SOYBEAN: "INOCULATION" AND EFFECT OF POTASH MANURING

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SOYBEAN: "INOCULATION" AND EFFECT OF POTASH MANURING.

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The soybean is a crop of the warmer temperate regions, and its production is concentrated in the tropics because of the pressure it demands over most other oil seeds in the market. There is a wide range of cultivars, and they can be regarded as adapted to a wide range of environmental conditions, thus helping to ensure a high yield in the field. In soybean agriculture, a certain amount of selection and the development of new varieties have already been undertaken. Selection results from the efforts to produce cultivars with better physiological characteristics, such as higher yields and better adaptation to different environmental conditions. The present experiment is to report a continuation of this research into the scope for artificial inoculation with native and/or non-native bacteria. The results achieved to date have not been very promising because of the rather indifferent mode of inoculation used, but there are indications that the time factor is involved, since the organisms, apparently, are not able to infect the roots in sufficient numbers during the first year of their entry into the soil. Whether they will be more effective in subsequent years can only be determined by repeating the experiment on a very small scale.

The other phase of the investigation is an extension of observations made by the Department of Agriculture in the "variety" plots in the Potash Department. The plants on these plots look better than those grown in the ordinary plots, with the lower leaves and stems being more robust and exhibiting symptoms of fertilizers. When treated with a liquid fertilizer, they exhibited an appreciable growth, indicating that they are capable of taking up the necessary requirements of the soybean if properly nourished. This will allow the75...
INTRODUCTORY.

Though essentially a crop of the warmer temperate regions, the Soy bean has of late attracted attention in the tropics because of the premium it commands over most other oil seeds in the world markets. Its introduction into Trinidad has opened up possibilities of far reaching importance. For the present however, it can only be regarded as a potential money crop and one of the few that can be grown by peasants in the wet weather. Its eventual success will depend on the attitude taken by those interested in the purchase of soy bean oil from elsewhere.

In order to secure a permanent place for the crop in native agriculture certain amount of selection work for desirable strains has already been undertaken and research into the factors governing optimum nodule production has also been launched. The present Experiment is in part a continuation of this research into the scope for artificial inoculation with patent cultures under prevailing conditions. The results achieved so far have not been very promising because of the rather indifferent mode of nodulation but there are indications that the time factor is involved, since the organisms, apparently, are not able to infect the roots in sufficient numbers during the first year of their entry into the soil. Whether they will be more effective in subsequent years can only be determined by repeating the experiment on the very same plots.

The other phase of the investigation is an outcome of observations made by Prof. Cheesman on appearance of Soy beans grown on the "variety" plots in the Botany Department. The plants on the whole looked stunted, with the lower leaves crinkled and yellow, showing symptoms of chlorosis. When treated with a little potash they revived to an appreciable extent, indicating that as far as the potash requirement of the soy bean was concerned, the soil was too deficient in that constituent to meet the demand. It was therefore decided to test this out on a similar soil type concurrently with the proposed "inoculation" experiment.
Present State of knowledge - other workers and their conclusions.

Some reference to the literature on "inoculation" has been made by previous workers.* The consensus of opinion is that due to a variety of causes, the inoculation of soybean is not always successful. According to Vorhees, (1) different varieties of soybean appear to have definite and different powers of resistance to infection with the symbiotic bacteria. This has been shown to be due to the existence of various strains of the organism which show difference in virility with different varieties of soybean. Thus Dunham and Baldwin (2) have in a recent paper stressed the necessity of using for seed inoculation only effective strains of nodule organism. They attribute many of the failures to obtain satisfactory results to the use of ineffective strains. But some of the plants grown on the I.C.T.A. farm however, especially those inoculated with "Humogerm" on field Q, last year, have produced a fair number of nodules and therefore there must be some other factor or factors responsible for the paucity of nodules over certain fields.

The beneficial effect of liming on nodule production has already been demonstrated by A. T. Perkins (3) and more recently by Albrecht and Davies (4). There is no indication as far as the present experiment is concerned that lime was the limiting factor to profuse nodulation. The relation of bacterial numbers to nodulation is of more immediate interest. Perkins has shown that where the number of nodule organisms is limited there is a distinct relation between the number of organisms present and the number of nodules formed. The importance of bacterial migration to infection of roots has also been emphasised by Thornton (5). The lateral spread of bacteria seems to vary greatly in different soils. With lucerne organisms on a well drained calcareous soil there was practically no spread. It is likely that the spreading of the bacteria is affected by season and may occur only under suitable conditions.

* Excellent and fairly comprehensive accounts of the work so far done have been submitted from time to time by Gibberd and Trotman, Hosking and Buckley, and Fuggles. Any repetition would here be superfluous.
of soil moisture and temperature. Thus Wilson (6) has shown an increase in number of nodules with increasing water content up to a point where the soil was waterlogged. The nodules in general are most numerous and active at time of flowering of the host plant, and it is significant that a fair number of them should be produced with no "inoculation" on the crops grown in wet seasons - e.g. field Q last year. 

Then there is the question of carry over of the bacteria through the dry period. Fuggles has maintained that the bacteria once established in the soil can stand the dry season. It is common knowledge that the cowpea nodule organisms do thrive and persist throughout the year in the I.C.T.A. farm soil, and therefore considering the intimate morphological/relationship demonstrated by Leonard (7) between them and the root nodule organism of soybean, it is but natural to expect that with frequent cropping with Soybeans, the soybean bacteria will also eventually establish themselves. As postulated by Thornton, the addition of organic matter to the soil will no doubt, just as in the case of clover, supply the energy to enable the bacteria to multiply. 

The value of inoculation when it proves successful is not limited entirely to enrichment of the soil in nitrogen after the stubbles are ploughed up. An immediate benefit in the form of increased yield of beans of higher protein content is claimed. Thus the University of Illinois (8) reports a gain of 11.9 bushels for inoculation. On the other hand Piper and Morse (9) in discussing this question favour the idea that inoculation may not notably increase the yield of beans, although plant growth and protein content will be significantly enhanced. Apparently the response of the crop to inoculation will depend on the state of fertility of the land, particularly on the amount of available nitrogen in the soil. The less productive soils especially in a climate which restricts the activity of nitrifying organisms may show a bigger percentage increase for inoculation than the more fertile ones.
The higher protein content of the beans from the inoculated plants seems to be associated with lower oil content and ash content. How far this will affect the total output of oil will depend on the increased yield obtained through inoculation. Potassic fertilisers in moderate quantities are known to be beneficial to plant growth since they increase the efficiency of the photosynthetic mechanism in the leaves. Their marked effect on legumes, however, still remains unexplained. Apparently the legumes are very sensitive and react to slight deficiency in available potassium in the soil. Russel (10) has described the symptoms of potash starvation. They vary according to the supply of nitrogen which primarily determines the leaf size and the number of leaves. In general the leaves appear dull in colour, die at the tips and along the edges looking as if they were scorched and later become definitely "bronzed". The plants are not only stunted in growth but may even fail to reach maturity.

The effect of potassium in correcting the harmful action of excess of nitrogen resulting from successful inoculation or otherwise is attributed to its action (catalytic presumably) in producing more sugar and starch in the leaf and thus restoring to more normal values the C/N ratio which has been disturbed by the excessive supply of nitrogen. Consequently it is not unreasonable to presume that with adequate supply of available Potassium in the soil the accumulation of carbohydrates in the plant will tend to raise the C/N ratio and thus induce early flowering and production of bigger weight of grain. In fact this has been observed by F. W. Morse (11) in plot experiments conducted over two seasons. "With an abundance of water the weights of seed with potash were triple the weights without potash." The yield of straw however, was not proportionately increased. It is not known whether the individual seeds were heavier or whether there were larger numbers of seeds of small size and weight. According to Russel, experiments with wheat and barley indicate that potassium compounds have a marked effect on the weight of the individual grains - "indeed to withhold
potassium is the surest way of producing stunted grain".

Relation of nodule formation to Potassic fertilisers.

Fellers (12) has found that with application of muriate of potash at rates varying from 50-400 lbs. per acre, nodule production is stimulated on limed plots but not on unlimed plots. Also A. T. Perkins (13) concludes from the evidence available that under general farming conditions, applications of phosphate and potassium and Calcium increase nodulation — "The manner in which these elements affect nodulation is at best problematical".
THE PRESENT EXPERIMENT.

Aim. To determine the effects of the following treatments on the yield of soybeans.

(1) "Inoculation" with "Humogerm" according to instructions (on the tin).

(2) Application of Muriate of Potash at the rate of 1½ cwt. per acre.

(3) Interaction if any between inoculation and Potash manuring.

Details of the Experiment.

Soil type.

The soil on the Experimental area - the South East corner of Field L - may be described as a yellow silty loam with lenticular gravel masses occurring as surface outcrops. It is derived from the Pleistocene detritus of Northern Range precretaceous quartzose schists. It readily breaks up into fine particles and when overcultivated it has a tendency to set to a puddled condition after heavy rains. The index of texture for soil on the college plots is found to range from 14 to 23 (Prof. Hardy).

In general, the farm soils - particularly Field Q - are rather deficient in available potash but nothing definite is known about the soil on Field L. As shown below, it has received dressings of Muriate of Potash in previous years.

Previous History of Experimental Area.

The Experimental area - about ½ an acre - was located on the South East portion of Field L.

Previous to the year 1928, the field was a savannah. Work commenced in August and the trees - mostly Saman trees - were felled and burnt for charcoal. The land was then tractor ploughed and the following crops taken ever since.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cropping</th>
<th>Manuring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1928-29</td>
<td>Late Maize</td>
<td>½ cwt. Sulp. Ammonia</td>
<td>Yield 1323 lb.</td>
</tr>
</tbody>
</table>
Year Cropping | Manuring (per acre) | Remarks
---|---|---
1929-30 Early Maize | 7 tons ground Limestone | Sown 16-27th July
| 3 cwt. Fish manure | Harvested 12th-November.
| 2 cwt. Super | 
| \( \frac{1}{2} \) cwt. Sulph. Potash | Yield 26990 lb.
| \( \frac{1}{2} \) cwt. Muriate of Potash | 

Late Bengal Beans.

In addition, a row of plants all round the experiments discarded at harvest.

1930-31 Early Bengal Beans

Manuring (per acre)

- 3 cwt. Fish
- 2 cwt. Super
- 1 cwt. Muriate of Potash

Yield of 16995 lb. (cobs)

1931-32 Early Sunn Hemp

It will be noted that the field has received 7 tons of ground limestone in 1929 and 2 cwt. of potassic fertilisers from the time it was reclaimed. An average crop of Maize is said to remove in 1500 lb. of grain - 40 lb. K, 14 lb. P and 27 lb. K. From this it is evident that the field was by no means very deficient in potash at the time of planting soybeans. In fact in patches where trees were burnt, there were indications that the soil was rich in potash.

Variety of seed. Nothing definite is known about the variety of seed used. It was fresh seed, harvested on Field Q, a couple of months back. Presumably it was a mixture of strains - the globose Venezuelan type predominating.
Design of Layout.

The Randomised Blocks layout was adopted; there being 6 blocks with the four treatments distributed at random in each block. The individual plots were all \( \frac{1}{40} \)th of an acre in area - i.e. 11 yards square - and contained 11 rows of plants, each row a yard apart. The spacing in the rows was 1' 6".

There was a discard of 1 yard - 2 rows - between blocks and another yard - 3 rows - between adjoining plots in each block. In addition, a row of plants all round the experimental area was discarded at harvest.

Tillage Treatment of Experimental Area.

The Balance plough was used for the first time. The field was not left in ridge furrows. After disc harrowing, the field was rolled with the Cambridge roller and then harrowed again with the chain harrow for seed bed.

Date of Application of Manure. - 19th Dec. 1931. Muriate of Potash at the rate of \( \frac{1}{2} \) cwt. per acre was applied in the morning by hand; fairly even distribution was obtained.

Date of Sowing. 19th Dec. 1931. The seed was sown by hand in the afternoon 3-4 seeds per hole. Approximately 8 lbs. each of inoculated and uninoculated seed was used for the whole area - i.e. about 32 lbs. per acre in all. The inoculation was done in the morning according to directions on the tin. Only a small quantity of the culture was available. It was thoroughly mixed with the moist but not wet seed along with a little sugar and the whole lot was left to dry in a shady corner.

The sowing was not particularly good - the rows were not quite straight. It was done late in the afternoon on a Saturday, and not unnaturally, the women - 12 of them - were in a hurry to retire for the day to do their shopping.

Dates of Other Field Operations.

Germination commenced about the 23rd of December and was
very uneven, presumably due to irregular depth of sowing and therefore supplies had to be dibbled in on the 4th January.

Supplies started germinating on the 7th and the next day the field was hoed with a fine tined hoe drawn by the mule.

14th Jan. 1932. - Singling and hand hoeing between plants in the row. Mule hoeing in the afternoon.


The weather. From the Rainfall graph it is evident that the season was on the whole an unusually wet one. It was possible to get a good plant. Towards the end there was a spell of dry weather which accelerated ripening.

Date of Harvesting.

Due to unavoidable circumstances harvesting had to be started rather too early. There was a certain amount of shelling of grain from a few plants but the large majority was on the whole not quite mature. So that it was decided to forego the straw weights. The plants were stripped of their leaves and stuffed into sacks. In the mean time, one plant per row - i.e. 11 plants per plot - was picked at random while making counts and left in a suitable place to dry. Later, the number of pods on each plant and the total weight of threshed grain from the 11 plants from each plot were determined.

Threshing - by hand - was done about 10 days later but in the mean time some of the grain, especially from the control plot in block I, had gone mouldy in spite of the care which was supposed to have been exercised in putting it out in the sun every day.

Yield Data.

Weighings were made to the nearest quarter and were checked
a fortnight later. There was no appreciable difference in the weights except for the lot which had gone mouldy.

<table>
<thead>
<tr>
<th>VI.</th>
<th>V.</th>
<th>IV.</th>
<th>III.</th>
<th>II.</th>
<th>I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>6.75</td>
<td>13.03</td>
<td>14.31</td>
<td>13.25</td>
<td>10.94</td>
<td>11.28</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>10.95</td>
<td>11.97</td>
<td>12.03</td>
<td>12.03</td>
<td>9.03</td>
<td>11.50</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>E</td>
<td>A</td>
</tr>
<tr>
<td>12.33</td>
<td>10.77</td>
<td>10.30</td>
<td>10.36</td>
<td>9.03</td>
<td>10.17</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>16.28</td>
<td>14.44</td>
<td>15.00</td>
<td>12.80</td>
<td>14.23</td>
<td>18.03</td>
</tr>
</tbody>
</table>

Total Yield in lbs.
A 46.31  B 50.21  C 51.66  D 49.44  E 42.23  F 50.98
Grand Total = 291.83

General Statement of Results.

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>MEAN YIELD in lbs.</th>
<th>DIFFERENCES FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Control</td>
<td>11.51</td>
<td></td>
</tr>
<tr>
<td>B. Inoculation</td>
<td>11.01</td>
<td>- 0.50</td>
</tr>
<tr>
<td>C. Potash</td>
<td>12.76</td>
<td>+ 1.27</td>
</tr>
<tr>
<td>D. Potash Inc.</td>
<td>13.34</td>
<td>+ 1.83</td>
</tr>
</tbody>
</table>

The differences are not statistically significant.

<table>
<thead>
<tr>
<th>Blocks</th>
<th>I.</th>
<th>II.</th>
<th>III.</th>
<th>IV.</th>
<th>V.</th>
<th>VI.</th>
<th>Total in lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Control</td>
<td>10.17</td>
<td>14.23</td>
<td>10.36</td>
<td>10.30</td>
<td>13.03</td>
<td>10.95</td>
<td>69.04</td>
</tr>
<tr>
<td>B Inoculated</td>
<td>11.50</td>
<td>9.03</td>
<td>13.03</td>
<td>15.00</td>
<td>10.77</td>
<td>6.75</td>
<td>66.08</td>
</tr>
<tr>
<td>C Potash</td>
<td>16.03</td>
<td>9.03</td>
<td>13.25</td>
<td>12.05</td>
<td>11.97</td>
<td>12.33</td>
<td>76.66</td>
</tr>
<tr>
<td>D Potash Inoculated</td>
<td>11.26</td>
<td>10.94</td>
<td>12.80</td>
<td>14.31</td>
<td>14.44</td>
<td>16.28</td>
<td>80.05</td>
</tr>
</tbody>
</table>

50.98 46.23 49.44 51.66 50.21 46.31 291.83
Plot VI.B - with the lowest yield figure - was particularly bad. The plants were stunted in growth and showed marked yellowing of the leaves.

Plots I.B, II.B, and II.C were gravelly and presumably had a high pH value since Bahama grass - cyanodon dactylon - appeared to flourish on them. There were traces of an old road running across. The yield figures for these plots are also comparatively speaking low; the plants were light green in colour right up to harvest in contrast to the dark green appearance of the rest of the field.

Plot I.C - was easily the best and gave the highest yield.

In general the tendency was for the fertility gradient to run downward diagonally in a north westerly direction from the farm road towards the railway line.

The variations in yield due to soil heterogeneity have been largely eliminated by the system of statistical analysis adopted.

Analysis of Yield Data.

The statistical technique adopted for working out the Randomised Blocks layout is the "Analysis of Variance" devised by R. A. Fisher which allows for variation due to soil heterogeneity. The analysis is set out below for the plot yields.

Analysis of Variance.

<table>
<thead>
<tr>
<th></th>
<th>D.F.</th>
<th>S.S.</th>
<th>Variance</th>
<th>St.Dev.</th>
<th>Log e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks</td>
<td>5</td>
<td>15.100</td>
<td>2.620</td>
<td>1.6186</td>
<td></td>
</tr>
<tr>
<td>Inoc. V. No Inoc.</td>
<td>1</td>
<td>.074</td>
<td>.074</td>
<td>Not Sig.</td>
<td></td>
</tr>
<tr>
<td>Interaction between Potash &amp; Inoc.</td>
<td>1</td>
<td>1.591</td>
<td>1.591</td>
<td>Not. Sig.</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>108.277</td>
<td>7.218</td>
<td>2.6866</td>
<td>.98646</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>142.446</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It will be noticed that the S.S. for Blocks is extremely low compared to that for error.
The following table gives the number of plants expressed as a percentage of total possible number (22 x 11 = 242), after germination - in this case only five rows per plot picked at random were counted; the total possible number being 22 x 5 = 110 after supplies were put in and at harvest.

<table>
<thead>
<tr>
<th>BLOCKS</th>
<th>CONTROL</th>
<th>INOCULATED</th>
<th>POTASH</th>
<th>POTASH INOC:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After Germ. (5 rows)</td>
<td>After Supplies (11 rows)</td>
<td>At Harvest (11 rows)</td>
<td>G.</td>
</tr>
<tr>
<td>I.</td>
<td>71.8</td>
<td>86.0</td>
<td>91.6</td>
<td>57.3</td>
</tr>
<tr>
<td>II.</td>
<td>74.5</td>
<td>90.5</td>
<td>88.0</td>
<td>67.3</td>
</tr>
<tr>
<td>III.</td>
<td>65.5</td>
<td>74.0</td>
<td>74.4</td>
<td>64.5</td>
</tr>
<tr>
<td>IV.</td>
<td>76.4</td>
<td>66.9</td>
<td>65.3</td>
<td>65.5</td>
</tr>
<tr>
<td>V.</td>
<td>76.4</td>
<td>91.3</td>
<td>81.4</td>
<td>44.6</td>
</tr>
<tr>
<td>VI.</td>
<td>70.9</td>
<td>83.9</td>
<td>81.0</td>
<td>43.6</td>
</tr>
<tr>
<td>Average</td>
<td>72.6</td>
<td>82.1</td>
<td>80.3</td>
<td>57.1</td>
</tr>
</tbody>
</table>

In no case was the number of plants under any treatment significantly bigger than that under any other. The increase in number of plants at harvest in some plots is due to late germination of supplies.
Discussion of Results.

Although the differences are not statistically significant, it is evident that the inoculated plots with no potash have given the lowest yield. The plant number on these plots was also low right through. This may be due to the fact that the number of seeds dibbled in per hole had to be limited to two because of the small quantity of inoculated seed available. Also, at the time of planting the inoculated seed there was a heavy shower of rain and in some cases the excess of water loosened the seed coats causing them to "slip" on handling. So that both the inoculated and the inoculated plus potash treated plots showed smaller number of plants at germination.

Also, the supplies that had to be dibbled in, in the inoculated plots did not come up so well as on the plots treated with potash in addition. These supplies were not inoculated since there was no more culture left. It was hoped, however, that the organisms present in the soil in places where the first lot of inoculated seeds failed to germinate would infect these supplies.

As regards nodule formation, counts could not be made for obvious reasons till after harvest. By that time, there was a general decay of nodules brought about by the bacteria attacking and destroying the nodule tissue. So that any evidence of viability of the original culture - which by the way was guaranteed sound till 31st March 1932 and kept in cold storage for most part of the time - is based on the appearance of a few - about 3-4 - root nodules on a small number of plants in the inoculated discard rows adjoining inoculated plots. Plants in uninoculated discard rows were entirely devoid of root nodules, indicating that the nodule organisms were not originally present in the soil, or if present were not in a state to infect the roots.

The indifferent mode of nodulation of inoculated plants may be attributed to the preliminary washing effected by the shower of rain while planting and also to the method of planting by hand which may have caused the bacteria held on to the smooth seed coat.
by the thin film of sugar to be easily rubbed off. The use of the planter and subsequent thinning out may have given better results and is recommended for any similar experiment in the future. As already indicated, the concentration of bacteria in the soil round the seed is an important factor determining the extent of nodulation, and it is not unreasonable to observe that the amount of culture available was not quite sufficient since it was just what was left over after inoculating seed on field G. It may be advisable to continue the experiment on the same area to see if the bacteria will establish themselves eventually and migrate to any appreciable extent.

In general, the plants with root nodules, appeared to be shallow rooted. Considering the size of an average plant, this may not be a desirable feature where intercultivation is practiced, since the plants will be easily dislodged. Also the presence of nodules did not bear any relation to the size of plants. Some of the most miserable looking plants had root nodules while some of the others more sturdy were entirely devoid of them. Apparently nitrogen was not the limiting factor to growth in all these cases. However this requires further investigation for after all the cost of culture and labour expended in treating the seed is relatively small.

As regards the effect of potash, it is unfortunate that the yield difference of 16.12% in its favour cannot be shown to be statistically significant. The error in the experiment is far too large, and no doubt due to the occurrence of patches of soil fertility where levelling operations and burning of saman tree stumps were carried out. Also the immature condition in which most of the seed was harvested, and the subsequent attack by fungi may have appreciably affected the error in the experiment. However, the yield of grain from the 11 plants per plot - i.e. 264 plants in all for the whole experimental area - show significant difference of 26.22% in favour of potash. These plants were kept in well ventilated situation and the grain was quite dry when threshed. The analysis is set out below.
The average number of beans in a pod is two. It is not known whether the effect of potash is to produce a large number of beans of small size, or a few large ones, or a combination of both. From the results of previous workers it may be gathered that the tendency is to produce heavier grains on the average.

There are indications, however, that application of material number of beans in the soil round the seed was not maintained after

(a) The amount of culture used was not quite sufficient
(b) Rain at the time of planting may have washed the bacteria off the seed.
(c) The method of planting by hand may have also caused the thin film of bacteria round the seed to be rubbed off.

It is suggested that the 'plots' be used in subsequent mechanization experiments and that the present experiment be continued over a longer area to see if the bacteria will eventually adapt themselves to any great extent.

Application of Muriate of potash at the rate of 15 lb.

per acre gave an increase of 11.1% in yield of grain but this difference was not significant. However, there are strong indications that potash has induced early maturity and production of heavier grains on the average. The field method for the experiment was by no means very efficient in potash and it is suggested that any future experiments are carried out on a soil that has not received any manure.
SUMMARY AND CONCLUSIONS.

Under the conditions of this experiment "Inoculation" has failed

(1) To show significant increase in yield of grain.
(2) To infect plants in sufficient numbers.
(3) To produce more than 2-3 root nodules on the small number of plants infected.

There are indications, however, that optimum concentration of bacterial numbers in the soil round the seed was not maintained since

(a) the amount of culture used was not quite sufficient
(b) Rain at the time of planting may have washed the bacteria off the seed.
(c) the method of planting by hand may have also caused the thin film of bacteria round the seed to be rubbed off.

It is suggested that the 'planter' be used in subsequent inoculation experiments; and that the present experiment be continued on the same area to see if the bacteria will eventually establish themselves or migrate to any great extent.

Application of Muriate of potash at the rate of 1½ cwt. per acre gave an increase of 16.12% in yield of grain but this increase was not significant. However, there are strong indications that Potash has induced early maturity and production of heavier grain on the average. The field selected for the experiment was by no means very deficient in potash and it is suggested that any similar experiment be carried out on a field that has not received any dressings of potassic fertilisers for some years.
The writer wishes to express his appreciation of the helpful suggestions given by Professor Wood during the course of the work described herein.