The Selection of types of *Cajanus Indicus* (Pigeon pea) suitable for cultivation in Trinidad. A continuation of previous work carried out on the College Farm.

Submitted in part requirement for the examination for the Associateship of the Imperial College of Tropical Agriculture.

by

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INTRODUCTION.

The objects of this paper has been the continuation of the selection work on *Cajanus indicus* (Pigeon pea) on the College Farm. This work was started in 1932-33 on the suggestion of Mr Stockdale, and extended in 1933-34 under the supervision of Usher-Wilson who has recorded the results of these preliminary selections and trials in his dissertation. The writer has considered that there is little need to reiterate the review of available literature on the subject as this has been ably carried out by Usher-Wilson. An attempt has been made in this year's work to simplify the whole experimental plan and base all the future work on commercial qualities as far as possible.
EXPERIMENTAL.

The material available for experimental work during this year, had been selected, and the crop planted before the writer had arrived in Trinidad. The planning of the layout and selection work was carried out by Usher-Wilson, in the light of his results during the previous year. The whole of Field 2 was devoted to this work.

a) Randomized Block Variety Trial.

Eight different types of pigeon pea were compared on their yield, and superimposed was a spacing trial. The experiment was arranged so that every one of the eight types formed individual plots in one block; their positions being randomized for each block; there being six blocks in all. This gave eight types replicated six times, thus giving 48 whole plots. Each one of these whole plots was subdivided into two sub-plots, and the two different spacings were randomized within the whole plot. This gave 96 sub-plots in the whole experiment.

The size of the whole plot was 24 feet by 45 feet, and the sub-plots were 24 feet by 22½ feet. The two spacings were 2½ feet by 3 feet and 4½ feet by 3 feet. This gave eight rows per sub-plot, each row being 3 feet apart, with 9 and 5 plants respectively in each row. Thus we get the following analysis of variance:-

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>D.F.</th>
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<tbody>
<tr>
<td>Blocks</td>
<td>5</td>
</tr>
<tr>
<td>Varieties</td>
<td>7</td>
</tr>
<tr>
<td>Error (a)</td>
<td>35</td>
</tr>
<tr>
<td>Whole plots</td>
<td>47</td>
</tr>
<tr>
<td>Spacing</td>
<td>1</td>
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<tr>
<td>Interaction</td>
<td>7</td>
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<tr>
<td>Error (b)</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
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The eight types under test were:

1 = Mass selection Strain A (Trinidad)

2 = " " " D erect (Hawaiian)

3 = " " " D spreading "

4 = " " " E erect "

5 = " " " E spreading "

6 = " " " G erect (Indian)

7 = " " " G spreading "

8 = " " White seed from Grenada.

The material has been described by Usher-Wilson in his dissertation, but the Grenada seed No.8 was collected by him during a visit to Grenada. This type may be described:- Plant medium height, somewhat spreading, flowers yellow, pods green, seed pure white and medium in size, it is considered a pure line strain, having been kept pure for about twelve years.

b) Purity Trial.

Eight strains some of them known to be self fertilised for one generation and others for two generations were tested for purity. These were planted in rows spaced five feet, and plants five feet in the rows.

c) Single plot Preliminary Yield and Comparison Test.

This consisted of twenty nine single row observation plots. Each was from a single plant selection or from selected seed. The parents being phenotypically pure for their type. These were planted out five feet by five feet.

d) Multiplication Plots.

These were planted up to bulk up seed of strains E erect and spreading, G erect and Grenada seed for sale
on the local market.

The plots of *E* erect and spreading - called 4 and 5 in this year's nomenclature - were 54 feet by 250 feet and the plants spaced 3 feet by 3 feet. The plot of *G* erect - No. 6 - was 185 feet by 140 feet, and the plot of Grenada seed - No. 8 - was 100 feet by 140 feet.

e) **Isolated Seed Multiplication Plots.**

Some of the seed from caged plants of 1933-34 were planted in isolated plots in order to be sure no cross fertilisation would take place. Some of these plants to be caged in 1934-35.

<table>
<thead>
<tr>
<th>Plot</th>
<th>History</th>
<th>Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.F. inter</td>
<td>F.111.19 Selled for one generation</td>
<td>Botany Dept.</td>
</tr>
<tr>
<td>S.F. tall</td>
<td>F.1.10 &quot; &quot; &quot; &quot;</td>
<td>&quot; &quot;</td>
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<tr>
<td>S.B1</td>
<td>Strain B yellow flower - Selled one gen.</td>
<td>Mycology Dept.</td>
</tr>
<tr>
<td>S.B2</td>
<td>&quot; &quot; dark &quot; &quot; &quot; &quot;</td>
<td>Field 16</td>
</tr>
<tr>
<td>S.G.</td>
<td>Indian type, selfed one generation</td>
<td>Field 22</td>
</tr>
<tr>
<td>S.S.C.</td>
<td>Strain C, selfed for two generations</td>
<td>&quot; 25</td>
</tr>
<tr>
<td>S.S.E</td>
<td>&quot; E &quot; &quot; &quot; &quot; &quot;</td>
<td>Cotton Station</td>
</tr>
<tr>
<td>S.S.F</td>
<td>&quot; F &quot; &quot; &quot; &quot; &quot;</td>
<td>Prof. Woods Garden</td>
</tr>
</tbody>
</table>

**Labelling of material for 1934-35.**

<table>
<thead>
<tr>
<th>1934-35</th>
<th>1933-34</th>
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<tbody>
<tr>
<td>Randomized Plot Trial</td>
<td>A.</td>
</tr>
<tr>
<td>1</td>
<td>D erect.</td>
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<tr>
<td>2</td>
<td>D spreading</td>
</tr>
<tr>
<td>3</td>
<td>E erect</td>
</tr>
<tr>
<td>4</td>
<td>E spreading</td>
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<tr>
<td>5</td>
<td>G erect</td>
</tr>
<tr>
<td>6</td>
<td>G spreading</td>
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<td>7</td>
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The History of Field 2.

In 1933-34 the field was manured with 4 cwts. of superphosphate, 4 cwts of muriate of potash and 4 cwts of sulphate of Ammonia, and then sown with sunnhemp for seed, in July. In August the sunnhemp seemed to suffer very badly from some disease, it wilted, then died out. The whole field was mown over. It was believed that the cause of the failure of the
sunnhemp was due to excess moisture. After the sunnhemp had been mown, the field was ploughed and soy bean planted, the crop established itself with some difficulty, being very patchy. The soy bean was harvested in January, giving only a medium yield. Directly after the harvest sweet potatoes were put in the field; on the southern end for about 2.5 acres was an experiment with manures, the treatments ranging from 0 - 16 tons per manure/acre, and additional dressings of Nicifos or muriate of potash at 1 cwt/acre. The rest of the field, about 1.3 acres, was also planted with sweet potatoes, and given a dressing of $\frac{1}{2}$ cwt Nicifos, $\frac{1}{2}$ cwt muriate of potash, and 20 cartloads of pen manure.

The non experimental sweet potatoes failed to establish, and the northern end was planted up with cowpea $\frac{2}{3}$ of the area and sorghum $\frac{1}{3}$ of the area. These crops were harvested in May and also the sweet potato experiment. All the crops were disappointing owing to the extremely dry weather.

The field was then ploughed over as a whole, and compost applied at the rate of 5 tons per acre. The south eastern quarter getting 5 ton of compost from the steading, and the rest of the field 16 tons compost from the depot. This wasdisc harrowed in. The field was sown on the 6th and 7th July, on the 9th rain fell, but dry weather again set in. The germination seemed on the whole quite good. In the early part of September a dressing of 4 cwt of blood meal was applied to the field.

Thus it will be seen that the field during the six months previous to planting with pigeon peas, was
in a high state of fertility, which was not exhausted to the fullest extent, owing to the long period of dry weather.

The Growth of the Crop.

The crop on the whole germinated very well: some supplying was done to fill in blanks. Plots 6 and 8 were very irregular, in 6 many blank patches, but still quite a fair stand. The multiplication plot of No.6 was so bad that it was scrapped, the land ploughed up, and planted in woolly pyrol. In the yield trial the plots of No.8 were also very bad, but nothing could be done to remedy this state, it was decided to leave them, and see if some statistical adjustment could be made for valid results.

In October the plants had grown so well, it was decided to put in bamboo poles, which would stand at least 9 feet above ground, to mark the corners of the plots; these would enable workers to keep their positions, when working in the plots. The poles were marked with the appropriate number of black "broken" rings, on a light blue background, to the plot number. In alternate blocks the rings had a white background, by this method the blocks were demarked.

By January, the poles inside the experiment were completely hidden by the crop, many of the plants having grown to a height of 15 feet. The extreme height of the plants had a profound effect on the crop's flowering. In the close spacing plots the plants were very spindly and tall, with only a small crown of leaves and long bare stems. The plants bore few flowers at the top, where they were not shaded to any extent by the canopy that was formed. This canopy was in general eight feet to ten feet above
the ground.

The competition was in the writer's opinion far too severe, as in some of the plots, several plants were found to be suppressed to such an extent that they only grew up to about 3 feet high, had an extremely thin stem and few leaves.

We may attribute this excessive growth to the excessively high state of fertility of the field when the crops were planted. There must have been quite a considerable residual fertility, as the weather precluded any leaching of the soil during the preceding six months, and the crop did not grow to any extent: with an extra application of 5 cwts of compost per acre would give the field a level of fertility far above the normal. This state of fertility for a crop which under usual conditions gets very little - if any - manure applied in general practice in the West Indies, may explain the extraordinary vegetative vigour of the crop. This effect was also enhanced by the favourable weather during the growing season.

There were very few indications of excessive moisture in the soil, which would markedly affect the growth of the crop.
Cultivations and Labour.

As this crop has to be considered from the economic or commercial side as well as the more academic side, it would not be inappropriate to discuss the special problems of labour relating to this crop.

With regard to the general preparation and cultivations before the crop is established, there is little divergence from the general practice of all tropical crops. When the crop is established there are several problems which are of importance.

In the plot experiment, the ground cover was excellent, there being only a negligible number of weeds even in the wider spacing; but in the plots which had suffered from bad germination or disease, weeds became established very quickly, especially knot grass and fowls foot grass, and these caused considerable trouble. This problem of grasses was more serious in the progeny lines in the other part of the field; the distance apart of the rows - five feet - did not allow the plants to form a compact canopy, and so the ground was not shaded sufficiently to check the growth of the weeds.

During the year no attempt was made at hoeing out the weeds, as the cost of labour would have been far too high; the weeds were cutlassed at intervals to prevent them from seeding: this checked them for the time, but to what extent the weeds - especially the knot grass - had established itself vegetatively is not known. The policy of only cutlassing the grasses may have been rather short sighted in view of the extraordinary vigour of these weeds, and the full effects will not be appreciated until the next crop
is established.

When the harvesting of the crop had to be considered, there was one great problem, which had to be considered: was the crop to be harvested in one complete picking, or did the crop justify two or more consecutive pickings. This question of one or more pickings depended on the eveness of maturity of the crop, and was of great importance to the farmer growing the peas on a large scale for sale on the open market.

A crop which showed an eveness of maturity that picking the whole crop once would harvest the majority of the crop and the remainder would not be worth the expense of picking; the plants could then be scrapped for the year. On the other hand a crop which was not so even in maturity would require an early picking for the first crop of ripe pods, and subsequent pickings as the later maturing pods justify the expense of picking.

This question also decided the method of picking. A crop that could be harvested in one picking, the cheapest method could be applied. This method is that the main branches of the plants could be cut off by means of a grass knife or a cutlass; then stacked up in a bullock cart - care should be taken that the workers do not shatter the pods, or the losses will be quite appreciable - carted into the steading, and spread on a prepared drying floor.

If however the picking is done at two or more periods during the harvest, it is necessary to pick the pods from the plants by hand. This could be done by piece-work, usually employing women or boys, who
are in general much better pickers than men. The cost of this method is much higher than the first method, although the final picking would be the same technique as in the first case.

This second method demands a good crop, and a large podded variety to justify the cost of picking in countries or areas where the rates of pay are relatively high, as in Trinidad.

**Supervision of Labour.**

The use of coolies necessitates very strict overlooking, especially in the plot experiments. In the multiplication plots, it was found that even when piece work rates were set at a level which the pickers had to work hard to get a fair day's rate, the coolies would idle when not watched closely. The overlooking was more difficult if the pickers were separated by a little distance, which was found necessary to prevent them from talking too much. Talking was found to definitely lower their efficiency. The writer found that by overlooking the field on horseback, the efficiency of the workers was raised considerably. These results were found by when weighing the half days picking under each of the different methods of working the gangs.

These experiments in working the gangs during picking the crop were definitely upset by the lack of co-operation of the farm overseer. It was found that when paying these workers, they were paid day wages for periods under experiment at piece work rates; so the attitude of the labourers, with regard to the crop, when they had been paid for some period, could not be
found with any reliability.

Their attitude when informed of the rates of pay fixed for picking, and their daily returns of weight picked, from which their total earnings could be calculated, did not bring forth any remarks worth considering, except a general grumble at the low rates of pay on such a difficult crop. The writer feels sure that if paid in the correct amounts that were owing to them, some valid remarks would have been made by the labourers, even if they refused to continue work at such rates. The impression gained was that any student working on a crop where there are some economic considerations with regard to labour, does not get the true aspect of the labourers point of view. The answers given to students questions are only those which the labourer thinks will please the student, and usually these are not the required answers.

This question of the attitude of the labourers is of importance when trying to establish a crop in the island to compete with imported "dhall". The cost of production must be low, and the main costs seem to be in the picking and preparation of the seed.
Genetical Problems.

The writer was at first concerned with both the commercial and agricultural, and the genetical problems of the crop. In January, Mr Chang-Choon took over the genetical side of the work, and he has a separate contribution at the end of this dissertation.

The Caging of plants for self-fertilisation.

The provision of an efficient cage for selfing plants was one of the most interesting problems attached to the field work of the crop in its early stages. The crop had not started to flower at that time, but previous workers had expressed dissatisfaction with the cages then in use. The main cause of dissatisfaction was the shedding of flowers before they had set seed, when the plant or part of the plant was enclosed in a muslin bag. Usher-Wilson devised a large muslin bag which effectively covered a complete plant. He suggested the main cause of shedding was due to the lowering of the light intensity under the very fine mesh muslin it was necessary to use. He also noted shedding was greater during rainy periods, when the insolation was not very high. The writer concurs with Usher-Wilson, and finds this is borne out as the plants' general growth indicates that it will not stand much shading.

The writer then devised a cage which he considers reduces this shedding to a marked extent, although this only rests on observation, not fully controlled experiments. The results with this cage were highly satisfactory during the year when over twelve cages were used on the farm.
The essential difference of this cage was the provision of a transparent top in the place of the muslin top formerly used. This was achieved by making a wooden frame 3 feet square of 2 inch by 1 inch battens. Over this was laid a 3 feet square of the transparent material. Then the muslin sides were lapped round the edges, and the whole made insect proof by tacking down with a 1 ½ inch by 3/8 inch wooden fillet all round. The method is shown in section in the small diagram. At the corners were nailed four short pegs about 6 inches long; these fitted into the hollow tops of the bamboo supports. The height of the supports was adjusted for the plant being caged, although two of the poles were made longer than the others, so that the top was set at an angle with horizontal to run off any rain water that tended to collect on top.

The first transparent material tried was cellophane. This was bought in sheets and cut to size. This was transparent enough but unfortunately not very strong. The main objection to cellophane was its hygrosopic nature. During the rainy days the cellophane stretched with the moisture, and bagged in at the top allowing rain water to collect on top of the cage. This trouble was not prevented when convex support wires were put in the frame, and when the material was not strong it very often split. At the suggestion of one of the Staff, Radiolite Glass was tried - this is really a fine wire netting which is covered in a thick layer of cellophane like substance forming a very strong and reliable glass substitute - it was found to be an excellent material, and all the cages were fitted with it. The cages lasted throughout
the season, and with a little care should be suitable for next year. Radiolite was sufficiently strong to need no support, and stood a fair amount of rough handling by native labour. It withstood the climatic conditions very well, although there was some tendency for the wire to rust if water was allowed to stand on it for any period of time. This of course was overcome by tilting the frame.

**Dwarfing and its cause.**

One very interesting problem arose in the strain F; this was of Hawaiian origin and known as the Prinsado variety, its description is found in Usher-Wilson's dissertation. In this strain there were found many dwarf plants, which other workers had put down as genetical dwarfs. Selfing had been carried out to eliminate this undesirable heterozygote in the strain, and produce a pure line of normal - or tall - plants. This selfing even over two generations does not seem to have produced any reduction in the number of so-called segregates; all selfing being carried out on tall plants.

The writers view on this subject is that these so called dwarfs are not due to purely genetical segregation of certain genes, which have a definite effect on the morphology of the plant, but due to some physiological factor in which the metabolic processes of the plant are upset, and the so-called dwarfs appear. These views were drawn from a series of field observations on this strain and other strains grown on the College Farm. This tendency to dwarfing is not peculiar to the Prinsado strain, but can be observed in other strains.

The general character of these dwarfs has been
described by Usher-Wilson. The differences of leaf texture and even leaf size noted, can be explained genetically but even greater differences can be produced by unbalanced supplies of nutrients, as shown by workers on manurial treatments. The most important factor in the dwarfing of the plant is in the growth of the flowering stems. The general morphology of the pigeon pea is an indeterminate flowering stem bearing short flowering spikes in the axils of the leaves. In the dwarf plant these stems are to all appearance determinate and bear secondary and tertiary branches, on which are borne the flowering spikes. These stems have very short internodes. This brings the whole to a short compact head. The effect of this is to produce a short, compact, flat topped bush, as shown by Usher-Wilson's photographs.

This dwarfing is not shown in the early stages of growth of a plant in any of the cases observed by the writer. An isolation plot of S.F. tall plants in the Botanical Dept. Gardens showed no signs of having any plants which could be called dwarfs, in November. The plants were planted late, and hence somewhat backward, but they were all healthy and practically uniform; they had not showed any signs of flowering. In December when the plants started to produce flower buds, it was found that many of the less vigorous plants showed the symptoms of dwarfing, later in the season when the plot was in full flower the differences were very well marked.

Some of the dwarf plants were pulled up, and their roots examined, compared with the normal plants. No exact measurements were taken as the method was too rough to justify such a course; it was noted that
dwarfing was correlated to some extent with a small number of main roots, and a tendency to benching. The lack of water and the amount of work involved precluded a detailed study of the root systems of these plants.

A few simple tests were carried out to find if there was any difference in the carbohydrate storage in the stems of the dwarf and normal plants. A portion of stem from each of these types of approximately the same maturity and stage in flowering was tested by sectioning, and staining with iodine in potassium iodide solution. The dwarf plants showed a much greater storage of starch grains especially in the cortical tissues. This was markedly so when the tests were carried out on material collected in the early part of the morning. The suggestion is that these plants have a markedly higher C/N ratio than the normal plants, owing to some metabolic change which gives the plants a lack of vegetative growth beyond a certain stage and an early maturity.

It was noted that the terminal buds of these dwarf plants were in the majority of cases dead, and some of them showed that the secondary branches, which had become terminal had also died. This factor in conjunction with shortened internodes produced the compact head of flowering spikes.

In the peasant rotation on Field 27 (b) there was a crop of local pigeon peas. This field had not received any artificial manure for the last two years, and the field was known to be patchy. During the rainy season large patches of the field were definitely waterlogged, standing water could be found in shallow depressions. As the growing season progressed, and the dry season set in, the effects of the waterlogging and the extent of each area waterlogged could be seen from the growth of the
plants. They were stunted, and dwarfed as in the Prinsado strain, although these areas also showed very marked symptoms of potash deficiency, small hard leaves with yellow tips and margins, the internodes short, early maturing and a stunted plant. Some of the stunted plants being only 2 feet to 3 feet high, as compared with the healthy plants which grew up to 10 feet or more in height. These plants tended to occur in the patches waterlogged, but several isolated plants were also found.

A comparison of the seed from Selfed Normal and Dwarf Plants.

During the previous years there had been no selfing done on the dwarf plants: only normal (or tall) plants had been selfed, and in one case a plant known as an "intermediate" form was selfed by Usher-Wilson. The progeny from this selfing showed precisely the same results as obtained from the normal plants.

This year dwarf plants were caged, and the seed collected was quite viable.

An experiment was set up in April when the seed was available, to test the progeny of a selfed normal plant as against the progeny of a selfed dwarf plant under as exactly comparable conditions as possible. These conditions were obtained by growing them in large galvanised iron bins; these bins were two feet in diameter and two feet deep. The soil used was taken from the farm depot as this was high in organic matters: it was sterilised by steam before the bins were filled.

To each of these bins was added artificial manures at the rate of one and one third ounces of a mixture of, 4 parts Ammonium sulphate, 4 parts of superphosphate and 2 parts of muriate of potash; to each bin. This amount was calculated
to give the equivalent of 10 cwts per acre of manure, to the soil area of the bin. This was then watered into the soil, precautions having been taken that waterlogging would not occur.

In each of the bins four holes were dilled equidistant from the centre and the sides of the bin (shown in plan): into each hole was placed two selected seed, and covered over. The bins were numbered from 1 to 16 with metal tags wired to the handle of the bin. In the bins numbered 1 to 8 were planted seeds from a selfed normal plant, and in bins numbered 9 to 16 seeds from a selfed dwarf plant, each bin then carefully watered every morning until the plants were established.

The germination was very good, only one seed from each type failing. When the plants had grown to six inches or more, the weakest of the two from each hole was removed. A few plants failed to establish, due to an attack of red spider, but except for one bin, the plants were in good condition. At first the bins were left in the open without any shade; but as the rains did not break in May it was thought advisable to put the plants under a palm leaf shelter; the extremely dry weather, and high insolation was affecting the young plants. The plants were left under shelter for about four weeks, then when they had reached three to four feet in height they were again put in the open.

Up to the time the writer left Trinidad, there was no evidence that there was any dwarfing in either of the types. All plants seemed identical in growth and habit, there were two stunted plants, but these were due to red spider attack. Not one of the plants showed symptoms of short internodes or
tertiary branching. This experiment is being continued until the plants flower and set seed: what effect flowering may have remains to be seen. There is no evidence as yet that the dwarfing was due to genetic factors which affect the plant during its early stages of growth.

The writer is of the opinion that the dwarfing of the plants is due to some nutritional starvation in the plant, which occurs at some period of its growth: this starvation checks the growth of the plant through its terminal meristems, these are either suppressed or killed. The low state of nutritional substance uptake after the check, and the alteration of conditions with regard to meristematic activity, would account for the sudden production of tertiary branches and the early maturity of these dwarf forms. This has some definite relationship to the excess carbohydrate storage shown by these forms. An explanation may be found in the root formation, and the production of root nodules, on which is based the nitrogen nutrition of the plant.

Vegetative Reproduction.

An attempt was made to reproduce these forms vegetatively by means of cuttings. A propagator was kindly loaned by the Botanical dept. In the sand was placed twenty woody cuttings taken one morning; of these ten were from normal plants and ten from dwarf. The leaf area was reduced by cutting each of the pinnae in half. These were carefully cut under water before being placed in the propagator bed. This first batch was not at all successful, most of the cuttings died. It was suggested that the technique was not correct. Later three batches of ten cuttings were taken one evening; the first batch were planted without any of the leaves touched; the second batch had the terminal pinna of the leaf removed. And
the remaining ten were planted with only half the usual number of leaves left. The usual number of leaves on the cutting was eight. During the period these were in the propagator they all slowly dropped their leaves; but after about two weeks, the batch that had not had its leaves touched, were found to be well rooted. The others had only a few rooted.

The ten cuttings that rooted well were transferred to small baskets full of sand, put in a separate propagator and watered every day with Krops solution. Unfortunately these all died back with a fungus disease, which worked from the top cut surface. Owing to the pressure of harvest and lack of good growing material these experiments were discontinued. The writer feels however that the plant is capable of being reproduced by cuttings if the correct technique is employed and vigorous material is used.

Diseases and Insect Pests. Fungus Diseases.

The crop as a whole did not suffer severely from diseases, but after harvest considerable damage was caused by insects.

The most damage was caused by a Wilt disease due to *Fusarium sp*; this disease was fairly common and especially troublesome in the yield experiment plots where even stands of plants were required. It was seldom that a plant recovered from an infection of this disease. Another disease somewhat similar in its effects was Collar and Stem Canker *Physolepora sp*, which could be distinguished from Wilt disease by a canker just about or above ground level; some of the infected plants recovered and showed very little damage at harvest.

The above two diseases were the only two which affected the plant number after the crop had been established; but the incidence of Rust *Uromyces dolicholi*. *Arthur*, was evident in
many parts of the field. This did no apparent damage to the crop, the infection was not very heavy in even the worst patches.

During the last year at the end of the wet season; in the last week of December, the crop was attacked by a "die back" disease in various isolated parts of the field. The parts affected were mainly the stems and shoots. The stems drying out in black lesions, on the surface of the dead tissues was a fine greyish film with patches of darker grey spores. Eventually the whole stem above the lesion wilted, and died back to the affected part. This disease was identified as *Corticium vagum*. The peculiarity of this attack was that it only occurred up to the level of about five feet above ground level in the field: no plant was attacked over this height, although the lower part may be badly affected. All the infected stems were eventually killed back to the lowest point of infection. All the infected areas seemed to be under deeper shade than general and the main infection was usually on the side away from the prevailing wind. It was suggested that the infection occurred in places where the humidity was higher than usual.

The attack was first noted and examined in the last week in December when there occurred several heavy showers of rain, but warm sunny days. The infection did not spread after being examined, as the period following was dry, and actually the beginning of the dry season. All strains of pigeon pea were attacked, the F strains were particularly susceptible in dwarf forms, owing to their low stature.

This was the first reported attack of *Corticium vagum* as a 'die back' disease on pigeon pea in Trinidad, although the fungus is known as one of the causative agents of 'damping off' in Trinidad soils.
Insect Pests.

The insect pests of the crop were not of any importance during the growing season; some plants suffered from jessid attacks, and a few odd plants from scale insects usually fostered by ants. These attacks were in general confined to the isolation plots in other parts of the college grounds. The greatest damage to the crop was by Bruchids, these were the cause of a tremendous amount of damage to seed. The primary infection was in the field prior to picking. The dry season being long and very intense the primary infection was particularly high, and during subsequent storage more than fifty percent of the seed was damaged to some extent, in some cases the damage was assessed as high as eighty percent. The two species concerned were *Bruchis obtectis* and *Bruchis chinensis*. The former being in the majority.

Steps were taken to reduce the losses during storage, the methods used are described by Linton and Martin in a previous College dissertation. A quantity of Indian type seed was used, as this was the first type harvested and showed a remarkably heavy infestation. The seed was spread out in the sun, on the concrete farm yard floor; if the layer of seed is not more than one inch deep many of the insects will leave the seed owing to the intense heat of the sun. The seed can then be rebagged with a very low infestation of adult insects. The serious drawback to this method is the adult insects driven off form a source of infection for fields near by, and the method does not remove the larvae still in the seed.

A more effective method described by previous workers, is the use of carbon bisulphide as a fumigant. The liquid is quite cheap to purchase, and is very effective and certain in action, if used in the right proportions. The best results are
obtained by filling a small iron bin, capacity one and a half cubic feet, and putting in 5 cc. of liquid soaked up in cotton wool. Then sealing the lid on with an old sack. After twenty four hours the bin can be opened, and all the insects will be found dead; this method has no effect on the germination of the seed. Periods longer than twenty four hours are liable to affect the viability of the seeds.

The use of carbon bisulphide as a fumigant should be done by skilled labour, as the substance is to some extent dangerous to handle. Bins containing the vapour are liable to explode if left in the sun or near naked flames.

RESULTS OF FIELD TRAILS.

Progeny Lines.

The main work done on these lines was genetical, but several of these have been carried on as suitable material to start a commercial strain.

The factors which influence the commercial value of a strain are many, but in dealing with such a heterogenous collection as these progeny lines, some definite attitude had to be adopted. The first consideration was that of numbers. There were far too many strains to handle with any possibility of success; so it was decided to reduce to as few as possible.

The second consideration was that of type of pea; here the market had to be considered; the opinions of the dealers and also the local East Indians were canvassed. The greatest importance was placed in uniform colour of the seed, in fact the pea will not sell at all if the seed shows a mixture of seed coat colour. The colour was not of great importance provided the bulk of the seed was uniform. The third consideration was yield; this could not be considered with any
reliability as there were so few strains of pure seed colour, so this was not assessed.

The seed for the next year's lines were picked for colour purity only. This was judged from a mass selection from each strain.

The types picked from the twenty nine progeny rows in the field are to be sown out in the next year to test their purity, and if suitable can be used as a parent form for a commercial strain. A description of the parent plant will be found in Usher-Wilson's dissertation, but these strains picked showed a remarkable uniformity within the strain, so it is not intended to describe the strains here, but only give a short note on each seed form and colour.

Line 9. This was the progeny from a single plant selection of a local variety of pea. The seed was full medium in size and dark brown in colour. The sample was very even and attractive to buyers.

Line 10. This was another single plant selection from a local strain, also a dark seed even in colour, and medium size, somewhat similar to Line 9.

Line 15. This was a single plant selection from a Hawaiian strain. The plant in habit was more spreading than usual but was high yielding, the whole progeny line gave an exceptionally high yield. The seed was white with light brown mottling, but the whole crop was uniform in size and colour. The size of the seed was medium, and it was full and round in shape, a very promising strain. This plant was selected from the strain that gave the highest yields in the yield Trial.

Line 19. This was an Indian type of pigeon pea, and showed a very uniform seed sample. This type was only kept on for stock; as the Indian form will not be carried on in the commercial trials.
Line 24. This line was only kept from the more academic points it raised. It was a selection from the Prensado variety of pea, an open pollinated plant, and the progeny showed a uniform growth with no dwarfing evident. The seed was dark and mottled but uniform in colour.

Also two lines were put in as these showed good yields in the yield trial, Lines 4 and 5, and the seed from the above appropriate lines was also used for planting up the yield trial for next year.

All the other lines were scrapped, as they were not considered to be of any value for future work, when compared with those selected.

Isolation Plots.

The seed from these plots was in the charge of Mr Chan Choong, but one selection was made by the writer from the isolation plot of S.B.1 on Field 16. This plot had two types of plants, both identical in growth and habit; but one quarter of the plants had light brown seed, and the rest a light cream seed. These two types of seeds were picked independently. The seed was very attractive, and as they were large in size, and the pod size was also rather big. It was thought that if one or other of these two types could be fixed, it would be an excellent commercial variety. Genetically it is possible that the brown coloured seed is recessive in character, and should breed true. The two strains are known as I.S.Bl and I.S.Bl light.

Multiplication Plots.

These plots were set out with the object of bulking up a suitable strain for sale on the local market. Little need be said of plots 4 and 5, as these both proved to be very mixed.
especially with regard to seed colour, and there proved to be many rogue plants in the plots. These two were not used at all, they were harvested late in the season, by the cheapest method; but unfortunately rain spoilt any attempts at trying to arrive at costing figures. Several heavy rain storms spoilt the drying of the stems on the drying floors.

The multiplication plot of the Indian variety was used for experiments in harvesting. The crop did not mature very evenly, the first picking was carried out in February, by the methods described previously in the paper, and about half the estimated crop was picked. The picking by hand was very slow, as the pods were so small. The piece work rates offered the pickers was finally fixed at 2 cents a pound of dry pods. The first picking yielded 690 lbs. of dry pods, and this threshed out at 300 lbs. of dry grain.

The total cost of picking and threshing is as follows:

<table>
<thead>
<tr>
<th></th>
<th>$</th>
<th>cents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picking</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Rolling and sifting</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Beating for remainder</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19</td>
<td>14</td>
</tr>
</tbody>
</table>

$19 14/100 for 300 lbs. of grain brings the cost per lb. of dry grain to 6 1/2 cents.

The threshing was rather difficult as the rolling did not break all the pods properly, and so the whole lot had to be hand beaten, as quite one third of the grain still remained unthreshed.

When this early crop was offered for sale in Port-of-Spain, only 3s a lb. was quoted, and the writer was told the price would drop to 2s a lb. when the Tobago crop came on the market.

The remainder of the crop on the field was not ready for harvesting till May, and the cost of this harvesting by the cheapest method came to over 3s a lb. This crop was very
irregular with regard to the maturity of the pods. The yield on this occasion was 240 lbs. of grain. The total yield of the plot was 540 lbs. of grain for 5/10ths of an acre. This would give 900 lbs. of grain to the acre.

This crop from the economic point of view was a complete loss, as the cost of harvesting the grain is nearly double the returns, this does not bring in the cost of cultivation and other outlays on the crop. The crop does not pay to grow in Trinidad under these conditions, even under favourable weather conditions such as prevailed during the year the crop will not mature evenly to allow cheap methods of harvesting all the grain at once.

One other view which influenced the final decision of the writer on this crop. The East Indians indigenous to Trinidad do not like the small hard grain of this variety, and only a few old men who emigrated from India would use this type for making "dhall". So in the face of these disabilities of the crop, it was decided to discontinue work on this variety in the future.

Randomized Block Variety Yield Trial.

The layout and description of this experiment will be found in the early part of this dissertation. The harvesting of this experiment employed a special technique. Each one of the sub-plots was hand picked by a gang of eight women pickers. These were prevented from straying on to any of the surrounding plots by passing a rope breast high round the main plot - this rope was supported by the bamboo marking poles - the pickers were then allowed to pick the sub-plot from the dividing line outwards to the rope. Each picking from a sub plot was put in a sack and carefully labelled. The weight of pods for each sub-plot was found, and also the plant number. These sacks were dried in the
sun, or in the drying shed, and then each sub plot was threshed by hand. The threshing was done by beating out the seed with a small wooden beater and then carefully winnowing the dried pods off. The seed weight was then obtained. The first picking was carried out in March, and took over three weeks full work to get all the plots picked and threshed. There was a second picking in April, for some of the plots still had a fair amount of seed maturing, but this did not bring in any results which would alter the relative positions of each of the varieties. The full tables of each plot and sub plot have not been entered here, but the totals for each plot and block of the experiments are in the following tables.

**Block Totals.**

<table>
<thead>
<tr>
<th>Block</th>
<th>Plant No.</th>
<th>Pod wt. lbs.</th>
<th>Seed wt. ozs.</th>
<th>Seed wt. ozs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>659</td>
<td>178</td>
<td>1,663</td>
<td>1,908</td>
</tr>
<tr>
<td>II</td>
<td>643</td>
<td>177</td>
<td>1,597</td>
<td>1,907</td>
</tr>
<tr>
<td>III</td>
<td>586</td>
<td>226</td>
<td>2,122</td>
<td>2,341</td>
</tr>
<tr>
<td>IV</td>
<td>688</td>
<td>193.5</td>
<td>1,854</td>
<td>1,990</td>
</tr>
<tr>
<td>V</td>
<td>674</td>
<td>194</td>
<td>1,880</td>
<td>1,976</td>
</tr>
<tr>
<td>VI</td>
<td>644</td>
<td>230.5</td>
<td>2,198</td>
<td>2,273</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3,894</td>
<td>1,990</td>
<td>11,362</td>
<td>12,395</td>
</tr>
</tbody>
</table>

**Plot Totals.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant No.</th>
<th>Seed wt. ozs.</th>
<th>Seed wt. ozs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>513</td>
<td>1,614</td>
<td>1,654</td>
</tr>
<tr>
<td>2</td>
<td>533</td>
<td>767</td>
<td>773</td>
</tr>
<tr>
<td>3</td>
<td>560</td>
<td>1,552</td>
<td>1,569</td>
</tr>
<tr>
<td>4</td>
<td>548</td>
<td>1,723</td>
<td>2,291</td>
</tr>
<tr>
<td>5</td>
<td>518</td>
<td>1,428</td>
<td>1,504</td>
</tr>
<tr>
<td>6</td>
<td>482</td>
<td>1,540</td>
<td>1,566</td>
</tr>
<tr>
<td>7</td>
<td>493</td>
<td>1,766</td>
<td>1,774</td>
</tr>
<tr>
<td>8</td>
<td>246</td>
<td>964</td>
<td>964</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3,894</td>
<td>11,362</td>
<td>12,395</td>
</tr>
<tr>
<td>Variety</td>
<td>Spacing</td>
<td>Seed wts. in ozs.</td>
<td>Total Spacing</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Wide</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>1</td>
<td>738</td>
<td>276</td>
<td>754</td>
</tr>
<tr>
<td>2</td>
<td>341</td>
<td>426</td>
<td>347</td>
</tr>
<tr>
<td>3</td>
<td>771</td>
<td>761</td>
<td>777</td>
</tr>
<tr>
<td>4</td>
<td>817</td>
<td>912</td>
<td>1056</td>
</tr>
<tr>
<td>5</td>
<td>763</td>
<td>665</td>
<td>963</td>
</tr>
<tr>
<td>6</td>
<td>706</td>
<td>634</td>
<td>716</td>
</tr>
<tr>
<td>7</td>
<td>721</td>
<td>1,047</td>
<td>721</td>
</tr>
<tr>
<td>8</td>
<td>403</td>
<td>561</td>
<td>403</td>
</tr>
<tr>
<td>Totals</td>
<td>5,260</td>
<td>6,102</td>
<td>5,737</td>
</tr>
</tbody>
</table>

Analysis of Results.

On the results of the first picking we get an analysis of variance of the seed weight, as in the following table.

Seed wt. (1st picking)

<table>
<thead>
<tr>
<th></th>
<th>D.F.</th>
<th>S.S.</th>
<th>M/S</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks</td>
<td>5</td>
<td>15,055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Varieties</td>
<td>7</td>
<td>76,705</td>
<td>104.7</td>
<td>2.23562</td>
</tr>
<tr>
<td>Error (a)</td>
<td>35</td>
<td>32,415</td>
<td>30.43</td>
<td></td>
</tr>
<tr>
<td>Whole plots</td>
<td>47</td>
<td>124,175</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spacing</td>
<td>1</td>
<td>7,365</td>
<td>85.93</td>
<td>1.10753</td>
</tr>
<tr>
<td>Interaction</td>
<td>7</td>
<td>8,666</td>
<td>35.18</td>
<td>0.21446</td>
</tr>
<tr>
<td>Error (b)</td>
<td>40</td>
<td>32,254</td>
<td>28.39</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>172,420</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Error (a) as % of General Mean = 25.7%

Error (b) = 24.0%

The significant difference of the total of two different plots = 259 at 1% point.

As both of the significances are at the 1% point this will give the plots which was definitely the best variety. There is no doubt about the significance of the spacing. The narrow spacing giving the greatest yield, but in one case as will be
seen in the yield tables there is an interaction, which is not significant.

The two plots which are outstanding are 4 and 7 these giving the greatest yields, and plots 2 and 8 of very low yield; though 8 is due to the low plant number in the plots.

The ratio of pod to seed weight was noted to a remarkably constant factor and hence of little importance.

The total yield of the plots was also calculated. This gave the following analysis:

\[
\begin{align*}
\text{D.F.} & & \text{S.S.} & & \sqrt{M/S} & & \text{Z} \\
\text{Blocks} & & 5 & & 11,412 & & \\
\text{Varieties} & & 7 & & 135,194 & & 138.9 & & 1.46818 & & \text{SIG.} \\
\text{Error (a)} & & 35 & & 35,836 & & 32.0 & & \\
\text{Wholeplots} & & 47 & & 182,442 & & \\
\text{Spacing} & & 1 & & 8,836 & & 1.17050 & & \text{SIG.} \\
\text{Interaction} & & 7 & & 10,151 & & \\
\text{Error (b)} & & 40 & & 34,151 & & 29.2 & & \\
\text{Total} & & 95 & & 235,560 & & \\
\text{Error (a) as } \% \text{ of General Mean} & & 24.6\% \\
\text{Error (b)} & & & & 22.6\% \\
\end{align*}
\]

This does not alter the general position of the different varieties except that 4 and 7 are definitely far superior in yield, and that 5 becomes the second highest yielding strain. As both 4 and 5 have increased their yield, it shows a definitely bad character in that they are not even maturing; 5 being the worst of the two, and in 5 which is a spreading form of 4 we get the interaction, in that the spreading form yields higher in the wider spaced plots than the narrow spaced plots.

An analysis of variance of the plant number was worked out and this gave significant results, but little importance is attached to this as the plant numbers are low, and any small variation due to an attack of disease in a relatively fixed
population would give a significant difference.

With regard to the general results from this experiment it was shown that 4 and 7 are definitely the highest yielding varieties in the experiment. But in view of the bad seed colour of most of the types - all of the varieties showed a mixed seed colour except numbers 6, 7 and 8 - the only two that were kept on for further trial were 4 and 5, as a relatively clean sample of the same seed could be obtained from the progeny lines.

It was disappointing to find that No 7 and Indian type with uniform brown seed, should be such a good yielding variety relative to the others; as this type could not be brought on for further trial owing to other considerations mentioned in another part of this paper.

The variety No. 8 was also very disappointing, this white seeded strain from Grenada was a very bad germinator and suffered very badly from Bruchid attack at Harvest. It was claimed this was a pure line, but the seed produced on the farm showed two distinct types, a pure china white seed and another dirty creamy white seed, this seems to point to a heterogeneous line which has been overlooked, as a casual examination it is not very striking, but closer examination, this difference in seed colour becomes obvious. On leaving Trinidad the writer passed through Grenada and the Agricultural Office of the Island informed him that the variety was a good germinator, and very heavy yielder in Grenada, it is suggested fresh seed should be imported from the island, and further work carried out on this variety which should be very successful with the local traders.

Summary.

(1) An outline of the experimental plan for the year is given.
(2) The history of the field on which the experiments were conducted is given together with the cultivation and labour problems which arose.
(3) The Genetical problems concerning the writer are discussed. a new type of selfing cage is described, and an attempt to solve the problem of dwarf plants in the Prensa do strain of peas on physiological grounds is explained with the results obtained.

(4) The pests and diseases occurring during the year are described, including a newly reported attack.

(5) The results from the field trials, together with the analysis of the results from the Randomized Block Variety trial.

Acknowledgments.

The writer would like to express his gratitude to all members of the Staff for their unfailing help in any little problem which he discussed with them, and would especially mention Prof. R.C. Wood for his continued interest and helpful criticism and suggestions throughout the investigation, also Profs. H.R. Briton-Jones and E.E. Cheesman for their co-operation in lending apparatus, and their criticisms and suggestions on many of the problems that arose.

APPENDIX

Work outlined for year 1935-

Variety Yield Trial.

The layout for the next year's yield trial will be in the form of a 7 x 7 Latin square, and the whole of Field 4 will be devoted to this. The plot size is 55 feet by 27 feet this will include border rows all round, so that no edge effect will be possible as during the previous year, this may have had a profound effect on the results. These border rows will also demarcate the plots, the plant used is the Indian variety which is quite distinct from any of the experimental varieties.

The plots have been subdivided into two sub plots to accommodate two spacings, namely 3 feet x 4 feet and 3 feet x 3 feet. Excluding the border rows there will be eight rows in each sub plot in the narrow spacing eight plants in each row, in the wide spacing six plants in each row, and one plant at the centre of the plot which will form a discard line across the plot between the two sub plots. By the layout of the subplots, the plants within each plot have their full ground space well within each subplot and the discard prevents any border effects.

The plant varieties used are as follows:

1. = variety 4 from last year's trial.
2. = " 5
3. = I.S.S.E. Seed from isolation plot of S.S.E.
4. = I.S.S.C. " " S.S.C.
5. = Variety 9. from progeny lines.
6. = variety 10 from progeny lines.
7. = St. Augustine Nursey seed.

The seed from the isolation plots were used as they came from a selection selfed for two years, and the seed colour was uniform, the seed in both cases was large, and smooth, and the
type seemed to be quite fixed.

The St. Augustine Nursery seed, was obtained from Mr. Gregory on the Government station, where they have bred this strain for eight years, by selecting the highest yielding plants every year and also they have fixed the type fairly successfully. This seed is from high yielding parents, and is a favourite type in the island, having a faintly mottled white or cream coloured seed.

The analysis for the experiment gives the following table:-

<table>
<thead>
<tr>
<th></th>
<th>D.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows</td>
<td>6</td>
</tr>
<tr>
<td>Columns</td>
<td>6</td>
</tr>
<tr>
<td>Varieties</td>
<td>6</td>
</tr>
<tr>
<td>Error (a)</td>
<td>30</td>
</tr>
<tr>
<td>Whole plots</td>
<td>48</td>
</tr>
<tr>
<td>Spacing</td>
<td>1</td>
</tr>
<tr>
<td>Interaction</td>
<td>6</td>
</tr>
<tr>
<td>Error (b)</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
</tr>
</tbody>
</table>

**Progeny Lines.**

The progeny lines for the next year have been detailed in the foregoing paper, and in addition lines of the varieties used in the yield trial together with those types which Mr. Choong has selected from his genetical work.

**Isolation plots.**

These have been left to Mr. Choong who was responsible for the selection of suitable seed for the isolation plots.

The same nomenclature to be used for those types carried on, or the labelling suggested by Mr. Choong in the case of selfed seed.
Sketch of new type cage

Section of frame