cottonseed; man labor and horse work, 15 cents an hour; legume seed, $3 an acre; ginning and wrapping, $5 a bale; fertilizers, prices of 1927, 1928, and 1929.
[2] Including credit from legume, hay, and pasture.
[3] Prices used in calculating cost and net gain. Low prices: Cotton, $35 a bale including cottonseed; man labor and horse work, 7½ cents an hour; legume seed, $2 an acre; ginning and wrapping, $3.50 a bale; fertilizers, 85 percent of prices of 1927, 1928, and 1929.
[4] Decrease.

Serious damage was frequently ascribed to the boll weevil, particularly where the crop was planted late, and in a few cases complaint

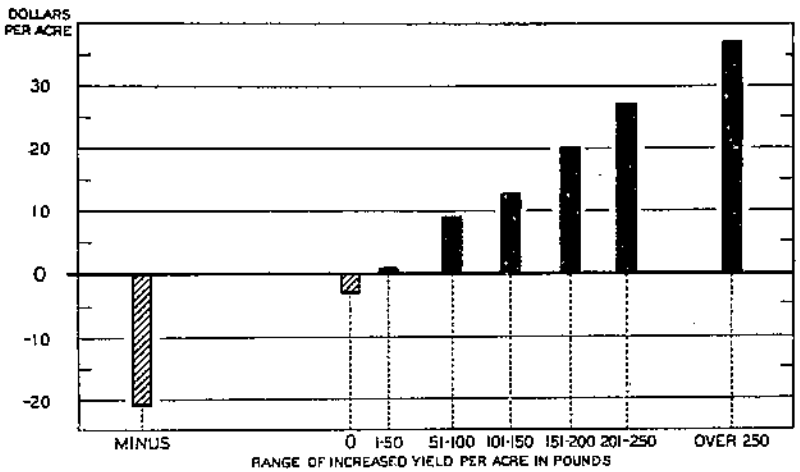

FIGURE 8.—NET MONEY GAIN PER ACRE ON COTTON AFTER WINTER LEGUMES ACCORDING TO THE INCREASED YIELD.

With cotton selling at 6 to 15 cents per pound, the yield of lint must be increased 30 to 50 pounds per acre, using winter legumes as fertilizers, before any net gain can be obtained.

was made of the ravages of the cotton flea hopper (*Psallus seriatus*). It sometimes happened that the cotton following the winter legume was planted considerably later than that which did not follow the legume and in these cases the damage from boll weevil was worse on the former crop than on the latter. Cotton flea-hopper damage was greater on the crop following the winter legume than on the check

crop. In one case the county agent, who had been in close touch with the farmer, said that the greater injury to the cotton following the winter legume was due to the dense shade of the crop caused by the much larger growth—that he had had the same experience with fertilized cotton versus unfertilized cotton.

The vegetative growth of cotton, corn, and other crops grown after winter legumes is excellent, but if the stand is not so good as on the check crop, or if damage caused by insects or diseases is great, there may be no gain in yield and may even be a loss. In the use of winter legumes for fertilizing, the first consideration is to get a good stand and growth of the legume, the second is to get a stand of the crop following the legume, and the third is to prevent insects and diseases from causing damage.

GRAZING VALUE OF WINTER LEGUMES

The number of the men interviewed who could furnish data on the grazing value of winter legumes was so small that it is hardly worth while to give averages. Those who had had long experience were positive in their assertions that, for grazing alone, the legumes pay. Usually oats or rye are planted with the winter legume when grazing is desired. Winter peas can be grazed earlier than hairy vetch but do not recover so well after grazing. A few farmers stated that their cattle and mules would not eat winter peas, but one farmer stated that cattle prefer winter peas to oats. The tips of winter peas are tender and well-flavored enough to make greens for the table.

An outstanding instance of the value of winter peas for grazing was furnished by the experience of a farmer in southern Alabama who grazed 30 hogs on 5 acres of this legume from March 1 to May 1, during which time they gained 75 pounds apiece. He estimated that 125 bushels of corn were fed to them during this period. The hogs sold for 9.4 cents a pound on foot and the corn was valued at $1 a bushel. It was figured that the net gain on the hogs, over and above the value of the corn fed to them, was about $17 per acre of winter peas.

Winter legumes and winter grains combined may be effectively used for grazing. Pasturing makes it possible to get returns a few months after planting and to keep the winter legumes from becoming too large to plow under easily.

REASONS WHY WINTER LEGUMES ARE SPARINGLY USED

With the good showing made by winter legumes in regard to both corn and cotton it may be asked why more farmers do not plant them. There are two chief reasons: (1) It takes time to get a new practice or a new crop started. It took time to make alfalfa and soybeans important crops. A few farmers in central New York raised alfalfa 100 years, more or less, under the name of lucerne before the crop spread eastward from California, and even after it was much talked about and written about, farmers were slow to plant it. (2) The expense of the seed, which has to be planted in the fall with the knowledge that the returns in increased yields of cotton and corn cannot be realized in less than a year, is discouraging to men who have little money.

Minor deterrents are conflict of work in cotton-picking time in getting the legume planted, difficulty of turning under the legume in

the spring with the small plows and teams that are commonly used, and difficulty in getting a stand of the following crop in first attempts. All these deterrents, except that of spending money for the seed a year before returns come in, can be overcome as farmers get more experience; and as country bankers are becoming acquainted with the benefits of winter legumes, they are more ready to lend money for such production.

PREPARING LAND FOR WINTER LEGUMES AND PLANTING THEM

PREPARING LAND

In the planting of vetch there were 26 cases out of 264 in which the land was first plowed (flat broken) and then harrowed; then the seed was planted. In 24 cases the land was not plowed but was harrowed with a disk harrow, and in 214 cases vetch was seeded in the middle between row crops.

Out of 193 instances of winter peas the land was plowed in 29 cases, disked without plowing in 19 cases, and seeded in row crops in 145 cases. With a 1-horse drill that runs between the cotton rows, the winter legumes can be planted without additional preparation of the land and, if a drill is not available, the seed may be broadcast and then covered with a 1-horse or 2-horse cultivator or with a 1-horse plow.

The indicated variations in the methods used in preparing the seed bed for winter legumes are largely due to the condition of the land to be prepared. Land in sod or grain stubble, or with considerable vegetative growth, requires plowing and harrowing for a suitable seed bed. Cowpea or soybean stubble frequently can be put in shape without plowing, the disk being used instead. Land that has been in row crops, like corn, cotton, peanuts, and tobacco, can be satisfactorily seeded to legumes without any preparation if the crops were cultivated well and were free from weeds.

SEED AND FERTILIZER

The quantity of vetch seed planted on 3,211 acres was 73,908 pounds or 23 pounds per acre. The smallest quantity per acre was 10 pounds and the highest 35. The average price paid was slightly more than 13 cents a pound, but the price ranged from 9 to 20 cents.

The winter peas planted on 2,490 acres amounted to 76,936 pounds, or an average of about 31 pounds per acre with a range of from 15 to 60 pounds. The price range was from 7½ to 15 cents and averaged nearly 9½ cents.

Most of the crimson-clover seed was raised at home and sowed in the chaff at the rate of 30 pounds per acre. This would be equal to about 20 pounds of clean seed which is a greater quantity than would be used if the seed had to be bought.

On the poorer soils it seems necessary to fertilize winter legumes in order to grow them successfully. In 179 cases out of 500, fertilizer was used at an average rate of 328 pounds per acre; in 321 cases it was not used at all. Superphosphate was the most common fertilizer and was used at the rate of nearly 300 pounds per acre; in central Alabama, which is near the supply of basic slag, farmers used from 400 to 600 pounds of the latter per acre which cost them $10 to $12 per ton.

INOCULATION

The first plantings of a winter legume are nearly always inoculated, either with a pure culture or with soil from an old field, or with both. Using both appears to be more effective in a majority of cases than depending on pure cultures alone. The few farmers who do not inoculate their first plantings do not get successful results. For later plantings on the same land, some farmers inoculate and some do not.

The method of inoculating with soil is, usually, to obtain some soil from the old field, dry it, and sift it to remove lumps and stones; then drill it with a fertilizer distributor at the rate of 50 or more pounds per acre. Sometimes the legume seed and the soil are drilled together, and if basic slag is used it is not uncommon to mix soil, seed, inoculation, and slag, and drill them together. Superphosphate is rarely, if ever, mixed in this way for fear of killing the inoculation.

SOWING

The method of broadcasting vetch and covering with scratcher, harrow, cultivator, or plow accounts for 140 cases out of 264; in the other 124 cases the seed was drilled in. In planting winter peas the broadcast method was used in 137 cases and the drill method in 56 cases. Drills are not numerous enough in this part of the country. Fertilizer distributors were used as drills on a number of farms and were classed as drills. In central Alabama many farmers mix basic slag and seed together and put it out with a fertilizer distributor by going twice to the row. In the case of 3-row drills, as the middle hole is usually closed, all the seed goes down the outside drills. Legumes in the middle drill row, if there is one, do not grow well because the middle is low and often wet and because there is no left-over fertilizer in the middles whereas there is unused fertilizer at the base of the old cotton stalks, close to the legume drills or rows.

One danger in drilling vetch seed on sandy land is that the young plants will be "sanded" or covered with sand. When vetch first comes up it flattens out on the ground; then with a rain, the water runs down the little drill furrows, washing out here and filling in there. If the vetch were upright when small, sanding would not be so likely to happen. The precaution against sanding is to fit a smoothing board or chain harrow on the rear of the drill so that no furrows will be left. The method of covering broadcast seed with a small plow is preferred to covering with a scratcher or harrow.

Drilling, properly done, gives better results than does broadcasting. Drilled plantings do not heave so badly during freezing and thawing weather. The 3-year average yield per acre of winter peas, green weight, at the Alabama experiment station, was 5,186 pounds for the broadcast plantings and 6,906 pounds for the drilled plantings of September 30. Similar results were obtained with hairy vetch and Monantha vetch of the same date of planting and for later dates of planting.[4]

The range of dates for sowing vetch and winter peas both north and south of latitude 33° is from about October 1 to the middle of November, but the averages for both vetch and winter peas and for farms both north and south of 33° fall in October (table 12). The

[4] BAILEY, R. Y., WILLIAMSON, J. T., and DUGGAR, J. F. Op. cit., table 12.

date of sowing crimson clover is earlier—usually in September. Bur clover is sowed anywhere from the middle of July to the middle of October.

TABLE 12.—*Average dates of sowing vetch and winter peas*

Legume and section	For cotton		For corn	
	Reports	Sowing dates	Reports	Sowing dates
Vetch:	*Number*		*Number*	
North of 33°	31	Oct. 15	102	Oct. 15
South of 33°	10	Oct. 27	73	Oct. 22
Winter peas:				
North of 33°	14	Oct. 20	13	Oct. 19
South of 33°	42	Oct. 17	100	Oct. 20

Figure 9 shows two fields of crimson clover near Laurens, S.C. In one the seed was sowed in cotton middles and scratched in lightly. In the other it was sowed without scratching or covering. These fields illustrate the advantage of a light covering for the seed. Occasionally good stands are obtained without covering but, as a rule, the ground needs scarifying either before or after sowing.

LABOR REQUIREMENTS

The time required in starting winter legumes depends largely upon the method of preparing the land which, in turn, depends upon the previous crop and the condition of the land. Grain-stubble land on which weeds have grown, and other land that is weedy, require plowing (flat breaking). Cowpea and soybean stubble and land on which peanuts have been grown usually can be prepared by disking or harrowing. Cotton and corn middles can be planted without preparation, provided the land is clean. Corn middles that contain cowpeas, peanuts, or other vegetation, usually cannot be seeded to winter legumes without preparation.

The average time required per acre to prepare the land and plant the legume seed with mule-drawn implements was 8.8 man hours and 12.4 mule hours for land that was plowed; 4.8 man hours and 6.1 mule hours for land that was disked and not plowed; and 3 man hours and 2.6 mule hours for land that was in tilled crops and received no further preparation previous to seeding. In the latter case, the excess of man hours over mule hours is the result of sowing some of the seed by hand (broadcast) and covering it with a mule-drawn implement.

METHODS OF TURNING VETCH AND WINTER PEAS

Both vetch and winter peas are somewhat "vincy" and if the growth is large it catches on the beam standard until the plow must be stopped and the vines pulled out by hand. If plowed under at an earlier stage of growth this does not happen, but farmers frequently let the plants get large on the theory that they will be better fertilizers.

It is a mistake to let the legumes grow so large. If planted October 1 or soon thereafter and if the stand is good, there will be enough

nitrogen in the legume for the following crop even if it is turned under 2 to 4 weeks before it reaches its maximum growth. Weights of 5,200 pounds of green vetch per acre, or 6,100 pounds of green winter pea vines per acre, contain as much nitrogen as 300 pounds of nitrate of soda.

Some farmers disk down the winter legume before plowing it, even if they have to disk twice to accomplish the job. In 45 cases of

FIGURE 9.—Crimson clover on adjacent farms near Laurens, S. C. Upper: Clover seed sowed in cotton middles and scratched in. Lower: Clover seed sowed in cotton middles but not covered.

vetch out of 264, the land was disked before being plowed for the subsequent crop, but in 219 cases it was plowed without preliminary disking. In 39 cases of winter peas out of 193, the peas were disked and then plowed, but in 154 cases plowing alone was sufficient. There is no need of preliminary disking if the legume is turned in time. The extra work is an extra expense and it delays other work. Then, too, when bunches of green vetch or winter peas are pulled

away from the bean standard and left on the ground at intervals they present a bad appearance and interfere more or less with harrowing; this could be prevented by earlier turning with good plows and accessories.

To plow under the larger growth often requires preliminary disking or the use of rolling colter and "slide", or both. The slide presses down the vetch and winter peas so that the rolling colter gets on top of them and cuts its way down through and into the soil. This cuts the furrow vetch loose from the field vetch (or peas) so that the vetch cannot catch on the beam standard and prevent the moldboard from turning and covering it. Even with colter and slide it is difficult to do a good job with a 10-inch plow. A walking plow cutting 12 to 14 inches wide does a better job, and the sulky plow cutting 14 or more inches wide does an excellent job. The disk plow is used by those who have it, and is effective for the purpose. Tractor plows, whether of the disk or moldboard type, are especially good because of their size and power. The rolling colter plow attachment is useful in turning under winter legumes, and should be in greater use. If the growth is large a slide or chain is needed on the moldboard plow to drag the plants down so they can be completely covered; a heavy chain is also useful on the disk plow. One end of the chain can be fastened to the right end of the doubletree (for right-hand plows) and allowed to drag behind, or the rear end can be attached to the beam standard with just enough slack in it so the furrow slice will barely miss it. The slide is merely a curved shank to which the rolling colter is attached.

Another way of plowing under winter legumes is known as the "hard-bed" method, considered by many an old-fashioned and careless way. Four furrows are usually thrown together, two on each side, to make a "bed." The beds are as far apart as the distance between the intended corn rows, leaving a rather deep furrow between the beds. If the rows are so wide that four furrows will not complete each bed then 1 or 2 additional furrows are thrown out or a middle burster is used to plow out the remainder at one "through". The original surface of the ground under the beds is unbroken, hence the name. The corn is planted in the bottom of the furrow immediately after "bedding" or at least within a very few days. This method is often practiced on sandy or sandy loam lands but not on clay. Heavy rains soon after the corn comes up would drown it by flooding the furrows in the clay soil, but in the sandy soils the water drains away.

A striking instance of this method was found in Edgefield County, S.C. On May 15, 1929, a field of 5 acres of vetch was disked down and then bedded with four furrows to the bed. The bedding was completed with a middle burster on that date and the corn was planted three days later in the bottom of the furrow. The corn was fertilized with 400 pounds of nitrate of soda and 100 pounds of potash manure salts per acre, and the measured yield was 105 bushels per acre (fig. 2).

A leading Georgia farmer insists that by the hard-bed method of preparing land for corn he has perpetuated vetch as a volunteer crop for six years. The land is bedded without previous disking and the vetch tops, which protrude above the beds, make seed before the middles are cultivated, and the vetch volunteers each fall. This

method permits the planting of corn sooner after the legume is plowed under than does the method of flat breaking land, but there is some risk from injury to following crops by so-called vetch worms and by the southern corn-root worm.

DATES OF TURNING LEGUMES AND OF PLANTING THE FOLLOWING CROPS

Winter peas are turned under somewhat earlier than vetch, especially south of 33° latitude. This tends to confirm the statements of a number of farmers that winter peas are earlier than vetch and can be plowed under sooner. On the greater part of the cotton land the winter legumes are turned under in April, although the average date of turning under winter peas south of 33° was March 29 (table 13).

TABLE 13.—*Average date of turning under vetch and winter peas and of planting following crops*

Legume and section	Estimates on—		Date of—		Interval
	Turning	Planting	Turning	Planting	
FOR COTTON					
Vetch:	*Number*	*Number*			*Days*
North of 33°	30	30	Apr. 23	May 8	15
South of 33°	10	10	Apr. 20	May 1	11
Winter peas:					
North of 33°	14	14	Apr. 19	May 10	21
South of 33°	44	45	Mar. 29	Apr. 19	21
FOR CORN					
Vetch:					
North of 33°	110	113	May 4	May 19	15
South of 33°	86	86	Apr. 26	May 13	17
Winter peas:					
North of 33°	14	14	May 1	May 12	11
South of 33°	112	112	Apr. 11	Apr. 28	17

The dates of turning under winter legumes for corn are mostly in the latter half of April and the first half of May, but for farms south of 33° the winter peas were turned under during the first half of April.

Most of the cotton was planted in April and most of the corn in May, but for both cotton and corn after winter peas in the more southerly latitude, the average planting dates were in April. The interval between dates of turning under the legumes and of planting cotton and corn was usually between 2 and 3 weeks, but in a considerable number of cases the interval was less than 2 weeks.

Granting the value of winter legumes as fertilizers and the desirability of extending their use in the South, it is still a question of how large a part of the farm should be planted with them. Most of the farmers interviewed stated that 5 acres to the mule is about as much as one can plow under within the limits of time when the legumes should be turned under. This would be about 20 to 25 percent of the crop land. The acreage of winter legumes that a farmer can handle satisfactorily depends primarily upon the length of time between the date when the plowing under can begin and the date when it should end. The date of beginning to turn under the legume may be advanced in five ways:

(1) By fertilizing the legume and getting a larger early growth; (2) by planting earlier in the fall for the same purpose; (3) by planting those varieties of winter legumes which naturally make the largest early growth; (4) by getting good stands; and (5) by turning at an earlier stage of growth than is customary. By these methods the date of beginning to turn down the legume may be advanced 15 or 20 days of which, perhaps, 10 to 14 may be utilized for field work.

The first method needs little explanation. On poor soils without fertilizer the growth is so small that it has little fertilizing value; if the legume makes a fair growth without fertilizer it makes a better growth with fertilizer and makes enough green manure early in the spring, hence can be plowed under earlier.

The second way has experimental evidence in its favor. At the Alabama experiment station the green weights of winter peas per acre for the years 1927–29 and for cuttings of March 22 were as follows: For planting of September 30, 5,909 pounds; of October 26, 4,265 pounds; of November 23, 1,545 pounds, and of December 19, 426 pounds.[5] The earliest planting, which had made nearly 6,000 pounds per acre on March 22, had as much nitrogen in it as 300 pounds of nitrate of soda. The planting of October 26 had made only 4,265 pounds on March 22 but by April 2 it had about caught up with the March 22 cutting of the earlier planting and weighed 5,948 pounds. It may be said, then, that the planting of September 30 had the equivalent of 300 pounds of nitrate of soda per acre 11 days earlier than had the planting of October 26, and on a comparable basis of fertilizing value could therefore have been plowed under 11 days earlier. In fact, the winter peas could have been plowed under with good results when the nitrogen equivalent was only 200 pounds of nitrate of soda per acre thus advancing the date of turning several more days. This, however, illustrates the fifth way of advancing the date of turning. In the same experiment, the yields of hairy vetch and Monantha vetch show similar results for different dates of planting.

The third way of advancing the date of turning depends upon the greater cool-weather growth, or early growth, of these legumes over hairy vetch. At the Alabama station the average green weight of hairy vetch for five years was 6,546 pounds on or about April 1 for the planting of October 1. For winter peas it was 9,136 pounds and for Monantha vetch it was 10,270 pounds. Monantha vetch, though making a large early growth, is not very winter-hardy even in the southern part of the area and is of less utility farther north. Hairy vetch may often equal, in early growth, these other legumes, depending on whether the winter has been warm or cold; but generally speaking it makes less early growth than these competitors.[6]

At the Georgia Agricultural College for the 2 years of 1925 and 1926 the weight of cured hay per acre on March 1 was 700 pounds of vetch and 1,650 pounds of winter peas; on March 23, 1,750 pounds of vetch and 2,300 pounds of winter peas; on April 6, 2,250 pounds of vetch and 2,300 pounds of winter peas; and on May 6, 3,900 pounds of vetch and 4,100 pounds of winter peas.[7]

[5] BAILEY, R. Y., WILLIAMSON, J. T., and DUGGAR, J. F. Op. cit., table 15.
[6] BAILEY, R. Y., WILLIAMSON, J. T., and DUGGAR, J. F. Op. cit., table 17.
[7] TABOR, P. WINTER FORAGE AND COVER CROPS. Ga. State Col. Agr. Bul. 321, table 2, 1926.

It may happen that whereas the green weight of winter peas is greater than that of vetch, the nitrogen content of the vetch is greater than that of the winter peas, but in most cases the winter peas contain more nitrogen on the earlier dates of plowing under, than does the vetch.

The fourth way by which the date of plowing under may be advanced involves the fact that with equal heights of plants, good stands produce a larger tonnage than poor stands. Getting good stands is a matter of quantity and quality of seed, preparation of land, and methods and time of planting. Thirty pounds of winter peas per acre planted September 30 produced a larger crop of green material than did 60 pounds per acre planted October 26. Drilled vetch exceeded the yield of broadcast vetch by 30 percent when planted September 30 and by a larger percentage for later plantings. Similar results were obtained with Monantha vetch and winter peas.[8]

The fifth way of advancing the date of turning has been mentioned incidentally. Experiments show that there is nitrogen enough for the subsequent crop considerably earlier than farmers think. The pounds of nitrogen per acre in the tops and roots of vetch at the Georgia Experiment Station were 40 pounds on March 26; 43 pounds, April 2; 70 pounds, April 9; 85 pounds, April 16; 162 pounds, April 23; and 192 pounds, April 30. These would be equivalent to 260 pounds of nitrate of soda for the first date; 275 pounds for the second; 450 pounds for the third; 550 pounds for the fourth; 815 pounds for the fifth; and 1,240 pounds for the sixth.[9] If smooth vetch or winter peas had been used it is probable that the quantity of nitrogen would have been greater at the earliest date.

In the cases cited there was enough nitrogen for a crop of corn or cotton even at the earliest date mentioned; hence plowing should begin at about that time. The earlier a farmer begins plowing under winter legumes the longer the period of time in which plowing may continue, hence the greater the acreage per mule.

Grazing is another consideration. One successful Georgia farmer says he plants all his crop land in winter legumes, then grazes all of it. By careful management the season for plowing can be made still longer. The ungrazed portion can be plowed under first, then the remainder can be grazed in succession and plowed under in succession.

Some men cut their winter legume for hay and follow with corn or other late crop. Some cut it high, getting as much hay as they need and turning under the growth that is left. There are several ways of managing to get feed and fertilizer and to extend the time of plowing under the legume. It is estimated that a minimum of one third of the crop area can easily be handled in winter legumes.

PERCENTAGE OF CROP LAND IN WINTER LEGUMES

Small farms were found to have a larger percentage of their acreage in winter legumes than large ones (table 14). This may mean that the small farmer, who does most of his own work and does it better than do hired hands, is the one most likely to use winter legumes. Hired hands are prone to do a very poor job of turning under legumes.

[8] BAILEY, R. Y., WILLIAMSON, J. T., and DUGGAR, J. F. Op. cit., tables 12 and 13.
[9] TEMPLE, J. C., THE VALUE OF AMMONIFICATION TESTS. Ga. Expt. Sta. Bul. 126, 17 p., 1919.

TABLE 14.—*Percentage of crop land devoted to vetch and winter peas on farms of specified size*

Size group (crop acres per farm)	Farms [1]	Crop acreage		Acreage in vetch and winter peas		
		Total	Weighted average per farm	Total	Weighted average per farm	Percentage of crop acreage
	Number	*Acres*	*Acres*	*Acres*	*Acres*	*Percent*
0 to 50	50	2,096	42	355	7.1	16.9
51 to 100	109	8,842	81	903	8.3	10.2
101 to 200	115	19,284	168	1,783	15.5	9.2
201 to 400	49	13,880	283	802	16.3	5.8
401 to 600	43	22,825	554	1,129	26.2	4.7
Over 600	20	27,375	1,369	581	29.5	2.1
Total and weighted average	386	95,302	247	5,553	14.4	5.8

[1] Some farmers gave estimates for more than 1 year.

Nearly 6 percent of the crop area of the 386 farms shown in table 14 was in vetch and winter peas. Farms north of the latitude of 33° had 4.7 percent of their crop acreage in vetch and winter peas whereas those south of that latitude had 6.6 percent of the crop acreage in these legumes. The farther south, the earlier is the growth of the legume and the greater the length of time in which to plow it under.

According to the best information available, about 84,000 acres of winter legumes were planted in Georgia in 1928 and 90,000 acres in 1929. This is about 0.8 percent of the total crop acreage of the State. If the percentage were as large for the whole State as for the farms represented in this study there would have been more than 800,000 acres of these legumes, and if they should average 5 acres to the mile it would amount to 1,875,000 acres for the State.

HOME-GROWN WINTER-LEGUME SEED

Most of the crimson-clover seed used by farmers in the Carolinas and in Georgia is of their own saving, according to the records obtained. This seed is stripped off or is beaten out by forks and is sowed in the chaff. In most instances the seed is "scratched in" after being sowed on top of the ground. One farmer who is very successful with crimson clover says that when he sows the chaffy seed in cotton middles he scratches the ground first, then sows the seed, but does not cover; when he sows the thrashed seed he sows first and scratches afterward.

In certain years the seed crop of hairy vetch is a total failure because of the attacks of the corn ear worm. Even where this has not happened, the yield has been low. Then, too, the vetch seed shatters badly and in many districts no thrashing machines are available.

Some seed of Monantha vetch has been saved by a few farmers in southern Alabama. This vetch grows well with oats and ripens with the early varieties of oats, so they can be harvested together. On a few farms, where it was grown alone, it was allowed to become dead ripe and to fall flat on the ground. Then it was raked with a horse rake without cutting, the roots breaking off at the ground. The crop was then gathered and thrashed. Monantha vetch holds its seed well in the pod; its weakness is its lack of winter hardiness.

With regard to winter peas, injury by aphids has been more or less prevalent, thus preventing seed formation, but the crop is usually large enough to turn under as a fertilizer before the aphids become abundant.

On the whole the prospects are not very encouraging for farmers to grow their own vetch and winter-pea seed.

CROPS PRECEDING AND FOLLOWING WINTER LEGUMES

About 80 percent of all the vetch and winter peas reported in this study were planted after cotton, as compared with 20 percent after all other crops. Vetch was planted after cotton in 211 cases, after corn in 24 cases, and after other crops in 29 cases out of a total of 264 cases; whereas out of 193 cases of winter peas, 157 followed cotton, 19 followed corn, and 17 followed all other crops. Among the "other crops" were cowpeas, soybeans, peanuts, and tobacco.

There are good reasons why it is the usual practice to plant winter legumes after cotton. Cotton middles are likely to be unoccupied whereas corn middles are usually planted with cowpeas, soybeans, peanuts, or velvetbeans. Then, cotton is laid by later than corn and the ground is cleaner, thus no preparation of the soil is required for the winter legume. Cotton stalks do not fall down across the rows as cornstalks frequently do in hard storms; thus there are no obstructions in the cotton middles.

It is comparatively easy to plant winter legumes after cowpeas, soybeans, peanuts, and tobacco, but the acreage of these crops is relatively small. If, in the organization of farms, a larger use could be made of cowpeas, soybeans, and peanuts, the practice of following them with winter legumes would increase.

Winter legumes are easily planted after tobacco. Crimson clover in North Carolina and winter peas in Georgia follow this crop to some extent. Tobacco does not follow these legumes because, although the resulting yield is good, the quality of leaf is not the best.

As to major crops that follow winter legumes, this study embraces 353 estimates for corn and 147 for cotton. It is clear that most farmers plant corn rather than cotton after winter legumes. Many would like to plant cotton after them, and about one third of those interviewed did so, but the complaint is made that the winter legume is not large enough to make much fertilizer when plowing for cotton should begin. This is partly true and partly not, as indicated under the heading Dates of Turning Legumes and of Planting the Following Crops. Those who use tractors can do better in this respect than those who use only mules.

Corn planting extends over a longer time than does cotton planting, hence there is more time to get the legume turned under and partly decayed before planting. Then, since cotton and corn are grown more or less in rotation or alteration, and since it is much easier to plant winter legumes after cotton than after corn, it is a natural sequence for the corn rather than cotton to follow the winter legume.

Crops other than cotton and corn following winter legumes were infrequent, but 2 cases of cowpeas, 4 of corn silage, 1 of sweetpotatoes, and 1 of sorgo silage were reported. In all cases the results were decidedly profitable. In two instances of corn silage the yield after vetch was equal to that on land which was manured at the rate of 10 tons of stable manure per acre.

An interesting case was that of sorgo silage following bur clover for 10 consecutive years during which time the bur clover volunteered every year. On a farm in Saluda County, S.C., 6 acres of this clover on a red-clay hill were fertilized each year with 500 pounds of superphosphate per acre. Cattle and sheep were grazed on the clover in February and March, the estimated value of such grazing being $8 per acre. The 10-year average yield of the sorgo following bur clover was estimated to be 10 tons per acre compared with 5 tons per acre not after it. In April 1930, the stand of clover was good and the dark-green foliage indicated health and vigor. The average date for planting the sorgo had been June 1, after the bur-clover seed had matured. The type of soil and the heavy use of superphosphate are probably responsible for the excellent results.

CROP ROTATION AND WINTER LEGUMES

The acreage of winter legumes is so small at present that they do not constitute a definite part of any cropping system. But if they could occupy 20 to 35 percent of the total crop area they could easily be fitted into practical crop rotations. Rotations are rarely inflexible. Often something interferes with the regularity of a planned system. The failure of a particular crop, the exigencies of the weather, an unfavorable topography, or the varying types of soil on the same farm, limit the application of such rotations. Nevertheless, crop systems may be approximated and if one system will not apply on the whole farm it can often be divided into two or more systems for different parts of the farm.

A 3-YEAR ROTATION

A possible rotation in which winter legumes can be used is that described in table 15. In this rotation one third of the land is in cotton; one third in summer legumes for hay, seed, and pasture; and one third is in corn.

TABLE 15.—*A 3-year rotation of cotton, summer legumes, and corn*

Item	First field	Second field	Third field
First-year period	Cotton	Summer-legume hay etc., followed by winter legumes.	Corn and interplanted legumes.
Second-year period	Summer-legume hay, etc., followed by winter legumes.	Corn and interplanted legumes.	Cotton.
Third-year period	Corn and interplanted legumes.	Cotton	Summer-legume hay etc., followed by winter legumes.

The cotton may be replaced, if desired, by other money crops, like peanuts or tobacco. If hogs are to be raised for market, peanuts could be planted on part of the land assigned to summer-legume hay, etc., but the peanuts would have to be harvested in time to permit the land to be planted in winter legumes. Part of the same field might be planted to crops of early potatoes, cantaloupes, watermelons, or sorgo for sirup, all of which are harvested early enough so that winter legumes can be planted after them.

This 3-year rotation would produce more feedstuffs than the average southern farm would consume, two thirds of the area being

assigned to feed crops, and the corn yield would be far above the average because this crop is preceded by winter legumes. It is, therefore, a rotation that assumes more livestock than the average southern farm possesses.

It may be asked why oats should not be introduced into this rotation where it would follow cotton and precede the summer legume. Perhaps there are farms on which this should be done but, in general, there is already more feed in this rotation than would be needed on the average farm, hence oats would merely add to the surplus feed, either of hay or grain. The date of planting the summer legume would be delayed as would the date of harvesting; there might not be time to plant the winter legume, depending on the latitude. At least, it would be easier to plant winter legumes after cowpeas and soybeans that are planted in April and May than after those planted in June. The winter legume should be planted in early October; if the double crop of oats-cowpeas interferes with this, the oats may well be omitted.

Another argument against oats in this rotation is the peak load of labor involved in June in harvesting the oats and planting the cowpeas. If oats-cowpeas are in the rotation a team could tend about 15 acres of cotton, 15 of oats-cowpeas, and 15 of corn; but if oats are omitted the team can tend 18 acres of cotton, 18 of summer legumes followed by winter legumes, and 18 of corn—or an increased acreage of 20 percent. This assumes a sandy loam soil in both cases and, in the latter case, it assumes that preparation of the old cotton land for summer legumes is by means of the disk harrow instead of the turnplow. If a tractor is used there would be about the same relative difference in acreage.

A further reason against oats for the average farm is the necessity of expensive harvesting and threshing machinery which the smaller farms cannot afford. There are conditions under which the oat crop is highly desirable but on the average farm and for the 3-year rotation described, its value is questionable.

The increased yield of corn following winter legumes has been found to average about 14 bushels per acre compared with corn not following the legume, hence on an 18-acre field the increased production of corn would amount to 252 bushels. Assuming a yield of 16 bushels per acre without the winter legume and 30 bushels per acre with it, the total production of corn on the 18 acres would be 288 bushels in the former case and 540 bushels in the latter.

With these yields, more corn can be grown on one fourth of the total land in crops when it follows a winter legume than on one third of the land without the winter legume. To illustrate: If 60 acres of crop land are available, then one fourth of the land, 15 acres, at 30 bushels per acre, will produce 450 bushels of corn whereas one third of it, 20 acres, at 16 bushels per acre, will produce 320 bushels.

A 4-YEAR ROTATION

With higher corn yields, the average southern farmer probably would prefer to have more than one third of his crop land in money crops and less than two thirds in feed crops, the proportions indicated for the 3-year rotation. Corn is not considered a money crop in the Southeast although a little is occasionally sold.

To increase the area of money crops and to decrease that of feed crops, a 4-year rotation is suggested, which may be considered the

same as the 3-year rotation plus another equal field of a money crop, usually cotton. One half of the crop area in this rotation is devoted to money crops of which cotton is the principal one although peanuts and tobacco may replace cotton on part of the area if desired (table 16).

TABLE 16.—*A suggested 4-year rotation*

Item	First field	Second field	Third field	Fourth field
First-year period.	Cotton followed in part by winter legumes.	Cotton	Summer-legume hay etc., followed by winter legumes.	Corn and interplanted legumes.
Second-year period.	Cotton	Summer-legume hay etc., followed by winter legumes.	Corn and interplanted legumes.	Cotton followed in part by winter legumes.
Third-year period.	Summer-legume hay etc., followed by winter legumes.	Corn and interplanted legumes.	Cotton followed in part by winter legumes.	Cotton.
Fourth-year period.	Corn and interplanted legumes.	Cotton followed in part by winter legumes.	Cotton	Summer-legume hay etc., followed by winter legumes.

A variety of crops may occupy the field assigned to summer-legume hay, etc., if all can be harvested early enough to permit the planting of winter legumes to be turned under the following spring for corn. About half of this field may be devoted to cowpeas or soybeans for hay. A small area may be in the same crops to be harvested for seed or to be grazed off. A few acres may be devoted to such crops as early potatoes, cantaloupes, watermelons, peppers, and sorgo for sirup. There should be a greater flexibility in the plantings of this field than in the other fields.

Part of the cotton land may be planted to winter legumes to be turned under the next spring for cotton or peanuts but the acreage will have to be limited or there will be too many acres of winter legumes to plow under in the limited time available for the purpose. Corn follows winter legumes in this 4-year rotation, as in the 3-year rotation, and may be interplanted to cowpeas, peanuts, soybeans, or velvet beans.

If the old cotton land is prepared for the summer legumes, with a disk harrow, one team will tend about 52 acres of all crops in this 4-year rotation which means 13 acres to each of the four fields. With a yield of 30 bushels per acre of corn the 13 acres will produce 390 bushels; this is about 100 bushels more than enough for home requirements on a 2-horse farm. It would require a little extra livestock to consume this surplus corn but perhaps that is not an objection. Extra cows would require extra hay and the area assigned to summer legumes is sufficient for feeding two or three extra cows. A few more hogs would help to consume the extra corn and the by-products from the cows.

ADAPTATION TO SHARE-CROP CONDITIONS

A serious difficulty in applying definite crop rotations to farms in the Cotton Belt is the fact that the share cropper who raises much of the cotton for a half share of the crop has little use for feed crops. He prefers to grow cotton continuously on the same land. Even when the landlord persuades the share cropper to raise corn and other feed crops, the latter is not interested and the landlord usually buys the share cropper's half of these feedstuffs.

Some lands are better for cotton than for corn and the tendency is to grow cotton more or less continuously on certain parts of the

farm or plantation. In the attempt, therefore, to apply crop rotations to the Cotton Belt it may be well to apply them to part of the farm and let cotton be grown continuously on other parts. If hogs are raised, crops that they can graze must be grown in fenced fields adjacent to their buildings. These may be in a rotation by themselves.

To illustrate a plan of growing cotton continuously on part of the farm, or plantation, and of using crop rotations on other parts of the farm the following example is given for 60 acres of crop land. One field of 20 acres will be devoted to continuous cotton production, and two fields of 17 acres each will be devoted to a 2-year rotation of crops as follows:

First year	10 acres of cotton, peanuts and/or tobacco, in varying proportions, followed by winter legumes.
	7 acres of summer legumes for hay and seed, followed by winter legumes.
Second year	12 acres of corn and interplanted legumes.
	2 acres of melons or substitute crop followed by winter legumes.
	3 acres of summer legumes for hay and seed followed by winter legumes.

In addition there will be two fields of 3 acres each on which a rotation of grazing crops for hogs will be grown. This rotation will be as follows:

First year	Corn and interplanted legumes.
Second year	Peanuts, Sudan grass, etc., for grazing.

This arrangement puts half the land in the money crops of cotton, peanuts, and (or) tobacco. Part of the 2 acres of melons or substitute crops, like early potatoes or sorgo sirup, may also be sold. One fourth of the land is put in corn and interplanted legumes (12 acres plus 3 acres); one sixth in summer legumes, such as cowpeas and soybeans, for hay and seed (7 acres plus 3 acres), and one twentieth in peanuts, Sudan grass, etc., for grazing by hogs.

If there is time to plant and turn under a larger acreage of winter legumes than has been planned for in the foregoing examples they can occupy part of the land devoted to continuous cotton. Their growth does not interfere with the growth of cotton unless they are turned under too late in the spring.

In southern Georgia and Alabama one team of two mules can tend this 60 acres of crops. The share cropper, if there is one, might tend the 20 acres of continuous cotton and he could work as a wage hand part of the time on feed crops.

If the acreage of continuous cotton shown in the foregoing plan is too large it can be reduced, and the rest of the land devoted to a 3-year crop rotation. A method of doing this would be to have one fourth of the land, or 1 field of 15 acres, devoted to continuous cotton production, and 3 fields of 13 acres each devoted to the 3-year rotation, as follows:

First year	13 acres of cotton, peanuts, and (or) tobacco in varying proportions.
Second year	10 acres of summer legumes for hay and seed followed by winter legumes.
	2 acres of cotton followed by winter legumes.
	1 acre of melons followed by winter legumes.
Third year	12 acres of corn and interplanted legumes.
	1 acre of melons or substitute crop.

In this system, as in the previous one, there will be a rotation of grazing crops for hogs on 2 fields of 3 acres each, in the following order:

First year_____ Corn and interplanted legumes.
Second year_____ Peanuts, Sudan grass, etc., for grazing.

In this arrangement the acreage of money crops and of feed crops is the same as in the preceding plan but the acreage in continuous cotton is only one half of all the acreage in cotton, peanuts, and tobacco, whereas in the previous arrangement it was two thirds of all cotton, peanuts, and tobacco. It would be easy to make the acreage of continuous cotton still smaller and arrange the remainder of the land in a crop rotation. All of the crops following the 10 acres of summer legumes, 2 acres of cotton, and 1 acre of melons in the last-mentioned plan are to be followed by winter legumes. Substitutes for melons may be early potatoes, and sorgo for sirup.

Any of these systems or any other that may be suggested might have to be modified in particular cases. There are certain areas of wild meadow hay that are not suitable for any other crop; there are lands suitable for corn that are not suitable for cotton; and in certain places modifications are required because of the topography of the fields. Within these limitations, however, a rotation system that provides for better yields of all crops, that gives ample acreages for the money crops and for feed crops, and that provides a reasonable distribution of labor for man and horse, is much to be desired.

The general use of winter legumes in the Southeastern States would still leave cotton and corn as the principal crops. It would not be likely to increase the corn acreage but would decidedly increase its total production. To the extent that cotton follows winter legumes it would be benefited directly; in any event, it would be benefited indirectly. The use of these legumes in preventing soil erosion and in furnishing hay and pasture is highly desirable, but their main use is in building the fertility of southern soils.

SUMMARY

This study was made in North Carolina, South Carolina, Georgia, and Alabama in 1929 and 1930.

The number of 1-year estimates was 353 for corn and 147 for cotton; of these 500 estimates, 264 were for crops after vetch, 193 for crops after winter peas, 32 for crops after crimson clover, and 11 for crops after bur clover.

The increased yield of corn after winter legumes averaged 14.1 bushels per acre; of cotton, 100 pounds of lint per acre.

The total extra cost for corn after winter legumes on 4,145 acres, over and above that on corn not after winter legumes, was $5.54 an acre on the basis of high prices, of which $2.87 was cash cost and $2.67 was noncash. At low prices the same items were $1.88 and $1.48 respectively.

The total extra cost for cotton after winter legumes on 1,877 acres, over and above that on cotton not after winter legumes, was $8.61 an acre at high prices, of which $3.80 was cash cost and $4.81 was noncash. At low prices these items were $2.39 an acre and $2.52 an acre respectively.

The net gain in value from the use of winter legumes for corn was $9.19 an acre at high prices, all costs considered, or $11.86 an acre

with cash costs only considered. At low prices the net gain would be $3.99 an acre, all costs considered, or $5.47 an acre if only cash costs are considered.

The net gain in value from the use of winter legumes for cotton was $9.69 an acre at high prices, all costs considered, or $14.50 an acre with only cash costs considered. At low prices the net gain would be $2.24 an acre, all costs considered or $4.76 with only cash costs considered.

The increased yield of corn after winter legumes was 2.1 bushels per acre greater on land south of latitude 33° than on land north of that line. The increase in yield of lint cotton was 10 pounds per acre greater south of latitude 33°.

Winter legumes have a residual effect the second year after planting according to the testimony of many farmers. This is confirmed by experimental evidence.

The grazing value of winter legumes is sufficient to pay all expenses, and even after grazing the fertilizer value is considerable.

In 79 percent of the cases studied there was no preparation of land before the winter legume was planted, because it was planted in the middles between row crops, mostly in cotton middles. In 12 percent of the cases the land was flat broken and in 9 percent it was disked and harrowed.

In 53 percent the winter-legume seed was broadcast and harrowed in or plowed in; in 47 percent it was drilled in.

The average rate of seeding winter legumes was 23 pounds per acre for vetch and 31 pounds for winter peas; the average price of vetch seed was 13 cents and of winter pea seed 9½ cents a pound.

In 179 cases out of 500 the winter legumes were fertilized at an average rate of 328 pounds of commercial fertilizers per acre. In the other 321 cases no fertilizer was used.

Pure-culture inoculation is commonly used on winter-legume seed, especially the first time they are planted on any piece of land. Many farmers also use soil from an old field that has grown the same kind of legume. Using both is called the double method.

In 373 of 459 cases the winter legume was plowed under in the spring without preliminary disking and in the rest of the cases it was disked once or twice before planting.

The rolling colter attachment to plows is little used but ought to be used everywhere to do a good job of covering winter legumes and, if growth is large, the plow should have a "slide" to press the growth down, or a heavy chain to drag it down.

The average time between the date of turning under winter legumes, including both vetch and winter peas, and planting corn thereafter, was 14 days at points north of the latitude of 33° and 17 days at points south of it. For cotton it was 17 days north and 19 days south of that line.

Most farmers think that 5 acres of winter legumes per mule is the practicable number, but with proper management and implements this acreage can be increased to 10 or more acres.

Experimental evidence shows that October 1 plantings of winter legumes make larger yields than plantings 3 or 4 weeks later; this is especially true of the early spring growth. Such evidence also shows that Austrian winter peas and Monantha vetch usually make a larger early growth than does hairy vetch.

The date of beginning to plow under the winter legume can be advanced by getting a larger early spring growth. This can be done by (1) using fertilizer on the legume, (2) planting the legume early in the fall, (3) using the kind of legume that makes the largest early growth, and (4) getting good stands of the legume.

The percentage area of winter legumes is greater on small farms than on large ones, and greater south of 33° latitude than north of that line.

About 80 percent of the winter legumes on the farms studied were preceded by cotton, 10 percent by corn, and 10 percent by all other crops. Seventy percent of these legumes were followed by corn and nearly all the rest by cotton.

Cowpeas grown for hay, corn silage, sorgo silage, and sweetpotatoes were found to be benefited by fertilizing with winter legumes.

Winter legumes can be fitted into various crop rotations. One fifth to one third of the crop land should be in winter legumes and even more if there are animals to graze the fields.

U.S. GOVERNMENT PRINTING OFFICE: 1933

For sale by the Superintendent of Documents, Washington, D.C. - - - - - - - - Price 5 cents

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