Growing winter legumes in Louisiana

Franklin Louis Davis

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Growing Winter Legumes in Louisiana

By

FRANKLIN L. DAVIS,
C. G. HOBGOOD, AND C. A. BREWER, JR.

A Good Crop of Austrian Winter Peas Ready to Be Turned Under

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

C. T. Dowell, Director
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ACKNOWLEDGMENT

The authors wish to express appreciation for the co-operation of County Agricultural Agents of the respective parishes and of the following men on whose farms or plantations the cooperative tests were conducted: Mr. M. E. Winn of Natchitoches Parish, Mr. J. G. Austin and Mr. J. Vaughn Christian of DeSoto Parish, Mr. E. B. Tatum of Lincoln Parish, Mr. S. O. Henry of Ouachita Parish, Mr. E. H. Burch of Washington Parish, Mr. C. Willis Roy and Mr. George H. Parker of St. Landry Parish, Mr. W. R. Gaar of Winn Parish, Dr. R. O. Young and Mr. Claud R. Hebert, plantation superintendent, of Lafayette Parish, and Mr. George W. Grant of Grant Parish. Dr. E. C. Tims of the Department of Plant Pathology kindly photographed the material shown in Figures 3-A, 3-B, and 4, and Mr. J. H. Jolly of the Fertilizer and Feed Stuffs Laboratory made the nitrogen analyses given in Tables 2 and 3. The winter legume tests on the Experiment Station farm were planned and conducted previous to 1939 by Dr. H. B. Brown, the late Dr. A. H. Meyer, and Mr. H. C. Lovett.
Growing Winter Legumes in Louisiana *

FRANKLIN L. DAVIS,
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INTRODUCTION

The growing of legumes was probably practiced by man before the time of the most ancient historical records. It is certain that they were used in the agriculture which gave rise to the earliest great civilizations. This is known from the records and remains of early civilizations on which ancient history is based and from the references to beans, lentils, and other legumes that were used for food during the earliest times recorded in the Bible. Various legumes have been used continuously from that time to the present. It is probable that legumes were not so important in the agriculture of sparsely populated countries. One can be sure, however, that they were grown regularly by the peoples who lived by means of a permanently settled cultivation of crops.

The value of legumes for enriching the soil was known at a surprisingly early date. Writings by the Romans disclose that they recognized the manuring value of legumes for soils as early as the second century B.C. The inclusion of legumes in a rotation of crops was urged by agricultural writers of Europe during American Colonial days. Writings of this same time record that the American Indians followed the practice of planting “peas” in their corn. Upon colonization of America, the need for maintaining the fertility of the land soon arose along the Atlantic seaboard. The problems produced by the depletion of soil fertility were at least temporarily solved for many pioneering farmers who moved westward to settle on the fertile lands of the broad Mississippi valley. Owing to the area of new lands available for cultivation, the growing of green manures did not become a general practice in the United States until only relatively recently.

The practices followed in regard to the use of legumes for maintaining and improving soil fertility are associated with climatic conditions. These practices may be loosely divided according to two areas—the North and the South.

In the northern states, where most of the winter precipitation is in the form of snow, there is little leaching as compared to the South. Low winter temperatures limit the use of annual winter
legumes. The best cropping systems in this area include small grains as winter cover crops, regular summer legumes, and mixed meadows or pastures in the rotation.

In the southern states the Coastal Plains soils are not well adapted for such summer legumes as alfalfa and the clovers that are grown in the North. On the other hand, the mild winters permit the growing of winter legumes annually between the regular summer crops. This has its advantages as use may be made of them, not only to prevent erosion and conserve the soil, but also to improve its fertility. In the southeastern states, where cropping has been persistent, considerable progress has been made in finding and adapting legumes and measuring their effects as green manure upon the yields of the crops that follow them.

The object of this bulletin is to make available the data of the Louisiana Agricultural Experiment Station on (1) the effect of green manures on the yields of following crops and (2) practices that may be used to avoid the difficulties often encountered in growing winter legumes the first few times.

EXPERIMENTAL

THE EFFECT OF GREEN MANURES ON YIELD OF FOLLOWING CROPS

Green manures are any crops that are turned into the soil. They may be grown either in the summer or in the winter. Winter cover crops are those that are planted in the fall and allowed to remain on the land during the winter. They may be either legumes or such non-legumes as oats and rye. When turned under in the spring, they become green manures.

A test to determine the effect of rye, oats, Melilotus indica, Austrian winter peas, and hairy vetch as green manures upon the yield of cotton was begun in 1930. Mineral nitrogen from nitrate of soda applied at the rate of 225 pounds per acre, which is 36 pounds of nitrogen per acre, was also included in the test. Data concerning the fertilizers used and the yields obtained are given in detail in Table 1 and summarized in Table 2.

After three consecutive crops of green manures the growth of cotton following the winter legumes became so undesirably rank that the winter cover crops were omitted for two years. During this time another test including a larger number of winter legumes was started. These tests were handled so that green manure crops would be grown on alternate years on each of the tests. The yields of cotton on the other years were taken as a measure of the residual effect of green manuring.

As shown by the figures in Table 2, 36 pounds of nitrogen per acre from nitrate of soda produced an average increase of 469 pounds of seed cotton per acre over the no-cover-crop check. There appears to be also a small residual effect from applications of ni-
### TABLE 1. YIELD DATA ON OLD WINTER COVER CROP TEST ON OLIVIER SILT LOAM AT BATON ROUGE

#### A. Winter Cover Crops and Fertilizer Used

<table>
<thead>
<tr>
<th>Plot No.*</th>
<th>Cover crop and source of nitrogen</th>
<th>Analysis of fertilizer† applied at rate of 600 lbs. per acre</th>
<th>Years grown, date turned and weight of green matter in tons per acre</th>
<th>Nitrogen content of green matter in lbs. N per ton, 1936</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rye (Secale cereale)</td>
<td>0-8-5</td>
<td>Apr. 1 1931 0.8 0.4 3.3 5.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Oats (Avena sativa)</td>
<td>0-8-5</td>
<td>Apr. 1 1932 1.4 1.4 2.9 5.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nitrate of soda- No cover crop</td>
<td>6-8-5†</td>
<td>Apr. 1 1933 11.5 10.5 WK** 7.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sour clover- limed§ (Melilotus indica)</td>
<td>0-8-5</td>
<td>Apr. 2 1936 12.9 10.5 WK** 7.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sour clover- not limed (Melilotus indica)</td>
<td>0-8-5</td>
<td>Apr. 3 1937 6.8 7.2 11.0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Austrian winter peas (Pisum arvense)</td>
<td>0-8-5</td>
<td>Apr. 4 1938 7.5 4.1 8.0 10.8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hairy vetch (Vicia villosa)</td>
<td>0-8-5</td>
<td>Apr. 5 1939 3.2 4.1 8.0 10.8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>No cover crop- Check</td>
<td>0-8-5</td>
<td>Apr. 6 1940 2.5 4.1 8.0 10.8</td>
<td></td>
</tr>
</tbody>
</table>

*Plots were 1/20 acre in size and each treatment was replicated four times.
†All fertilizers were applied to cotton. Nitrate of soda was applied to Plot No. 3 only on those years that the winter cover crops were turned under. The minerals were applied each year.
§Total nitrogen content was not determined previous to 1936.
Three tons of lime per acre were applied in the fall of 1929.
**Melilotus indica was winter killed in 1933.

#### B. Cotton Yields

<table>
<thead>
<tr>
<th>Plot No.*</th>
<th>Source of Nitrogen</th>
<th>Yield of seed cotton in lbs. per acre</th>
<th>7 year av.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rye (Secale cereale)</td>
<td>1572 1536 1002 1454 1153 2000 1327</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Oats (Avena sativa)</td>
<td>1565 1292 1080 1432 1151 1821 1310</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nitrate of soda - No cover crop</td>
<td>1902 1855 1119 1518 1762 1999 1603</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sour clover- limed§ (Melilotus indica)</td>
<td>2211 1933 1410 1655 1601 2104 1681</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sour clover- not limed (Melilotus indica)</td>
<td>1997 1822 1239 1556 1529 2147 1614</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Austrian winter peas (Pisum arvense)</td>
<td>2163 2109 1270 1631 1634 2153 1720</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hairy vetch (Vicia villosa)</td>
<td>2298 1942 1341 1643 1692 2096 1725</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>No cover crop- Check</td>
<td>1459 1270 1033 1409 1254 1911 1294</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2. Summary of Yield Data on Old Winter Cover Crop Test on Olivier Silt Loam at Baton Rouge

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Cover crop and source of nitrogen</th>
<th>Ave. tons green matter turned under</th>
<th>Analysis of fertilizer applied to cotton† per acre</th>
<th>First year Ave. of 1931, 1932, 1933, and 1934</th>
<th>Second year Ave. of 1934 and 1935</th>
<th>Third year Yield for 1935 only</th>
<th>Yield check Ave. over first year</th>
<th>Yield check Ave. over second year</th>
<th>Yield check Ave. over third year</th>
<th>Inc.</th>
<th>Inc.</th>
<th>Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rye (Secale cereale)</td>
<td>0-8-5</td>
<td>1.6</td>
<td>1184</td>
<td>7</td>
<td>1501</td>
<td>29</td>
<td>1454</td>
<td>45</td>
<td>1432</td>
<td>23</td>
<td>1518</td>
<td>109</td>
</tr>
<tr>
<td>2 Oats (Avena sativa)</td>
<td>0-8-5</td>
<td>1.8</td>
<td>1209</td>
<td>32</td>
<td>1451</td>
<td>-21</td>
<td>1432</td>
<td>23</td>
<td>1518</td>
<td>109</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Nitrate of soda- No cover crop</td>
<td>6-8-5†</td>
<td>7.6</td>
<td>1649</td>
<td>472</td>
<td>1757</td>
<td>285</td>
<td>1655</td>
<td>246</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Sour clover- limed (Melilotus indica)</td>
<td>0-8-5</td>
<td>7.6</td>
<td>1649</td>
<td>472</td>
<td>1757</td>
<td>285</td>
<td>1655</td>
<td>246</td>
<td>1556</td>
<td>147</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Sour clover- not limed (Melilotus indica)</td>
<td>0-8-5</td>
<td>7.6</td>
<td>1649</td>
<td>472</td>
<td>1757</td>
<td>285</td>
<td>1655</td>
<td>246</td>
<td>1556</td>
<td>147</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Austrian winter peas (Pisum arvense)</td>
<td>0-8-5</td>
<td>5.4</td>
<td>1747</td>
<td>570</td>
<td>1712</td>
<td>240</td>
<td>1631</td>
<td>222</td>
<td>1631</td>
<td>222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Hairy vetch (Vicia villosa)</td>
<td>0-8-5</td>
<td>6.0</td>
<td>1750</td>
<td>573</td>
<td>1719</td>
<td>247</td>
<td>1643</td>
<td>234</td>
<td>1643</td>
<td>234</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 No cover crop- Check</td>
<td>0-8-5</td>
<td>6.0</td>
<td>1750</td>
<td>573</td>
<td>1719</td>
<td>247</td>
<td>1643</td>
<td>234</td>
<td>1643</td>
<td>234</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Plots were 1/20 acre in size and each treatment was replicated four times.
†All fertilizers were applied to cotton. Nitrate of soda was applied to Plot No. 3 only on those years that the winter cover crops were turned under. The minerals were applied each year.
§Three tons of lime per acre were applied in the fall of 1929.

The increases in yields following Austrian winter peas and hairy vetch exceeded those obtained from nitrate of soda every year except in 1936. These green manure crops produced an average increase in yield of 572 pounds of seed cotton per acre the first year and had a residual effect which gave from 240 to 247 pounds of seed cotton per acre the second year and from 222 to 234 pounds the third year. These increases in yields are over 100 pounds of seed cotton per acre more than those obtained from 225 pounds of nitrate of soda per acre.

The yields obtained from turning under *Melilotus indica* were not as good as those from peas and vetch. However, as shown in Table 1, the green growths turned under on the *Melilotus indica* plots were either very large or too small. These data, as well as observations made in the field, indicate that the turning under of excessive growth of winter legumes may result some years in reduced yields of the following crop. In this test the smaller increases in yields resulting from turning under large tonnages of green manures were not made up for by larger residual effects. Turning un-
nder very large tonnages of green leguminous matter frequently produces a rank, “weedy” growth of cotton. Under the climatic conditions of the southern part of Louisiana this frequently results in the loss of some of the cotton from boll rot. In addition to this effect, the maturity of cotton following green leguminous manures is delayed. In seasons of heavy boll weevil infestation, most of the late setting bolls are punctured and never mature. These two factors are largely responsible in limiting the higher yields of cotton that would normally be expected from larger green manure crops.

Rye and oats, the non-leguminous cover crops used in this test, are not very valuable as green manures. Over the 7-year period they gave average annual increases in yields of only 34 and 16 pounds of seed cotton per acre, respectively. This can be ascribed to their low nitrogen content. Only at the beginning of the experiment did they increase the yield of cotton by more than 100 pounds of seed cotton per acre. The larger yields obtained at that time were in all probability made possible by a larger reserve supply of nitrogen in the soil.

In another winter cover crop test, begun in 1934, the value of Austrian winter peas, oats, Hungarian vetch, hairy vetch, Persian

**TABLE 3. YIELD DATA ON NEW WINTER COVER CROP TEST ON OLIVER SILT LOAM AT BATON ROUGE**

**A. Winter Cover Crops and Fertilizers Used**

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Cover crop and source of nitrogen</th>
<th>Analysis of fertilizer applied at rate of 600 lbs. N per acre</th>
<th>Years grown, date turned and weight of green matter in tons per acre</th>
<th>Nitrogen content of green matter 1937†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No cover crop-no fertilizer</td>
<td>0-0-0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>Nitrate of soda*</td>
<td>6-8-5</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>No cover crop-Austrian winter peas</td>
<td>0-8-5</td>
<td>7.9</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Oats</td>
<td>0-8-5</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td>5</td>
<td>Hungarian vetch</td>
<td>0-8-5</td>
<td>10.6</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>No cover crop-no fertilizer</td>
<td>0-0-0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>7</td>
<td>Hairy vetch</td>
<td>0-8-5</td>
<td>9.6</td>
<td>0.6</td>
</tr>
<tr>
<td>8</td>
<td>Persian clover</td>
<td>0-8-5</td>
<td>3.9</td>
<td>3.6</td>
</tr>
<tr>
<td>9</td>
<td>Oregon vetch</td>
<td>0-8-5</td>
<td>11.0</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>Southern bur clover</td>
<td>0-8-5</td>
<td>2.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

**TABLE 3. YIELD DATA ON NEW WINTER COVER CROP TEST ON OLIVER SILT LOAM AT BATON ROUGE**

**A. Winter Cover Crops and Fertilizers Used**

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Cover crop and source of nitrogen</th>
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<th>Years grown, date turned and weight of green matter in tons per acre</th>
<th>Nitrogen content of green matter 1937†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No cover crop-no fertilizer</td>
<td>0-0-0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>Nitrate of soda*</td>
<td>6-8-5</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>No cover crop-Austrian winter peas</td>
<td>0-8-5</td>
<td>7.9</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Oats</td>
<td>0-8-5</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td>5</td>
<td>Hungarian vetch</td>
<td>0-8-5</td>
<td>10.6</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>No cover crop-no fertilizer</td>
<td>0-0-0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>7</td>
<td>Hairy vetch</td>
<td>0-8-5</td>
<td>9.6</td>
<td>0.6</td>
</tr>
<tr>
<td>8</td>
<td>Persian clover</td>
<td>0-8-5</td>
<td>3.9</td>
<td>3.6</td>
</tr>
<tr>
<td>9</td>
<td>Oregon vetch</td>
<td>0-8-5</td>
<td>11.0</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>Southern bur clover</td>
<td>0-8-5</td>
<td>2.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>
**TABLE 3. (Continued) YIELD DATA ON NEW WINTER COVER CROP TEST ON OLIVIER SILT LOAM AT BATON ROUGE**

**B. Cotton Yields**

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Cover crop and source of nitrogen</th>
<th>Yield of seed cotton in pounds per acre</th>
<th>4-yr. aver.</th>
<th>Increase or decrease over nitrate of soda applied annually</th>
<th>Average tons of green matter per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No cover crop-No fertilizer</td>
<td>465 695 740 1198 775</td>
<td>643</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Nitrate of soda**</td>
<td>818 1380 1299 2173 1418</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Austrian winter peas (Pisum arvense)</td>
<td>1094 1230 926 2037 1322</td>
<td>- 96</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Oats (Avena sativa)</td>
<td>399 763 780 983 731</td>
<td>- 687</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Hungarian vetch (Vicia pannonica)</td>
<td>1123 1553 1055 2253 1497</td>
<td>79</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>No cover crop-No fertilizer</td>
<td>517 663 775 1317 818</td>
<td>- 600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hairy vetch (Vicia villosa)</td>
<td>1121 1416 1125 1840 1376</td>
<td>- 42</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Persian clover (Trifolium resupinatum)</td>
<td>640 1308 975 1851 1194</td>
<td>- 224</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Oregon vetch (Vicia sativa)</td>
<td>1032 1399 1126 2197 1439</td>
<td>21</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Southern bur clover (Medicago arabica)</td>
<td>815 1199 1049 1856 1230</td>
<td>- 188</td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

*Plots were 1/27 acre in size and each treatment was replicated four times.
**All fertilizers were applied to cotton. Nitrate of soda was applied to cotton every year.
†Total nitrogen content was not determined previous to 1936.

clover, Oregon vetch, and Southern bur clover as green manures was compared to that of nitrate of soda. The data concerning the fertilizers used, the growth of the cover crops, and the yields of cotton are given in Table 3.

There are three interesting points in these data. First, the increases in cotton yields obtained in this test from the use of Austrian winter peas and the vetches as soil improving crops were about the same as those in the previously reported test. Second, the average yield produced by cotton after oats had been turned under was actually less than that made on either of the untreated check plots. Third, the yield of cotton following bur clover and Persian clover, neither of which ever produced a green growth as large as 4.0 tons per acre, lacked on the average about 200 pounds per acre of seed cotton equalling that produced by 36 pounds of nitrogen from nitrate of soda.

These yields are interesting because of the information they give on the amount of green growth of winter legumes necessary to make it profitable to grow them for green manures. The figures
show that the vetches and Austrian winter peas, whose average annual growth exceeded 4.0 tons of green matter per acre, all produced within 100 pounds per acre as much seed cotton as did 225 pounds of nitrate of soda. The average annual green-matter growth of 3.2 tons per acre made by Persian clover and 2.1 tons of Southern bur clover failed by 200 pounds per acre to produce as much seed cotton as the nitrate of soda. Thus it appears that it takes a growth of at least 3.5 to 4.0 tons of green leguminous matter per acre to produce as much cotton as will 225 pounds of nitrate of soda.

The total nitrogen content of the winter legumes provides further explanation of their effect upon the yield of cotton. As shown in the table, they contained from 9.5 to 14.4 pounds of nitrogen per ton of green matter. The average for all of them in this test was 11.8 pounds of nitrogen per ton. This is in line with an average nitrogen content of 10.1 pounds per ton for the legumes in the other test in 1936. Thus it is readily seen that, since winter legumes contain from 10 to 12 pounds of nitrogen per ton of green matter, it requires at least 3.0 to 3.5 tons of green growth to supply as much nitrogen as is provided by 225 pounds of nitrate of soda. Since decomposition is necessary to make the nitrogen of organic material wholly available to plants, growths of winter legumes less than 3.0 to 3.5 tons per acre would hardly be expected to have the same effect as 36 pounds of nitrogen from nitrate of soda.1

A photograph of the cotton following oats and Austrian winter peas in 1937 is reproduced in Figure 1.

Turning under hairy vetch and Austrian winter peas at the North Louisiana Experiment Station at Calhoun, Louisiana, (13) over an 8-year period has produced an average annual yield of 1,112 pounds of seed cotton per acre when phosphate and potash fertilizers were applied to the cotton. Two hundred and forty pounds of nitrate of soda per acre in addition to phosphate and potash gave an average of 1,063 pounds of seed cotton per acre. The no-nitrogen check plot, which received only phosphate and potash, produced 729 pounds of seed cotton for the same period. The average yield when the minerals were applied to the winter legumes in the fall was 1,010 pounds of seed cotton per acre. The average increases for the 8-year period in pounds of seed cotton—

(1) The nitrogen contained in the roots of the legumes has not been taken into consideration in this discussion. Rogers and Sturkie (12), in recent work at the Alabama Experiment Station, found that the roots of inoculated hairy vetch contain only from one-tenth to one-fifth of the total nitrogen in the plant. The tops of inoculated hairy vetch grown on unfertilized plots which produced an average of 535 pounds of total dry matter, or about 2 tons of green matter per acre, contained 80 to 83 per cent of the total nitrogen. On fertilized plots, where the growth was approximately trebled by applications of phosphatic fertilizers, the tops contained 85 to 90 per cent of the total nitrogen in the plant. The ratio of tops to roots was highest on the treatments that produced the largest yields.
per acre were: 334 pounds from nitrate of soda and 384 pounds from green manures when the minerals were applied to the cotton and 281 pounds when the minerals were applied to the winter legumes. In this test the hairy vetch and Austrian winter peas made an average growth of 7 to 9 tons of green matter per acre regardless of whether or not they received the phosphate and potash fertilizers.

Probably the greatest returns from the use of winter legumes as green manures are those obtained on the Red and Mississippi River alluvial soils. Haddon (5), at the Northeast Louisiana Experiment Station at St. Joseph, Louisiana, has got annual increased yields of from 796 to 1,109 pounds of seed cotton per acre from turning under the following winter legumes: Austrian winter peas, Southern bur clover, and hairy, Hungarian, Common and Woolypod vetch. These increases represent the average annual yields for periods ranging from 4 to 9 years. The untreated check plot produced an average yield of 970 pounds of seed cotton per acre for the 9-year period. No mineral fertilizers were used.

![Image](image.png)

**Fig. 1.—Cotton following oats (left) and Austrian winter peas (right). Yield following oats: 731 pounds seed cotton per acre. Yield following peas: 1,322 pounds seed cotton per acre.**

**THE EFFECT OF INOCULATION ON GROWTH OF WINTER LEGUMES**

Following numerous reported failures of inoculation of winter legumes in the fall of 1936, the Experiment Station began some cooperative tests to study the factors affecting nodulation and the growth of winter legumes. Austrian winter peas (*Pisum arvense*) and common vetch (*Vicia sativa*) were used. The tests were lo-
cated on farms in the Coastal Plains hills and in areas where difficulty had been encountered in successfully growing winter legumes. All tests were located either on soils that had never grown winter legumes or where they had been considered as failures.

The moisture content, temperature, and reaction of the soil were determined at the time of planting. Observations were made of the number and location of nodules formed during the growing season. Just previous to turning the legumes under, duplicate cuttings of each treatment were made for the purposes of estimating the amount of growth and of obtaining samples of the green matter for chemical analyses. The field data concerning the dates of planting and cutting, the soil moisture content at planting, the fertilizer treatment and the growth of legumes in tons per acre are given in Table 4.

As indicated by the yields given in Table 4, the inoculation failed to produce good nodulation on the vetch in the test in Lin-

![Fig. 2.—Inoculated and uninoculated vetch in Natchitoches Parish test on March 11, 1938. Green matter per acre: inoculated, 5.8 tons; uninoculated, 0.6 tons.](image)

coln Parish and on both the peas and vetch in the DeSoto Parish test in 1937-38. The peas in the Lincoln Parish test were nodulated from organisms present in the soil before planting. These failures of inoculation were undoubtedly the result of planting when the soils were too dry, as shown by the soil moisture contents of 1.5 and 1.9 per cent. Vetch, planted later after a rain had fallen, was well inoculated and made a growth of 2.2 tons per acre on rows
### TABLE 4. GREEN GROWTH OF WINTER LEGUMES IN TONS PER ACRE, SOIL MOISTURE CONTENT AT PLANTING, GROWING PERIOD, AND INOCULATION AND FERTILIZER TREATMENTS

#### A. Austrian Winter Peas

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<th>Soil No.</th>
<th>Location of test (Parish)</th>
<th>Soil moisture %</th>
<th>Date planted</th>
<th>Date yields taken</th>
<th>1937-1938 Experiments</th>
<th>Average growth of peas 1937-38:</th>
<th>Average growth of vetch 1937-38:</th>
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**B.S** = Super., **PL** = Lime, **PK** = Potash, **NP** = Nitrate of Soda

1938-1939 Experiments

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<tr>
<th>Soil No.</th>
<th>Location of test (Parish)</th>
<th>Soil moisture %</th>
<th>Date planted</th>
<th>Date yields taken</th>
<th>1938-1939 Experiments</th>
<th>Average growth of peas 1938-39:</th>
<th>Average growth of vetch 1938-39:</th>
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**B.S** = Super., **PL** = Lime, **PK** = Potash, **NP** = Nitrate of Soda

*Super. or P indicates 225 pounds of 18% superphosphate per acre; Lime or L indicates 1,000 pounds per acre of lime; K indicates 50 pounds per acre of muriate of potash; N indicates 100 pounds per acre of nitrate of soda; basic slag was applied at the rate of 330 pounds per acre in 1937 and 500 pounds per acre in 1938.

†Plants on the not inoculated plots were nodulated from an organism in the soil.

††Treatments not included in 1938-39.
## B. Common Vetch

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Average growth of vetch 1937-38: 0.7 2.1 3.2 4.1 4.7 2.6 3.0 3.5 3.9
Average growth of peas 1937-38: 1.4 2.4 3.6 4.4 5.1 3.5 4.1 3.9

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<td>4.3</td>
<td>2.9</td>
<td>4.5</td>
<td>1.4</td>
<td>3.2</td>
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Average growth of vetch 1938-39: 0.8 2.0 4.1 3.6 4.8 2.4 4.0
Average growth of peas 1938-39: 1.2 2.3 4.6 4.0 5.5 3.1 4.2

*Super. or P indicates 225 pounds of 18% superphosphate per acre; Lime or L indicates 1,000 pounds per acre of lime; K indicates 50 pounds per acre of muriate of potash; N indicates 100 pounds per acre of nitrate of soda; basic slag was applied at the rate of 330 pounds per acre in 1937 and 500 pounds per acre in 1938.
†Plants on the not inoculated plots were nodulated from an organism in the soil.
‡Treatments not included in 1938-1939.
§Grazing by livestock damaged vetch.
adjoining the test in Lincoln Parish. Furthermore, vetch planted on September 20 in the Ouachita Parish test when the soil was very dry failed to become inoculated and consequently made very little growth. These data and observations show that inoculation may fail if winter legumes are planted when the soil is too dry.

Legumes are able to utilize elemental or atmospheric nitrogen only when they are inoculated with their symbiotic bacteria. Uninoculated plants must depend upon the soil for their nitrogen just the same as non-leguminous plants. If sufficient soil nitrogen is available to them, they may make very good growth. Thus, Table 5, which gives the total nitrogen content of the soils and the growth made on the uninoculated plots, shows that the amount of growth is related to the available nitrogen. In order to be of the greatest value as soil improving crops, legumes must be inoculated and must use atmospheric nitrogen.

A photograph taken on March 11, 1938, of the inoculated and uninoculated vetch plots in the Natchitoches Parish test is shown in Figure 2.

### TABLE 5. TOTAL NITROGEN CONTENT OF SOILS AT PLANTING AND GROWTH OF PEAS AND VETCH ON UNINOCULATED PLOTS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Location of test (Parish)</th>
<th>Year</th>
<th>Total nitrogen in soils (Lbs. per Acre)</th>
<th>Growth on uninoculated plots (Tons of green matter per acre)</th>
<th>Peas</th>
<th>Vetch</th>
<th>Average</th>
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*Inoculated by nodule organisms present in the soil.

As shown in Table 4, the plants on the uninoculated plots at four of the locations were nodulated. Austrian winter peas had been grown in these fields before. Inoculating the seed improved the growth of both the peas and vetch on all of the locations, as shown by the yields.

Photographs were made of both pea and vetch plants taken from the uninoculated and inoculated plots of the Washington Parish test and are reproduced in Figures 3 and 4. These photo-
Fig. 3-A.—Plants and roots of vetch showing growth and nodulation of inoculated and uninoculated vetch grown on soil previously inoculated by a crop of Austrian winter peas. Growth of green matter per acre on March 23, 1938: inoculated, 1.9 tons; uninoculated, 0.2 tons.
graphs show the different types of nodulation produced (1) when prepared inoculants were used on the seed and (2) when the plants were inoculated by nodule organisms present in the soil. The few large, well-located nodules resulting from using good inoculants were more effective than the more numerous, small, scattered nodules produced by the nodule organisms living in the inoculated soil. From these results, inoculation of the seed of winter legumes to be planted on soils that have previously grown the crop can be expected in many instances to be profitable.
Fig. 4.—Growth and nodulation of inoculated and uninoculated Austrian winter peas grown on soil previously inoculated by a crop of Austrian winter peas. Growth of green matter per acre on March 23, 1938: inoculated, 2.6 tons; uninoculated, 1.6 tons.
The root nodule organisms (*Rhizobium leguminosarum*) require mineral nutrients the same as other plants. They also require organic nutrients as a source of energy since they are not able to utilize sunlight to produce their organic compounds as green plants do. Since the nodule organisms are associated with legumes which normally use relatively large quantities of calcium and phosphorus, they are adapted to a comparatively high level of calcium and phosphorus nutrition. The stimulating effects of phosphorus- and calcium-containing fertilizers upon these organisms have been noted many times. Such a stimulation is apparent in the improved nodulation and increased growth of the legumes on the fertilized plots in these tests.

A comparative rating of the different fertilizer treatments according to (1) size of plants, (2) color of plants, (3) location of nodules, (4) size of nodules, and (5) characteristic shape of nodules was made in December, 1937. The rank of the different treatments of each of the tests is given in Table 6-A. These rankings are summarized and a composite score for each treatment is calculated in Table 6-B.
TABLE 6-A. RATING OF FERTILIZER AND LIME TREATMENTS FOR AUSTRIAN WINTER PEAS AND VETCH ACCORDING TO (1) SIZE OF PLANTS, (2) COLOR OF PLANTS, (3) LOCATION OF NODULES, (4) SIZE OF NODULES, AND (5) CHARACTERISTIC SHAPE OF NODULES IN DECEMBER, 1937

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Winter legume</th>
<th>Rank of treatments in each test*</th>
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<th>3</th>
<th>4</th>
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<td>Vetch</td>
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</table>

*The inoculation and fertilizer treatments are represented by symbols as follows: PL—superphosphate and lime; P—superphosphate; L—lime; BS—basic slag; PK—superphosphate and muriate of potash; PN—superphosphate and nitrate of soda; I—inoculated, not fertilized; and NI—not inoculated, not fertilized.

TABLE 6-B. SUMMARY OF RATINGS OF VARIOUS TREATMENTS AS GIVEN IN TABLE 6-A.

<table>
<thead>
<tr>
<th>Inoculation and fertilizer treatment</th>
<th>Rank and number of occurrences in each</th>
<th>Total composite score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inoculated; superphosphate and lime</td>
<td>1 1 1 - - -</td>
<td>15</td>
</tr>
<tr>
<td>Inoculated; basic slag</td>
<td>2 2 1 - -</td>
<td>18</td>
</tr>
<tr>
<td>Inoculated; superphosphate alone</td>
<td>4 - 1 1 -</td>
<td>23</td>
</tr>
<tr>
<td>Inoculated; superphosphate and muriate of potash</td>
<td>5 1 2 - -</td>
<td>25</td>
</tr>
<tr>
<td>Inoculated; superphosphate and nitrate of soda</td>
<td>7 2 1 - -</td>
<td>26</td>
</tr>
<tr>
<td>Inoculated; lime alone</td>
<td>5 4 1 -</td>
<td>28</td>
</tr>
<tr>
<td>Inoculated; not fertilized</td>
<td>4 3 2 1 -</td>
<td>31</td>
</tr>
<tr>
<td>Not inoculated; not fertilized</td>
<td>1 8 2 1 -</td>
<td>51</td>
</tr>
</tbody>
</table>

*The total composite score is calculated by totalling the product of the number of occurrences in each rank and the rank number.

The data in these tables clearly indicate the stimulating effect of phosphorus and lime upon nodulation. The effects of phosphorus and lime upon nodulation and increased nitrogen fixation by the plants are substantiated by the chemical analyses of the plants.
THE EFFECT OF FERTILIZERS ON GROWTH OF WINTER LEGUMES

A satisfactory growth for green manuring of as much as 3 tons of green matter per acre was made on the inoculated, unfertilized plots at only three of the locations tested. Of these three, one (Soil No. 217) was on sugar cane land in St. Landry Parish, and the winter legumes followed corn and soybeans which had been disced down and turned under. Both the others were on hill land that had been cropped to cotton and corn. On the other eleven locations, the yields of the winter legumes were considerably below the tonnage necessary for a good green manure crop. The average growth per acre for both Austrian winter peas and vetch for the two years on the unfertilized plots was 2.2 tons.

In contrast to this relatively small tonnage are the yields produced by any of the treatments that included superphosphate or basic slag.

The soil treatment that gave the largest growth was lime and superphosphate. The lime was applied at the rate of 1,000 pounds per acre and the superphosphate at 225 pounds of 18 per cent material per acre. While the lime and superphosphate treatment gave the best results, it was also the most expensive. Consequently, the use of lime on all soils cannot be recommended. An increased growth resulted from the use of lime at most of the locations, as shown by the yields. An unusually large response was obtained on a few soils. Lime should be applied to such soils when tests of their acidity and lime requirement show them to be very acid and in need of liming.

No beneficial effects were observed from the applications of nitrate of soda in combination with superphosphate over superphosphate alone during the 1937-38 season. This treatment was not included in the tests the second year.

Muriate of potash in addition to superphosphate produced an increase in growth at two of the locations in 1938-39. These tests were on Waverly silt loam at Baton Rouge and Ruston sandy loam at Robeline. However, both the superphosphate alone and basic slag treatments produced satisfactory growths in each of these tests. It does not appear from these data that additional potash is required by winter legumes if they are given applications of phosphate fertilizers.

The results obtained from the use of superphosphate and basic slag are possibly the most valuable from the viewpoint of farm practices. Applications of 330 pounds of basic slag per acre in 1937-38 gave average increases in growth of 50 per cent for Austrian winter peas and 52 per cent for vetch. In 1938-39 when 500 pounds of basic slag per acre were used, the tons of green matter per acre of both peas and vetch were doubled. Two hundred and twenty-five pounds of 18 per cent superphosphate were used per acre both years. The increased growth obtained from this application was greater than that obtained from 330 pounds of slag per acre in 1937-38 and less than the increased growth produced by
500 pounds of slag per acre in 1938-39. By interpolating on the basis of the average yields produced in these tests, it is found that 429 pounds of basic slag per acre gave the same response in growth as 225 pounds of 18 per cent superphosphate per acre.

A further comparison of the efficiencies of these two materials for winter legumes, in relation to the acidity of the soil on which they are used, can be made. The average growth of peas and vetch and the soil reaction (pH) at each of the tests are given in Table 7.

**TABLE 7. COMPARATIVE EFFICIENCIES OF SUPERPHOSPHATE AND BASIC SLAG FOR WINTER LEGUMES**

I. **Yield Weights for 1938 in Tons per Acre**

<table>
<thead>
<tr>
<th>Fertilizer treatments</th>
<th>No. 214</th>
<th>No. 215</th>
<th>No. 212</th>
<th>No. 216</th>
<th>No. 213</th>
<th>No. 217*</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil reaction at planting (pH)</td>
<td>6.70</td>
<td>6.20</td>
<td>6.20</td>
<td>5.60</td>
<td>5.60</td>
<td>5.00</td>
<td>5.88</td>
</tr>
<tr>
<td>225 lbs. 18% superphosphate</td>
<td>4.50</td>
<td>5.20</td>
<td>5.95</td>
<td>5.00</td>
<td>0.50</td>
<td>6.00</td>
<td>4.53</td>
</tr>
<tr>
<td>330 lbs. 12% basic slag</td>
<td>3.10</td>
<td>3.42</td>
<td>5.44</td>
<td>4.10</td>
<td>0.95</td>
<td>4.42</td>
<td>3.62</td>
</tr>
<tr>
<td>Increase from superphosphate over basic slag</td>
<td>1.40</td>
<td>1.78</td>
<td>0.51</td>
<td>0.90</td>
<td>-0.45</td>
<td>1.58</td>
<td>0.91</td>
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</table>

II. **Yield Weights for 1939 in Tons per Acre**

<table>
<thead>
<tr>
<th>Fertilizer treatments</th>
<th>No. 275</th>
<th>No. 272</th>
<th>No. 276</th>
<th>No. 271</th>
<th>No. 270</th>
<th>No. 277</th>
<th>No. 273</th>
<th>No. 274</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil reaction at planting (pH)</td>
<td>6.20</td>
<td>5.60</td>
<td>5.50</td>
<td>5.50</td>
<td>5.30</td>
<td>5.20</td>
<td>5.20</td>
<td>5.00</td>
<td>5.44</td>
</tr>
<tr>
<td>225 lbs. 18% superphosphate</td>
<td>2.95</td>
<td>6.00</td>
<td>4.02</td>
<td>4.15</td>
<td>4.25</td>
<td>3.82</td>
<td>3.02</td>
<td>3.17</td>
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<tr>
<td>500 lbs. 8% basic slag</td>
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<td>4.00</td>
<td>3.85</td>
<td>4.31</td>
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<tr>
<td>Increase from basic slag over superphosphate</td>
<td>0.00</td>
<td>-0.50</td>
<td>0.23</td>
<td>1.10</td>
<td>0.50</td>
<td>0.73</td>
<td>0.98</td>
<td>0.68</td>
<td>0.52</td>
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*Olivier silt loam cropped with sugar cane, St. Landry Parish.
†Percentage of P2O5 by analysis by official method of Association of Official Agricultural Chemists.
‡Guaranteed percentage of P2O5.

The data in Table 7, with few exceptions, show that the differences between the yields obtained from superphosphate and from basic slag are in favor of the superphosphate on the less acid soils and in favor of basic slag on the more acid soils.

The comparative increases in tonnage of green matter produced by the superphosphate, basic slag, and superphosphate and lime treatments over that of the inoculated untreated plots at each of the tests are shown graphically in Figure 5.

The growth of vetch following an application of 500 pounds of basic slag per acre in comparison to that of the unfertilized plot in the St. Landry Parish test is shown in Figure 6. Similar photographs of the unfertilized and superphosphate plots and of the basic slag and unfertilized plots in the Natchitoches Parish test are reproduced in Figures 7 and 8.
Fig. 6.—No fertilizer and 500 pounds of basic slag per acre on inoculated vetch in St. Landry Parish test. Picture made March 20, 1939. Green matter per acre: not fertilized, 1.4 tons; basic slag, 4.3 tons.

Fig. 7.—No fertilizer (right) and 225 pounds of superphosphate per acre (left) on inoculated vetch in Natchitoches Parish test. Picture made on March 21, 1939. Green matter per acre: superphosphate, 4.3 tons; not fertilized, 2.2 tons.
DISCUSSION

The inclusion of legumes in the crop rotation is generally accepted as a practical way of maintaining soil fertility. Turning the entire legume crop into the soil is an effective method of building up soils. Leguminous green manures improve fertility by directly adding nitrogen and organic matter. In the soil, these in turn produce the secondary effects of better tilth, improved water-holding capacity, greater microbiological activity, and increased availability of the nutrient elements as the organic matter decomposes.

The usual seasons of the Cotton Belt permit the growing of winter legumes without serious interference with the annual summer crop. Turning the legumes under as green manures normally produces as large increases in the yield of the crop immediately following as can be obtained from the use of commercial nitrogenous fertilizers. In addition, they have a residual effect which appreciably increases the yields of crops for two or three consecutive years.

The growing of winter legumes in the southeastern states has not been as general as their value as soil-building crops justifies.
The necessity of inoculating and using fertilizers to get them established on most of the upland cotton soils has been a seriously limiting factor to the extension of their acreage. Practically all legumes require soils having relatively high levels of phosphorus and calcium fertility. Only those upland soils on which cotton or other crops have been well fertilized are sufficiently fertile to produce real good growths of winter legumes.

In addition to the necessity of phosphate fertilization for the plants themselves, difficulty in inoculating the crop is often experienced. This is an old problem on soils of the Coastal Plains. Chemical analyses of Coastal Plains soils show that practically all of them are low in calcium and phosphorus (4,11).

Several investigators have shown the value of phosphatic fertilizers in stimulating the nodulation and growth of legumes. Helz and Whiting (7) have shown that nodulation was stimulated by applications of phosphates when not used in amounts large enough to inhibit germination. McTaggart (10) reported increases in tonnage, percentage nitrogen, and total nitrogen content of Canada field peas, soybeans, and alfalfa from the application of phosphorus and lime over lime alone. Large increases in the growth of winter legumes were obtained from the use of superphosphate and basic slag, as reported by Bailey et al (3).

The chemical analyses of plants made in connection with this work, as well as the analyses reported by Albrecht and Klemme (2) show that liming improves the utilization of phosphorus by legumes. Earlier work by Albrecht and Davis (1) showed that calcium exerted a physiological effect within the plant, which resulted in an increased nodulation of soybeans. Hutchings (8), also working with soybeans grown in specially prepared cultures, found that at low calcium levels phosphorus was seldom effective in increasing nodulation and growth but was always effective when associated with higher calcium levels. In recent work, McCalla (9) found that nodule-forming organisms grown in a calcium-deficient clay medium became abnormal and failed to infect the host. They remained abnormal as long as they were deprived of calcium and became capable of forming nodules only after being supplied with calcium. These researches suggest that a calcium-deficiency of Coastal Plains soils is responsible for the difficulty in maintaining an effective nodule-forming organism in many of these soils over a period of years.

Successful nodulation and satisfactory growth of winter legumes can be expected on any soil when the seed are inoculated and fertilizers used. There is evidence, however, that a low moisture content of the soil at planting may cause the inoculation to fail with a subsequent failure of the crop. Failures of nodulation in these tests occurred only when the seed were planted in very dry soils. The effects of a high temperature and low moisture content of the soils are not differentiated because soil temperature
rises as the soil becomes dry and is low when the soils are moist. The soil temperatures recorded in these tests were considerably below the temperatures which the organisms can withstand. In testing the relation of moisture content to nodulation, Helz and Whiting (7) found that the inoculation of soybeans failed at low soil-moisture contents. Similar results have been reported by Harper and Murphy (6). After all, it seems to be only reasonable to plant winter legumes when there is sufficient moisture in the soil to germinate the seed, the same as is practiced with other crops.

**SUMMARY**

**WINTER COVER CROPS AS GREEN MANURES FOR COTTON**

The data obtained in experiments with winter cover crops used as green manures for cotton are reported. The results of the tests showed the following:

1. Average annual increases in yield of from 500 to 600 pounds of seed cotton per acre were obtained from turning under the following winter legumes on Olivier silt loam at Baton Rouge: Austrian winter peas, hairy vetch, *Melilotus indica*, common vetch, and Hungarian vetch.

2. In addition to the increase obtained the first year, there was a residual effect from leguminous green manures that gave annual increases of from 240 to 300 pounds of seed cotton per acre the second year and about 200 pounds the third year.

3. Growths as large as from 10 to 12 tons of green matter per acre failed during some seasons to produce as great an increase in cotton yields as smaller tonnages gave.

4. Three and a half to 4 tons of green leguminous manures produced on the average larger increases in the yield of cotton than did 36 pounds per acre of inorganic nitrogen from nitrate of soda.

5. Winter legume growths of 3 tons or less of green matter per acre did not produce as much cotton as did 36 pounds of nitrogen per acre from nitrate of soda.

6. Use of two non-leguminous cover crops, rye and oats, on the average did not appreciably increase the yield of cotton.

**INOCULATION AND FERTILIZERS FOR WINTER LEGUMES**

The field data obtained from 14 inoculation and fertilizer experiments with Austrian winter peas and common vetch located throughout the state are also reported. The results of these tests showed the following:
1. Planting winter peas or vetch when the soil is too dry to germinate the seed may be expected to result in an unsatisfactory nodulation of the plants and a consequent failure of the crop.

2. An increased growth of winter legumes was produced by applications of (1) superphosphate, (2) basic slag, and (3) superphosphate and lime on all soils tested.

3. Five hundred pounds of basic slag per acre applied to inoculated vetch and Austrian winter peas doubled the average yield of green matter on the tests in 1938-39. In 1937-38, 330 pounds of basic slag per acre gave an average increased top growth of 50 per cent for Austrian winter peas and 52 per cent for vetch.

4. The average increase in growth obtained from 225 pounds per acre of 18 per cent superphosphate for both peas and vetch on all tests was 83 per cent.

5. The average growth produced by the combined treatment of superphosphate and lime exceeded that produced by any other treatment.

6. Practically all soils of the interior Coastal Plains require phosphate fertilization to produce satisfactory green manure crops.

RECOMMENDATIONS FOR GROWING AUSTRIAN WINTER PEAS AND VETCH

In order to avoid the difficulties frequently encountered in growing winter legumes the first few times it is recommended that the following practices be observed:

1. **Plant between September 15 and October 20 when the soil is moist.** The inoculation of winter legumes planted on land for the first time will most likely fail if seeded when the soil is dry and hot. Later plantings, especially in the southern part of the state, may be quite successful if a mild winter follows.

2. **Use plenty of seed to insure a good stand.** Twenty pounds of hairy vetch per acre or 30 pounds of Austrian winter peas or common vetch per acre is sufficient if the seed are drilled. These amounts should be increased by at least 5 pounds per acre if the seed are broadcast and covered with a cultivator, sweep, middle buster, or small turning plow.

3. **Inoculate the seed.** Inoculation of the seed each year can be considered as an insurance against a crop failure until it is known that effective nodule-forming organisms are established in the soil.

4. **Plant the seed from 2 to 3 inches deep in heavy soils and from 2 to 4 inches deep in light sandy soils.** A stand may be obtained from deeper plantings than this if ideal weather conditions
prevail, but any increase in depth of planting increases the risk of a poor stand, which may result from a heavy rain packing the soil.

5. Use from 200 to 250 pounds of superphosphate or from 400 to 500 pounds of basic slag per acre on winter legumes planted on cotton land unless it is known that the soil is well supplied with phosphorus. The quantity of fertilizer used can be decreased after one or two good crops have been grown.

6. Leave the soil well bedded, with the seed in the ridges. Winter legumes will “drown out” on poorly drained soils during the rainy season that usually occurs in late winter or early spring.

7. Turn the crop under as soon as the top growth on a 25-foot section of the row equals 15 to 16 pounds of green matter.* Unfertilized winter legumes on hill land will seldom produce this much growth the first time they are grown, and must be turned sooner. However, where a vigorous growth is made, experiments have shown that only small increases in yield of the following crop can be expected to be obtained from turning under considerably larger tonnages of green manures.

*When the top growth on 25-foot sections of the row equals 15 to 16 pounds, the tonnages per acre are:
4½ to 4¾ tons of green matter per acre on rows 3 feet wide;
3¾ to 4 tons of green matter per acre on rows 3½ feet wide;
3¾ to 3½ tons of green matter per acre on rows 4 feet wide.


