EXPERIMENTS ON THE REHABILITATION OF CACAO IN TRINIDAD

A PROGRESS REPORT.

1. Findings in the Montserrat District
2. Comparison of the findings in other cacao growing areas with those in the Montserrat District.

PART II: Progress of Rehabilitation Experiments.

1. General.

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5. Growth of Supplies.

6. General Discussion and Summary

Dissertation submitted in part fulfilment for the Associateship of the Imperial College of Tropical Agriculture.

July, 1940.
INTRODUCTION

The Cacao Industry of Trinidad had enjoyed a period of prosperity from 1870 to the years immediately following the Great War. Since 1921, however, there has been a steady decline in the average price of cacao actually felt by the growers. The price of cacao on the Montserrat District was 10.50 cents per pound in 1910, but in 1926 it had declined to 8.77 cents.

PART I

Review of Investigations into the Cacao Industry of Trinidad before Rehabilitation.

1. Findings in the Montserrat District
2. Comparison of the findings in other cacao growing areas with those in the Montserrat District
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PART II

Progress of Rehabilitation Experiments.

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5. Growth of Supplies
6. General Discussion and Summary
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APPENDIX I

List of Fields Used in Analysis for Part I

APPENDIX II

Picket Yield Maps
The Cacao Industry of Trinidad had enjoyed an unrivalled period of prosperity from 1870 to the years immediately following the Great War. Since 1921, however, there has been an almost continuous and heavy decline of cacao exports from this island. This was due in part to the general world depression, and to the continuous downward trend of cacao prices in particular, but it can also be attributed to the internal organisation of the Industry. The average price of cacao actually fell from $13.90 per fanega for the period 1910-20 to $6.67 for the years 1930-36, being little over half that of the former level.

Direct competition with peasant producers in West Africa, who produced cacao at a much lower cost than was possible by the planters in Trinidad, was largely responsible for the initial decline in prices. Although this cacao was inferior in quality to that grown in the West Indies, recent advances in manufacturing processes have annulled this defect, and it is the cacao produced in the old world, which now governs the price level. It is for this reason that a rise in prices to anything approaching former levels cannot be anticipated. It is generally considered that specific areas in West Africa have now reached peak production and a decline in yield can be expected in future years, but any tendency for a rise in price level, resulting from the development of new markets, would be mitigated by the expansion of cacao growing to at present undeveloped land.

In Trinidad the prosperity of the early years had blinded cacao growers to defects in their organisation and to the steady deterioration of their estates. During the years of prosperity planters had heavily mortgaged their estates to finance further expansion.
the depression in the Cacao Industry since the war the strain of interest charges to meet these mortgages resulted in serious neglect of cultivation and diminished efficiency.

The decline in cacao exports resulted from a number of causes. The fall in price level and the increase in costs of production led to the abandonment or conversion to other crops of certain hopelessly unproductive areas. The increasing age of fields, and neglected cultivation resulted in a decline in the yields of individual fields. The appearance of Witches Broom Disease has aggravated the situation, has hastened the abandonment of production on some areas, and is a permanent menace to others. Although the decline in output of Estates can be partly attributed to the decreasing acreage under cacao, the downward trend of yields per acre gives rise to grave concern amongst those directly interested in the Industry.

In 1936 the Government started a subsidy scheme to tide the planters over the depression and to assist producers in increasing the efficiency of their estates. It has already been stated that a rise in prices to any great extent cannot be expected, and although the subsidy has temporarily eased the planter's financial stress, it has not solved the problem of declining yields. The revival of the Cacao Industry in Trinidad must depend on the continuous production of high quality cacao, on arresting the decline in yields and on increasing the yields per acre far above the present standards. It has been attempted to show that all attempts to planters for improving their Estates, either the continuance of traditional methods of cultivation, complete replanting or rehabilitation. Shephard (24) states that "...the belief expressed by many planters, that yields per acre will be restored to their old level by a resumption"
of traditional methods of cultivation, is based on erroneous premises. In point of fact these obsolete methods make no adequate provision for replacing the increasing number of unprofitable trees in a field.

Replanting consisting of the removal and replacement of every shade and cacao tree involves an immediate loss of revenue and increase in expenditure, which few planters could contemplate on any extensive scale. Rehabilitation on the other hand consists of systematic replacement of cacao trees considered incapable of earning profits, and the retention of those trees giving satisfactory yields. Under this system revenue is maintained and the increase in expenditure is not prohibitive, so that it could be undertaken on an extensive scale. At the present time Rehabilitation seems to offer the only hope of restoring some measure of prosperity to the Cacao Industry of Trinidad.

Part I of this Dissertation reviews the investigations carried out by the Economics Department of the Imperial College of Tropical Agriculture before any Rehabilitation had been attempted. It stresses the need for immediate action in stemming the decline in yields per acre, and offers a possible practical solution to this problem.

Part II is devoted to the progress of certain experiments in Rehabilitation which are being carried out in all districts under consideration. It has been attempted to show that although the loss of revenue and increased costs entailed through replanting are prohibitive, rehabilitation can be undertaken with little extra expenditure: and that the removal of a high percentage of unprofitable trees does not greatly affect the yield of the field as a whole. No concrete results can yet be expected from these rehabilitated fields as the supplies have not yet come into bearing, but
the treatment, growth and survival of supplies and any other relevant data have been discussed. 

A preliminary survey by the Economics Department of the Imperial College of Tropical Agriculture in 1929 showed that the falling output of estates in Trinidad was due to a decrease in the acreage under cacao and to a decline in the yields of cacao per acre. The general downward trend of production in individual fields gave rise to grave concern, and led to a further investigation into the conditions existing in individual cacao fields in 1931. The investigation was started in the Montserrat district, but the scope has since been enlarged to embrace other cacao producing areas in Trinidad.

The field technique adopted has been fully explained by Sheppard (23), and it is not considered necessary to give full details here. Briefly the procedure followed was the selection of fields of different ages on a wide range of soil types. Every individual tree or plot site was recorded on each field as to its yield and to the general factors influencing yield. The estimation of yield of individual trees presented some difficulties, especially as regards the estimation of pod weight; but the differences obtained were so large and consistent that any minor errors in the estimation of yield were slight in comparison. From such data as was collected it was possible to discover why and to what extent fields were profitable. It was possible to trace the trend in yields and profits by comparisons of different aged fields on the same soil type, and to compare the suitability of soils for cacao production.
REVIEW OF INVESTIGATIONS INTO THE CACAO INDUSTRY OF TRINIDAD BEFORE REHABILITATION.

A preliminary survey by the Economics Department of the Imperial College of Tropical Agriculture in 1929 showed that the falling output of estates in Trinidad was due to a decrease in the acreage under cacao and to a decline in the yields of cacao per acre. The general downward trend of production in individual fields gave rise to grave concern, and led to a further investigation into the conditions existing in individual cacao fields in 1931. The investigation was started in the Montserrat district, but the scope has since been enlarged to embrace other cacao producing areas in Trinidad.

The field technique adopted has been fully explained by Shephard (23), and it is not considered necessary to give full details here. Briefly the procedure followed was the selection of fields of different ages on a wide range of soil types. Every individual tree or picket site was recorded on each field as to its yield and to the general factors influencing yield. The estimation of yield of individual trees presented some difficulties, especially as regards the estimation of pod weight; but the differences obtained were so large and consistent that any minor errors in the estimation of yield were slight in comparison. From such data as was collected it was possible to discover why and to what extent fields were profitable. It was possible to trace the trend in yields and profits by comparisons of different aged fields on the same soil type, and to compare the suitability of soils for cacao production.
Findings In the Montserrat District.

The Montserrat District situated in the Central Range was the first area to be extensively developed for cacao production in Trinidad. The results of the initial investigation in this district between the years 1931 and 1935 have been published in a very comprehensive survey by Shephard (23), and the findings given here are a summary of this work.

Variation in Picket Yield. The great variation existing between the yields of individual trees in all age classes was one of the most striking factors brought to light by this investigation. On all the fields examined a high percentage of the yield was contributed by a comparatively low percentage of the pickets. For example on Chocolate soil 77% of the total yield was contributed by 37% of the pickets, and on Brasso Clay 78% of the total yield was made up by only 26% of the pickets. Every field was characterised to a varying degree by the accumulation of unprofitable pickets comprising blank sites, young supplies and mature poor bearing trees, yielding less than one lb. of cacao per year. Shephard (23) stated that 60 to 90 per cent. of the pickets on Brasso Clay yielded not more than one lb. of cacao, and that on the better soils 30 to 50 per cent. of the pickets were cultivated at a loss.

Recent investigations have shown that although the genetic variability in yielding capacity of cacao trees is high, damaged or diseased trees and poor sites are the main causes of low bearing.

Age of Field. The yield trend of fields of varying ages on the same soil type were found to decline with increasing age over 30 years in every case. This falling trend may have been accelerated in recent years by the neglect in
cultivation. Peak production appeared to be reached 20 to 30 years after planting. Although the general trend was shown to be irrespective of different soil conditions, it was clear that on poor types such as Brasso Clay, the yield declined very rapidly 20 years after planting. On the better type of soils peak production was not attained until 30 years after planting and the downward trend was very much more gradual - some fields over 70 years of age on Chocolate soil still showing good yields. Important as this fact is the causative factors of declining yields and the extent to which they can be ameliorated is of far greater concern to the planter. An examination of individual trees within the fields investigated revealed the underlying causes for the downward trend of field yields. Pechard (23) showed that many factors such as falling insects, beetles, thrips, witchrumin, canker, black spot, etc., contributed to the decline in yield of fields on the poorest soil types. On the other hand on Chocolate soil the older the field the higher was the average yield of the original trees. This effect was noticed on fields up to 70 years of age, when no falling off in yield of individual trees was visible. It would be expected from this that the older the field on good soil the greater would be the yield. In point of fact the reverse was found to be the case. This apparent paradox can be explained by two causes: the great variation in yield from tree to tree, and by far the most important factor of accumulating casualties amongst the older trees. Casualty Factors. A surprisingly high casualty rate was
revealed amongst the originals and supplies. This effect was most noticeable on the poorer soils. On Brasso Clay, for example, 26% of the originals required replacement during the first 20 years, while on the 40 year old fields only 20% of the originals had survived. As this high rate of mortality is combined with a decline in the yield of surviving trees after about 20 years, the unprofitable state of these fields 40 years after planting can be readily envisaged. On the other hand, the rate of decline in yields per acre on good soils is retarded by the tendency for individual trees to increase their yield with age.

On examining the causes of casualties Shephard (25) showed that many factors such as falling immortelles, beetles, thrips, witchbroom, canker, black pod, cutlas and other wounds were found to exercise a cumulatively depressing effect on yield through casualties. On good soils he attributed casualties almost entirely to physical agencies, and not to any deficiencies in the soil. For example, the very high mortality of trees on Chocolate soil (only 5% of the originals remained on the 60 year old fields), which is the most fertile of those examined, was found to be due to the enormous dimensions attained by immortelles on these soils. As a result of which more are blown down and each one causes more extensive damage amongst cacao trees than on less fertile soils. By contrast, on the Brasso Clay soil large areas of unproductive pickets caused by landslips and deficiencies in the soil were found in every field, and this factor accounted for the majority of poor bearing trees and casualties. Drought on the light Brasso Sand type, and flooding in the low lying alluvial areas were also shown to contribute to the depressing effect on yield in these cases.
Supplying. The view held by many planters that supplies cannot be established in mature cacao fields was shown to be erroneous by Shephard (23). He found that on good soils trees of any particular age class gave much the same average yield irrespective of the age of the field. Since casualties were due mainly to physical agencies, the continual supplying of these areas is essential if the yields are to be maintained.

Supplying on a poor soil such as Brasso Clay was shown to be a very different matter. Trees of the same age within different aged fields diminished rapidly in yield with increasing age of the field. Casualties and poor bearing trees were largely due to landslips and soil deficiencies, so that supplies could never be expected to come into profitable bearing on these sites. On this account the abandonment of these areas and the concentration of effort in restoring the yield in the better areas was recommended.

All through this investigation it was evident that soil type was the main factor influencing the productivity of cacao. On good soils such as Chocolate, Brasso Sand and Alluvial, there is no valid reason why cacao should not be brought into a much more productive and profitable condition than at present, even on the oldest fields. On the other hand the prospect of increasing yields on poor Brasso Clay soils cannot be viewed with any optimism.

As a result of his findings in the Montserrat District Shephard (24) put forward a plan for the rehabilitation of the Cacao Industry in Trinidad. He recommended the retention of all profitable trees in a field and the replacement of unprofitable pickets by specially selected seedlings. He suggested that estates
should be divided into blocks so that the whole estate could receive systematic treatment under careful supervision once in every five years. He also advised the concentration of effort on the better type of soils rather than trying to improve the yields of hopelessly unproductive areas, such as that on poor Brasso Clay, which is doomed to failure from the start. For the latter areas he recommended abandonment or conversion to other crops, only where experience had shown that this was liable to be successful. Exact details of the procedure now known as 'Rehabilitation' are given in Part II of this Dissertation.

Noruppa District. The Noruppa District is situated in the centre of the south coast of Trinidad. Being in its isolated position cacao production was not developed until the beginning of this century. Cacao cultivation is confined mainly to the more sheltered parts of the area, along the river beds, being surrounded by unutilized land occupied by forest. In 1880 the district suffered a severe set back from the ravages of a hurricane, which decimated the whole zone of cultivation.

Noting the gross details of the results in this district, it is found that there was an increase in yield of individual plots with increasing age on all soil types. In all fields there was a large percentage of poor yielding and non-bearing plots. From estate records of individual fields it was evident that yields per tree were declining with increasing age. In both the Moruga Marly Silt and Clay soils the yield of any tree class was considerably lower in the 40 year old class than on the 40 year old fields. On the better Montserrat soils it will be remembered that the yield of any age class increased.
Comparison of the findings in other cacao growing areas with those in the Montserrat District.

Following the investigation in the Montserrat District, the work was extended to include fields in other cacao growing areas in Trinidad. The fields selected do not offer the opportunity of comparing performance on a complete range of soil types and ages of cultivation, but the results indicated a great similarity to the findings in Montserrat.

A brief description and summary of the results in each district is followed by a more general comparison of all the areas.

**Moruga District.** The Moruga District is situated in the centre of the south coast of Trinidad. Owing to its isolated position cacao production was not developed until the beginning of this century. Cacao cultivation is confined mainly to the more sheltered parts of the area, along the river beds, being surrounded by uncultivated land occupied by forest. In 1933 the district suffered a severe set back from the ravages of a hurricane, which swept the south coast of Trinidad.

Gething (8) gives details of the results in this district. He found that there was an increase in yield of individual trees with increasing age on all soil types. In all fields there were a large percentage of poor yielding and non-bearing trees. From estate records of individual fields it was evident that yields per acre were declining with increasing age. On both the Moruga Marly Silt and Clay soils the yield of any age class was considerably lower in the 60 year old fields than on the 40 year old fields. On the better Montserrat soils it will be remembered that the yield of any age class increased...
with the age of the field, but the data available in the former case was very limited. Cacao is for the most part cultivated on the sides of steep valleys. The Rio Claro District. The Rio Claro District is situated to the South East of the Montserrat District in the central range. As at Moruga this area was not developed for cacao production much before the beginning of the century. The area is interspersed with a complex number of soils of which the predominant types are Princes Town Marl and Naparima Red Clay. The former is very suited to cacao growing although inferior to the Chocoloate soil of the Montserrat District for productivity. The Naparima Red Clay is unsuited to cacao production and is similar in many respects to the poor Brasso Clay soil. In recent years Witches Broom Disease has been very prevalent in this area, and methods of control employed seem to have been inadequate to meet the situation. Chinbuah (6) showed the great similarity between the findings in this district and in Montserrat. He found that the older the trees in any field the higher the yield per picket. He also showed that yield of individual trees in any age group increased with the age of the field up to 40 years on all soil types. The great variation in picket yields and high percentage of low or non bearers was also very marked. This was especially noticeable on the Naparima Red Clay soil, where 50% of the pickets yielded nothing whatsoever, and a further 23% of the trees yielded below an average of 1 lb. of cacao and accounted for only 13% of the total yield. He stressed the importance of the influence of soil type on productivity.

Toco District. This district is situated in the extreme
North East of Trinidad, extending along the North coast. The land is very hilly and the cacao is for the most part cultivated on the sides of steep valleys. The area is subject to the highest annual rainfall (110" per year) in the island. Because of the inaccessibility of the district, cacao production was not fully developed till the beginning of the twentieth century, although a certain amount of cacao had been grown previously. The soils here are definitely unsuited to cacao production.

Montagu (17) stated that all individual cacao estates in the Toco District had shown an equally disastrous decline in production of cacao since 1921. He attributed this not to a reduction in the acreage under cacao but to general neglect in cultivation and falling yields. He showed that there were far too high a percentage of unproductive pickets in all fields examined, and that within any one field the older the tree the higher was the average yield.

General Comparison.

For this comparison the findings in all fields of each district have been grouped together and compared with the results obtained on the best (Chocolate) and the worst (Brasso Clay) soil types in the Montserrat District. Although this comparison gives no details of differences which occur within the districts concerned, it shows the general similarity to findings in Shephard's work. The very large proportion of unprofitable pickets in these areas stresses to an even greater degree than in Montserrat the necessity for the formulation and execution of a scheme for the revival of the industry.

Unproductive Pickets. Table 1 reveals that the percentage of unproductive pickets is high in all districts.
TABLE 1. Percentage Frequency of Trees arranged in Yield Classes in Three Districts compared with that on a Good and Bad Montserrat Soil.

<table>
<thead>
<tr>
<th>Yield of Pickets in lb.</th>
<th>Percentage Frequency of Pickets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHOCOLATE SOIL</td>
</tr>
<tr>
<td>0'</td>
<td>18.0</td>
</tr>
<tr>
<td>0.1 - 1.0</td>
<td>21.6</td>
</tr>
<tr>
<td>1.1 - 2.0</td>
<td>21.7</td>
</tr>
<tr>
<td>2.1 - 3.0</td>
<td>16.5</td>
</tr>
<tr>
<td>3.1 - 4.0</td>
<td>9.5</td>
</tr>
<tr>
<td>4.1 - 5.0</td>
<td>5.7</td>
</tr>
<tr>
<td>over 5.0</td>
<td>7.0</td>
</tr>
</tbody>
</table>

TABLE 2. Analysis of Unproductive Pickets

<table>
<thead>
<tr>
<th></th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
<th>% Frequency</th>
<th>as % Non Bearer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanks</td>
<td>3.3</td>
<td>18.4</td>
<td>12.9</td>
<td>41.6</td>
<td>20.0</td>
<td>47.8</td>
<td>25.8</td>
<td>49.5</td>
<td>7.0</td>
<td>15.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 4 years</td>
<td>8.0</td>
<td>44.4</td>
<td>3.5</td>
<td>11.3</td>
<td>2.8</td>
<td>6.7</td>
<td>4.2</td>
<td>8.0</td>
<td>11.9</td>
<td>26.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>over 5 years</td>
<td>6.7</td>
<td>37.2</td>
<td>14.6</td>
<td>47.1</td>
<td>19.0</td>
<td>45.5</td>
<td>22.2</td>
<td>42.5</td>
<td>26.0</td>
<td>57.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
but to a varying degree. In Moruga nearly 30% of the pickets as compared with 18% on Chocolate soil give no yield whatsoever. At Toco as many as 50% of the pickets contributed nothing to the field yield, which is even worse than on the poorest soil in Montserrat, with 45% of unproductive pickets. The Rio Claro District is little better than either of these in this respect.

A more detailed examination of the non bearers indicates to some extent the neglected state of cultivation (Table 2). On the Montserrat soils less than 20% of the unproductive pickets were blank sites, whereas in all other districts over 40% of the non bearers were accounted for by unoccupied sites in the field. The degree to which non bearers over five years of age contribute to unproductive pickets gives an indication of the relative suitability of the districts to cacao production. It will be seen that on Chocolate soil only 6.7% of all pickets fall in this class as compared with 26% on Brasso Clay. In other areas the range of the percentage frequency of trees over 5 years of age yielding nothing falls between these limits, indicating that Moruga is more suited to cacao production than Rio Claro and that Toco is little better than the Brasso Clay soil in this respect.

Supplying. The extent to which supplying has been carried out can also be seen from Table 2. On the Montserrat soils it had been quite considerable, where even on Brasso Clay 27% of the unproductive pickets were young supplies under 5 years of age. In all other districts, however, supplying has been badly neglected and on an average, less than 9% of the unproductive pickets were young supplies. At the present rate of supplying in these areas it would take over 25 years to replant all
<table>
<thead>
<tr>
<th>Yield of Pickets in lb.</th>
<th>CHOCOLATE SOIL</th>
<th>MORUGA DISTRICT</th>
<th>RIO CLARO DISTRICT</th>
<th>TOGO DISTRICT</th>
<th>BRASSO CLAY SOIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 - 1.0</td>
<td>6.8</td>
<td>12.3</td>
<td>10.9</td>
<td>16.4</td>
<td>22.1</td>
</tr>
<tr>
<td>1.1 - 2.0</td>
<td>16.5</td>
<td>21.3</td>
<td>16.3</td>
<td>24.8</td>
<td>26.3</td>
</tr>
<tr>
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<td>21.1</td>
<td>20.1</td>
<td>15.9</td>
<td>19.5</td>
<td>21.0</td>
</tr>
<tr>
<td>over 3.0</td>
<td>55.9</td>
<td>46.3</td>
<td>56.9</td>
<td>39.3</td>
<td>29.6</td>
</tr>
</tbody>
</table>
the unoccupied sites, assuming that no further casualties occurred. A field which is never supplied is a wasting asset, and the neglected state of cultivation is very evident.

Yield Classes. The degree to which each yield class contributes to the total yield is shown in Table 3. Although it cannot be considered to be altogether a merit to have 100% of the yield contributed by high yielding trees, the extent to which the total yield is made up by high yielders gives a fair indication of the capabilities of production. On the Chocolate soil and in the Rio Claro District well over 50% of the total yield was contributed by trees yielding over 3 lb. of cacao; next in order of merit came Moruga, then Toco, and finally the Brasso Clay soil, on which only 30% of the total yield was given by high yielding trees. The Moruga and Rio Claro Districts are fully capable of bearing high yielding cacao and their low average yields compared with those of the Chocolate soil (see Table 4), are due as much to the high percentage of unproductive pickets as to any other factor.

From a combination of Tables 1 and 3 it can be seen that on all areas except the Chocolate soil a comparatively small number of trees account for a very high percentage of the total yield. In Moruga 88% of the yield is contributed by only 35% of the pickets. In Rio Claro 31% of the pickets account for 89% of the total yield. In Toco 84% of the total yield is given by only 23% of the number of pickets, and on the Brasso Clay soil 77% of the yield is made up by 26% of the pickets. By contrast over 60% of the pickets on Chocolate soil contribute to 93% of the yield, showing that
TABLE 4. Profitability of cacao grown in three districts compared with that on a good and bad Montserrat soil.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>District</th>
<th>Average Yield per Picket per Year</th>
<th>Percentage of Unprofitable Pickets</th>
<th>Profitability per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate Soil</td>
<td>Moruga District</td>
<td>1.9</td>
<td>39.6</td>
<td>+16.05</td>
</tr>
<tr>
<td></td>
<td>Toco District</td>
<td>1.2</td>
<td>64.2</td>
<td>+80.40</td>
</tr>
<tr>
<td></td>
<td>Brasso Clay Soil</td>
<td>0.7</td>
<td>30.8</td>
<td>-86.35</td>
</tr>
</tbody>
</table>

*Note: The table represents the profitability of cacao grown in different districts, with the chocolate soil in Moruga District yielding the highest average, while the brasso clay soil in the same district shows the lowest profitability.*
there is much less wastage of productivity on these areas.

**Profitability.** The profitability of cacao production in the districts under consideration is shown in Table 4. All pickets yielding over an average of 1 lb. of cacao were considered profitable at the prevailing price level. Profitability was assessed with the average price of cacao for the period 1930-35 of 65¢ per lb., and an average production cost of $21.00 per acre (Shephard [24]).

On Chocolate soil the profitable pickets easily outnumbered the unprofitable, but in all other areas the reverse is the case. The average yield on Chocolate soil was nearly twice as large as that at Moruga and Rio Claro, and three times that at Toco and on Brasso Clay. Furthermore the Chocolate soil showed a handsome profit of $16.05 per acre, even with the abnormally low price. Moruga and Rio Claro Districts just managed to pay their way, while Toco and the Brasso Clay areas sustained a heavy loss.

**Age Composition of the Tree Population.** Owing to the lack of a sufficient number of fields of varying ages within any one district, the percentage frequencies and percentage of total yields by various age classes have been grouped together for all three districts outside the Montserrat area. No fields under 45 years of age could be found on Chocolate soil. The results are shown in Table 5. Gething (8), Montagu (17), and Chinbuah (6) have shown that in common with Shephard's (23) findings, within any one field the older the tree the higher was the average yield in all districts. On the 20 to 30 year old fields about two thirds of the original trees have survived in all cases. On the 30 to 40 year old
<table>
<thead>
<tr>
<th>AGE CLASSES</th>
<th>Fields 20-30 Years of Age</th>
<th>Fields 30-40 Years of Age</th>
<th>CHOCOLATE SOIL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Districts</td>
<td>BRASSO CLAY SOIL</td>
<td>All Districts</td>
</tr>
<tr>
<td></td>
<td>% Frequency</td>
<td>% Yield</td>
<td>% Frequency</td>
</tr>
<tr>
<td>Blanks</td>
<td>12.3</td>
<td>-</td>
<td>4.4</td>
</tr>
<tr>
<td>1 - 4</td>
<td>2.7</td>
<td>-</td>
<td>10.6</td>
</tr>
<tr>
<td>5 - 9</td>
<td>3.1</td>
<td>0.2</td>
<td>10.6</td>
</tr>
<tr>
<td>10 - 19</td>
<td>17.1</td>
<td>7.9</td>
<td>13.9</td>
</tr>
<tr>
<td>20 - 29</td>
<td>6.1</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td>over 29 not 0s</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Originals (0s)</td>
<td>58.7</td>
<td>88.1</td>
<td>60.5</td>
</tr>
</tbody>
</table>

* not originals.

* Originals 45 years of age.
fields on Brasso Clay a further 25% of the originals have been lost contrasted with only 11% in the combined districts. The casualties on Brasso Clay have, however, been resupplied, whereas in the other areas the number of blank pickets have accumulated with increasing age of the fields.

The value of supplying can be seen on the Chocolate soil for, although the originals have suffered a very high casualty rate, the supplies which replaced them now contribute over 40% of the total yield.

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Summary.

Shephard (23) has shown that in the Montserrat District the continual downward trend of field yields per acre is due to accumulating casualties amongst the older trees. On good soils these casualties were caused mainly through physical factors and there is no reason why they should not be replaced by supplies, as the average yield per tree of any particular age class was constant on fields of varying ages on the same soil. On poor soils, such as Brasso Clay casualties were due as much to deficiencies in the soil as to any other factor, and the decline in yield was accelerated by the decrease in the average yield of originals with increasing age.

The findings in the three cacao growing districts of Moruga, Rio Claro and Toco show great similarity to the results obtained in the Montserrat area. The districts as a whole do not approach the state of cultivation or productivity on Chocolate soil, but are generally better than that on Brasso Clay. There is little to choose between the suitability of the Moruga and Rio Claro Districts to cacao production for, although the average yields and profitability are slightly higher at Moruga, there were 10% more unprofitable pickets at Rio Claro, indicating neglect rather than soil deficiency. The position at Toco shows that a combination of poor soils and neglect in cultivation has resulted in very low productivity.

The large percentage of poor bearing trees and unproductive pickets was the most striking feature of these investigations. The fact that 75% of the pickets both at Toco and on Brasso Clay yielded less than 1 lb. of cacao each, readily accounts for their unprofitable state. It is surprising that the Moruga and Rio
Claro areas should show a profit when as many 60 and 70 per cent. of the pickets respectively were cultivated at a loss (Table 4). It indicates that these districts could be brought into a very much higher state of productivity than at present.

The accumulation of blank sites and unprofitable trees with increasing age of the fields, and the lack of supplying tree casualties is evident in all districts, especially outside the Montserrat area, and is mainly responsible for the continued decline of yields per acre at Moruga and Rio Claro. The replacement of unprofitable pickets by selected seedlings, and at the same time improving the conditions of growth, seems to offer the most practical means of regenerating the cacao fields on good soils.

Replanting versus Rehabilitation. Replanting offers greater scope for generally improving field conditions than is possible in Rehabilitation. The felling of all immortelles prior to replanting removes one of the main causes of tree casualties on fertile soils. The planting of Dadap species of immortelle is to be recommended, as these can be climbed and pruned when they reach unwieldy dimensions. Replanted cacao bears at a much earlier age than supplies due to the lack of competition with well
PART II. PROGRESS OF REHABILITATION EXPERIMENTS.

(1) General.

The Trinidad Cacao Industry once the greatest asset of the Colony is fast becoming its primary liability. It has been shown in Part I that the accumulation of unproductive and unprofitable pickets with increasing age of the fields is largely responsible for the continued downward trend of field yields. On most fields the unprofitable pickets are so numerous as to reduce the average field yield to an unprofitable or barely profitable level.

There are at the moment two methods open to planters to restore the yield of their fields to the old levels of productivity. The first, replanting, entails the complete removal and replacement of all cacao and shade trees on the selected area. The second, rehabilitation, consists of the systematic replacement of trees considered incapable of earning profits and the retention of trees, which give satisfactory yields. It is thought advisable to consider the merits and disadvantages of both systems of improvement before going into details of the method of Rehabilitation.

Replanting versus Rehabilitation. Replanting offers greater scope for generally improving field conditions than is possible in Rehabilitation. The felling of all immortelles prior to replanting removes one of the main causes of tree casualties on fertile soils. The planting of Dadap species of immortelle is to be recommended, as these can be climbed and pruned when they reach unwieldy dimensions. Replanted cacao bears at a much earlier age than supplies due to the lack of competition with well
established trees. The use of improved planting material, cuttings and budded plants, will also hasten early bearing, will result in a greater uniformity of quality, and it is hoped will result in greater yields than can at present be expected. The main disadvantage of replanting is undoubtedly one of cost and the loss of income entailed by this operation. Certain damage may also be caused to neighbouring fields by exposure to wind, sun, diseases and pests.

In the case of rehabilitation the merits and disadvantages are the converse to those of replanting. The low cost and maintenance of revenue are the greatest assets. The removal of low bearing trees should not greatly affect the yield of the field, although some temporary damage through exposure may be sustained by the remaining trees. The slow rate of growth of supplies planted in a mature field is one of the main disadvantages, but it is hoped that this difficulty may be partly overcome by improving the conditions for growth. The rate of increasing the field yield by this method will be slow and no great uniformity in quality will result.

The balance of facts favours replanting over rehabilitation but the prime consideration is one of cost. Replanting results in the immediate loss of revenue and large increase in expenditure, whereas in rehabilitation the revenue is maintained and the increase in expenditure need not be great. Some of the costs of both these operations may be offset by the sale of bananas and ground crops grown for shade, but this aspect of the subject is fully discussed in section 4. Replanting on any extensive scale is totally beyond the powers of the majority of impecunious planters to-day, as it is now impossible for them to borrow capital as they were wont in the era of prosperity. Rehabilitation on the other hand, can, and should be, under-
taken by all planters on soils which are suited to cacao production. It offers the only hope of improving yields on a large scale at a comparatively small cost, which is essential if the Cacao Industry is to survive in Trinidad.

Rehabilitation.

Part II of this Dissertation sets out to give a progress report of the first attempts at rehabilitation undertaken in Trinidad. No final conclusions can yet be formed as to the efficacy of this treatment, as few of the supplies in the experimental areas have yet reached bearing age. As a result of this investigation, however, certain facts as to the practical value and difficulties of rehabilitation have been brought to light, and these will be discussed in due course. It may be advisable to clarify observations on the progress of rehabilitation by discussing first principles in a general way.

Removal of unprofitable trees. The recognition of poor bearers presents one of the most difficult, though not insurmountable, aspects of rehabilitation. General appearance of the trees is often misleading and identification can only be made by an assessment of the individual yield of each tree. A single inspection is often unreliable as some trees are early and others are late bearers, and some trees yield well only in alternate years. Pound (19) has shown that the number of pods borne by a tree is not a good indication of its yield of dry cacao, and this factor should be considered when marking trees for removal.

Shephard (24) gives a practical method by which some of these difficulties may be overcome. He recommends that in the year preceding rehabilitation trees yielding little or no cacao should be marked with a daub
of paint at each successive picking. The low yielders should then be easily recognisable at the time when cutting out is to be done. In old fields supplies may take 15 to 20 years to reach maturity, so that trees under this age should not be removed unless damaged or otherwise rendered unthrifty. Damaged or diseased trees should be removed even when they have given good yields in the previous year, if they show no prospect of recovery.

The standards to be employed in determining low yield are debatable. It should be the ultimate aim of the planter to remove all unprofitable trees. At the present price level a tree yielding less than 1 lb. of cacao is unprofitable, and should be cut out, but this standard will of course vary with seasonal fluctuations in yield. It is probable that after the first attempt at rehabilitation many low yielders will be left in the field. Rehabilitation, however, should be a continuous process once started, and the planter should not rest until all unprofitable pickets have been replaced by potentially high yielding supplies.

Pruning. Heavy pruning has not been a common practice in Trinidad in past years. Van Hall (27) has shown that in Surinam heavy pruning resulted in the control of Witches Broom disease, and a large increase in yield after the initial set back. The failure of planters to adopt this practice was one of the main causes resulting in the complete failure of the Cacao Industry in Surinam through the spread of Witches Broom disease. This is of particular significance to planters in Trinidad to-day. Severe pruning should be undertaken in the rehabilitation programme, not only to remove diseased wood, but also to allow the free circulation of air and light, which is essential to the growth of young supplies. Many of the older trees in a cacao field grow proportionately
large and unwieldy, occupying more space than is their right. Pound (18) has shown that these high branches, besides overshading supplies, produce poor pods, and pruning should be undertaken to induce cropping near the ground.

The regulation of shade in a rehabilitated cacao field is a difficult problem. It is essential that supplies should not be overshaded, and yet over enthusiastic pruning may increase the incidence of thrips and so depreciate the canopy as to be definitely harmful. It should only be carried out under the most careful supervision. Briton-Jones and Cheesman (2) have emphasised the importance of close supervision in this operation, and the treatment of each tree as an individual rather than the field as a whole.

Supplying. Supplying has been neglected by planters in Trinidad in recent years, and where carried out has been done so without sufficient supervision. The use of suckers is not to be recommended unless the parent was an exceptionally high yielding tree. Only seedlings or cuttings from the highest yielding trees should be used, and greater attention should be given to the provision and maintenance of nurseries. The preparation of sites for supplies should receive the utmost care. It is of paramount importance in any rehabilitation programme that conditions within the field should be the optimum possible for the growth of supplies. The regulation of overhead shade has already been discussed, temporary or ground shade should be provided in the form of tannias or cassava immediately round the supply, and bananas between the supplies. These will provide a subsidiary income and will be trimmed back or removed when the supplies become established. Such matters as draining, round ridging and manuring are important, but will depend on soil conditions.
The care and maintenance of supplies after planting is of as great significance as the initial preparation. Arrondeering (hand weeding round supplies) should be practiced as cutlass wounds are one of the main causes of casualties to young cacao plants.

Method of Rehabilitation. Operations for the rehabilitation of a cacao field have been fully described by Shephard (24). The time table which he recommends for the Montserrat area is as follows:

1. Marking unsatisfactory trees (January)
2. Establishment of nurseries (January)
3. Application of fertilisers (February)
4. Weeding (February)
5. Draining and application of lime to soil removed from drains (February)
6. Removal of unsatisfactory trees (March)
7. Preparation of sites to receive supplies (March)
8. Heavy pruning (March - April)
9. Roundridging (March - April)
10. Planting temporary ground shade (April - May)
11. Planting cacao supplies, permanent shade and wind breaks (July - August)

This time table will of course have to be modified to suit different climatic and soil conditions. For example the manuring, draining and roundridging required will depend entirely on the type of soil and topography of the field.

Shephard also recommends that only part of an estate should be treated at a time to ensure close supervision. He suggested that estates should be divided into five blocks and that each block should be treated systematically at five yearly intervals.
TABLE 6. Chemical Analysis of soil types on Rehabilitated Fields.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Fields</th>
<th>Average Yield</th>
<th>Texture, Reaction, Organic Status</th>
<th>Nutrient Status</th>
<th>Chief Nutrient Deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dry Cacao lbs. per acre</td>
<td>I.T.</td>
<td>pH</td>
<td>Organic Matter %</td>
</tr>
<tr>
<td>Chocolate soil</td>
<td>17D, 24B</td>
<td>540</td>
<td>43</td>
<td>7.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Brasso Sand (Good)</td>
<td>21C</td>
<td>420</td>
<td>22</td>
<td>6.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Brasso Sand (Bad)</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>5.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Alluvial Soil</td>
<td>21A, 21D</td>
<td>480</td>
<td>20</td>
<td>6.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Brasso Clay (Good)</td>
<td>-</td>
<td>-</td>
<td>37</td>
<td>6.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Brasso Clay (Bad)</td>
<td>257B</td>
<td>150</td>
<td>40</td>
<td>6.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Princes Town Marl</td>
<td>51B2</td>
<td>300</td>
<td>62</td>
<td>6.6</td>
<td>6.1</td>
</tr>
<tr>
<td>Moruga Marl Silt</td>
<td>28C</td>
<td>300</td>
<td>16</td>
<td>5.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Quartz Schist</td>
<td>33A</td>
<td>240</td>
<td>25</td>
<td>5.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Provisional Standards: Lower limits of adequacy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandy Soils</td>
<td>(10)</td>
<td></td>
<td>5.2</td>
<td>3.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Clay Soils</td>
<td>(36)</td>
<td></td>
<td>6.0</td>
<td>4.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>
Soil type has been shown to be an important factor in the productivity of cacao. Many of the cacao soils in Trinidad show marked mineral deficiencies, and any programme for improving yields should be accompanied by a suitable manurial policy. Hardy et alia (9), (10), (11), (12), (13) have examined the cacao soils of Trinidad in detail, and the information contained here has been drawn from their published works.

Table 6 shows the texture, reaction and organic and nutrient status, and deficiencies for the soil types on which rehabilitation experiments have so far been undertaken. The code number of rehabilitated fields on the varying soil types and the average yields of dry cacao in lb. per acre have also been added, but it should be understood that the analysis figures refer to the soil type and not to the individual fields in question. The relative suitability of these soils to cacao production and general manurial policies which may be adopted are discussed below. It is evident, however, that every field will require manuring according to its own merits, and no hard and fast rules can be laid down for this operation.

Chocolate Soil. Chocolate has been shown to exhibit almost ideal characters for cacao production. It is a friable clay loam of unusual depth, free draining but it does not dry out under droughty conditions. The organic matter content is very high (6.0) in the surface six inches and shows considerable penetration down to 3½ feet. The C/N ratio is sufficient and the plant nutrient supply is exceedingly abundant. The surface soil is usually devoid of CaCO₃ but is usually distinctly alkaline, becoming acidic below the 6" level. The lower zone of the soil in nitrogen, phosphate and potassium.
contains high concentrations of CaCO$_3$ phosphate and potash, is soft, sandy and porous, and is frequently penetrated by cacao roots. The bulk of the feeding roots of cacao are, however, confined to the surface 12 inches of soil. The exceptional fertility of this soil indicates that declines in yield are due to defects in the tree population and not to any deficiencies in the soil.

Brasso Sand. This soil type shows appreciable variation in fertility status and the manurial policy must be governed by local requirements, which should be determined through experimentation or soil analysis. It is a light, friable, free draining, sandy soil, and is very liable to dry out during the dry season. The reaction is generally acidic and application of limestone is to be recommended. The C/N ratio and organic matter penetration are usually low and may be improved through organic manuring. The plant nutrient supply is almost entirely confined to the surface few inches of soil. Nitrogen, phosphate and potash are adequate on the good types of this soil, but may be very deficient on the worse types. Where yields are low an application of 2 lb. of sulphate of potash, and 1 lb. of superphosphate per tree should be tried. This may increase the tree canopy and through leaf fall enhance the organic matter in the soil.

Alluvial. The alluvial soils of the Central Range, where fields 21A and 21D are situated, are derived by hill wash from the neighbouring clay, silt and sand soils, and may go down to a depth of 6 or 8 feet. They are usually of a silty-clay nature and are of variable fertility, although they can be very productive. Their reaction is generally slightly acidic and they may show deficiencies in nitrogen, phosphate and potassium. Owing to the low
lying situations in which these soils are formed, flooding and scouring may occur, and the importance of draining and roundridging in such areas is of paramount importance. Manurial policy should be based on analyses of soils in particular fields or by experimentation.

Brasso Clay. Brasso Clay is actually less clayey than the fertile Chocolate soil but differs from it in two respects. The structure of the former is more compact, being less porous and spongy, and overlies a heavy impervious blue clay, as compared with the porous calcareous sandstone subsoil of the Chocolate type. It suffers from severe cracking in dry weather and waterlogging under wet conditions. The organic matter percentage may be relatively high in the surface soil, but the C/N ratio is usually low, especially on the poorer types. The reaction is generally acidic, and the CaCO₃ content is low on the bad types.

Plant nutrients are sufficient in the surface 9" of soil, but below this level there is a rapid drop in the supply. The occurrence of gypsum in layers at varying depths below the surface is a very harmful factor in the productivity of these soils. These layers are often exposed by landslips, which tend to increase with the age of the field, and this feature is mainly responsible for the rapidly declining yields of many fields on this soil type. Manurial experiments on Brasso Clay showed no response on the better fields even with dressings as high as 5 tons ground Limestone per acre, 2 lb. of ground rock phosphate and 2 lb. of potassium chlorate per tree. A similar dressing on a bad type produced no increment in yield in the first year, but showed a 30% increase in the 2nd year after application. In general, however, manuring, with the exception of liming is not recommended on this soil type.
Princes Town Marl is a heavy black clay soil overlying a highly calcareous marl parent material. It shows slight acidity at the surface but becomes distinctly alkaline at the 2' level. The organic matter content is exceptionally high and exhibits great penetration, being over 0.5% 21 inches below the surface. The C/N ratio is high indicating a cacao soil of high productivity. The available nutrient supply is very abundant in the top soil, with the exception of phosphate, which is always characteristically absent. The soil is fertile, differing from the Chocolate by its low phosphate content and by the presence of highly calcareous layers at varying depths up to within 2' of the surface. The effect of these calcareous layers on productivity is not yet fully understood. In low sites this soil may be subject to severe waterlogging.

As would be anticipated manural experiments have shown a very large response to phosphatic manuring. At one centre the application of 3 lb. of superphosphate per tree increased the yield by 77% in the first year. This dressing is probably on the generous side and an application of 2 lb. per tree of a suitable phosphatic manure in the first year, and 1 to 1½ lb. in each subsequent year would probably suffice.

Moruga Marly Silt. The structure of the surface soil is very friable, loose and sandy. The texture of the subsoil is also friable but is more compact, giving rise to a loamy sand. The reaction is usually slightly acidic on the surface, becoming more so in the subsoil until layers of free CaCO₃ are reached at varying depths below 2½ feet, when there is a sudden change to alkalinity. The organic matter content is high in the surface soil with a high C/N ratio and with considerable penetration. The nutrient status is definitely low, available phosphate, potash and
The good texture, the high C/N ratio and its good lime status, even though the reaction is acidic, indicate that this soil should support good cacao crops if suitably manured. Large increases in yield were actually obtained in manural experiments on this soil type. A basal dressing of 2 lb. per tree of potassium sulphate increased the yield by 400%, while superphosphate, 4 lbs. per tree, in addition, further raised the yield by an additional 50%.

This phenomenal response to potash and phosphate manuring emphasises the requirement of Moruga Marly Silt for these fertilisers - and a suitable manural policy must accompany any programme of rehabilitation.

Quartz Schist. This soil arising from coarse compact beds of quartzite grits is usually sandy and shallow. Its reaction is highly acidic. The organic matter and nitrogen content are low, and the C/N ratio is inadequate. It is insufficiently supplied with mineral nutrients and available phosphate and potash are generally deficient. The soil is naturally free draining, but may show a tendency for erosion on hill slopes.

The deeper soils might benefit from phosphate and potash manuring, but on the whole Quartz Schist soils are unsuited to cacao production because by analysis, its reaction, C/N ratio and available phosphate and potash contents are below the limits of adequacy for cacao soils. Many cacao trees on this soil show a marked tendency for marginal leaf scorch, which may be partly due to the low potash content.

(v) Bearing of Supplies. Only a few of the supplies in the experimental areas have yet come into bearing.

(vi) Growth of Supplies. Owing to the lack of information regarding bearing, the growth of supplies, planted at the time...
Field Reports on Rehabilitation Experiments.

The general principles of rehabilitation have already been discussed. No final conclusions can yet be formed as to the practical efficacy of this regeneration scheme but certain facts as to the value and difficulties of rehabilitation have already been brought to light. The problems encountered are discussed in reports on experimental fields from the following aspects.

(1) The conditions existing in experimental areas before and after rehabilitation.

(ii) The removal of unprofitable trees and parts of trees, and the effect of this operation on total yields in subsequent years. Difficulties were encountered in the latter observations to distinguish between the trends in yield due to seasonal fluctuations and to rehabilitation treatments. For this purpose the yields of fields have been compared with those of the whole estate, the latter being derived on an acreage basis to avoid any irregularities resulting from a change in the acreage under cacao on the estate in question. Estate yields were only available up to the end of the 1936-37 season, but the initial variations in yield could be compared. Where estate yields were not available the yields of rehabilitated fields have been compared with those of fields in the same district, which have not been subjected to any special treatments. This comparison was not possible with fields in the Montserrat District rehabilitated in 1934 and 1935, owing to the lack of a sufficient number of untreated fields.

(iii) Heavy pruning and its effect on yield of pruned trees in subsequent years.

(iv) Supplying. The methods and extent of supplying, subsequent treatment and mortality of supplies are discussed. In most cases the causes of casualties amongst supplies have not been recorded on the field sheets, but wherever possible these have been noted.

(v) Bearing of Supplies. Only a few of the supplies in the experimental areas have yet come into bearing.

(vi) Growth of Supplies. Owing to the lack of information regarding bearing, the growth of supplies, planted at the time
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21A</td>
<td></td>
<td>Alluvial</td>
<td>21A</td>
<td>7.5</td>
<td>7.0</td>
<td></td>
<td>18.9</td>
</tr>
<tr>
<td>21C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21D</td>
<td></td>
<td>Brasso Sand</td>
<td>1937</td>
<td>6.0</td>
<td>0.9</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>257B</td>
<td></td>
<td>Brasso Clay</td>
<td>1935</td>
<td>5.3</td>
<td>2.1</td>
<td></td>
<td>4.8</td>
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<td>17D</td>
<td></td>
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<td>1936</td>
<td>22.7</td>
<td>5.0</td>
<td></td>
<td>30.0</td>
</tr>
<tr>
<td>24B</td>
<td></td>
<td>Chocolate</td>
<td>1937</td>
<td>14.2</td>
<td>7.0</td>
<td></td>
<td>7.0</td>
</tr>
<tr>
<td>51A</td>
<td></td>
<td>Princes Town Marls</td>
<td>1937</td>
<td>12.7</td>
<td>1.3</td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>33A</td>
<td></td>
<td>Quarts Schists</td>
<td>1938</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28C</td>
<td></td>
<td>Morlich Silt</td>
<td>1939</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of rehabilitation on the fields in question, have been compared by taking their girth measurement. Both the maximum and minimum girth at a height of one foot above ground level was measured, and an average of the two was taken for the final estimate. This investigation has been fully described in Section 5, but will also be mentioned in the field reports.

(vii) Any other relevant data.

(viii) Costs. Detailed costs have only been kept on one rehabilitated field. Comparison between the costs of replanting and rehabilitation are discussed in Section 4.

Fields concerned in this investigation. The fields which have been subjected to a programme of rehabilitation are set out in Table 7. This table also shows the soil type of the field, the year when rehabilitated, and the percentages of total number of trees, and parts of trees, and of total yields removed in the cutting out operations. The first six of these fields are situated in the Montserrat District, field 51B2 at Rio Claro, field 33A at Toco, and field 28C in the Moruga District. On field 33A no low yielding trees were removed, but the field was in such a neglected condition that 18 per cent. of the pickets had to be supplied; the history of the supplies in this attempt at regeneration in the Toco District are included in the reports. The yields of the parts cut on heavily pruned trees on field 21A could not be obtained from the information available. It can be seen that, on most of the fields, although the number of trees removed was quite considerable, the proportion of the total yield contributed by these trees was small in comparison. The extent and effect of this cutting out treatment is discussed in detail in the reports of individual fields.
(a) Montserrat District.

The first series of experiments in rehabilitation have been conducted in the Montserrat District. These experiments have been carried out more extensively and, so far, more successfully than in other cacao growing districts in Trinidad.

FIELD 21A.

Field 21A is an old field planted 84 years ago on a good alluvial soil. It lies in the bend of a river and about two thirds of the length of the bank is low lying and subjected to annual flooding and scouring. Field Map XIII (Appendix II) clearly illustrates the deleterious effect which these depressed areas have on the yield of trees growing near the river. Prior to 1934 the practice of replacing all dead trees and supplying all unoccupied sites every year had been followed. Owing to the great age of the field there are comparatively few original trees left standing, and the picket composition is made up of supplies of all ages. It was due to the early age of bearing and vigour of these supplies, which encouraged the planter and the Department to conduct their first experiment in rehabilitation. The field was first counted in 1931-32, and it was found that 19.2 per cent. of the pickets produced no cacao at all, and that a further 29.7 per cent. were unprofitable (yielding less than 1 lb. of cacao each).

Removal of trees. The selection of poor trees for removal was based on their appearance in May 1934 only, and resulted in the cutting out of trees from 7.5 per cent. of the pickets. The records collected two years previously showed that these trees had actually yielded 7 per cent. of that seasons total yield, or an average of 1.4 lb. per picket, which shows the
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TABLE 8. Trend in Yields and Survival of Supplies of an 84-year-old Field on Alluvial soil - Rehabilitated in 1934.
great difficulty of recognising poor yielding trees from their appearance alone. The inaccuracy of appearance as indicating the yield of a tree was further illustrated when field counts were made in the following year, revealing that many poor bearers were still present in the field. It is probable, however, that many of the trees removed, which had yielded well in 1931-32, were either diseased with canker or had suffered casualty in the intervening period. Some trees which yielded numerous poor quality pods were also cut out. The previous records of yields were utilised in 1937 to remove unprofitable trees from an additional 6 per cent. of the pickets, which contributed less than 1 per cent. of the total yield.

Despite the cutting out treatments in 1934 and 1937, actually an average of 47.5 per cent. of the pickets were unprofitable in the seasons 1937-38 and 1938-39, compared with 35.3 per cent. in 1931-32. These figures do not include supplies under 5 years of age. The total yields in 1931-32 were, however, nearly 25 per cent. higher than in the former period, which may account to a large extent for the apparent increase in unprofitable pickets after rehabilitation.

In order to prevent overshading of the supplies 18.9 per cent. of the trees were either pruned or had composite parts removed in 1934. The trends in yield of the whole field and of the pruned trees are shown in Table 8. It appears that a considerable drop in yield was experienced in the year following rehabilitation, for although the yield of the estate rose from 100.0 per cent. in 1931-32 to 107.6 per cent. in 1934-35, the total yield of the field dropped to 76.9 per cent. over the same period. The trees removed in 1934 could not be directly responsible for this drop in yield, as they only contributed 7.0 per cent. of the total yield in
but it is possible that the cutting out and severe pruning treatments had a deleterious effect on the remaining trees. It can be seen, however, that complete recovery had taken place by 1936-37, for whereas the field yield was only 71.2 per cent. of the 1931-32 total, the estate yield had fallen to 68.6 per cent. of the original total, which can be explained by seasonal variation. The very low yields in 1938-39 were due to the adverse weather conditions in that year.

To return to the rehabilitation of this field before the supplies planted in this field before the rehabilitation programme was started, and revealed some illuminating facts. He found that 66 per cent. of the supplies planted between 1924-25 and 1931-32 in the low lying areas near the river had failed to survive, and that of the remainder only 4 out of 19 had borne any cacao at the end of 15 years. Also that on 36 of these sites no less than 52 re-plants had died over the same period. He stated that the depressed areas had a high index of fertility, but had never given good yields. The rest of his report dealt with the supplies on the remainder of the fields, and revealed that 113 trees planted between 1924-25 and 1931-32 had yielded a total of 613 lb. of cacao during the period 1934-35 to 1931-32, but it is possible that the cutting out and severe pruning treatments had a deleterious effect on the remaining trees. Shephard (25) reviewed the history of young supplies, planted in this field before the rehabilitation programme was started, and revealed some illuminating facts. He found that 66 per cent. of the supplies planted between 1924-25 and 1931-32 in the low lying areas near the river had failed to survive, and that of the remainder only 4 out of 19 had borne any cacao at the end of 15 years. Also that on 36 of these sites no less than 52 re-plants had died over the same period. He stated that the depressed areas had a high index of fertility, but had never given good yields. The rest of his report dealt with the supplies on the remainder of the fields, and revealed that 113 trees planted between 1924-25 and 1931-32 had yielded a total of 613 lb. of cacao during the period 1934-35 to 1931-32.
1938-39. They commenced yielding at 5 years of age at an average rate of 0.4 lbs. of cacao, gradually increasing in yield each succeeding year, until they were bearing over 1.5 lbs. of cacao per picket at 11 years of age. The early age of bearing of these supplies is encouraging, and indicates that supplies can be brought into bearing in an established field at a much earlier age than is generally believed possible.

To return to the rehabilitation of this field; before the supplies were planted in 1934 great care was taken to improve the conditions for growth. The drainage system was overhauled, the beds were roundridged or cambered, and bananas, tannias and cassava were planted around the supply sites to provide additional ground shade. In the majority of the rehabilitation experiments no records have been kept of the actual number of seedlings planted. The first record of these supplies appears on the count sheets in October of the season following rehabilitation (usually done in the previous May), so that these figures have to be taken.

In 1934 supplies were planted on 63 sites, this or 8.2 per cent. of the total 768 comprising the field, and in 1937 a further 80 seedlings were planted or 10.4 per cent. of the total number of pickets. As can be seen in Table 8, the mortality of these supplies has been great, despite the precautions that have been taken; up to the end of 1939-40 no fewer than 23.9 per cent. of the 1934 supplies had died, but the majority of these losses occurred in the first three years following planting. In 23.7 per cent. of the 1937 supplies have also failed to survive up to the present time. These very heavy losses can largely be accounted for by the extremely high death rate of supplies planted in the low lying areas near the river. 49 out of the 143 seedlings supplied in 1934 and 1937 were planted in these depressed
areas and as many as 23 failed to survive. 8 of the 1934 mortalities on poor sites were resupplied in 1937 and 5 of these have again succumbed to the unfavourable conditions. On the remainder of the field only 11 out of the total of 94 supplied have met with some casualty. Expressed in a different way it shows that the loss on the good areas was only 11.7 per cent., compared with a 46.9 per cent. mortality on the poor areas. These figures agree with Shephard's (25) claim that supplying on poor areas was a waste of money and effort, as it only degenerated into the supplying of supplies.

The slow rate of growth of supplies on sites near the river was evident from a comparison of their average girth measurement with those on the better part of the field. The average girth of the 6 year old supplies in the depressed areas was only 4.6 cms. compared with 5.8 cms. on the remainder of the field (see Table 21). Similar figures were obtained for the 3 year old supplies, on bad sites the average girth being 1.7 cms., and on the good sites 2.2 cms.

The yields of the 6 year old replants on this field are rather disappointing considering the care that was taken over their establishment. 1939-40 was an exceptionally high yielding year for cacao in the Montserrat District, and yet the 48 supplies planted in 1933-34 only gave a total of 5.9 lb. of cacao in this season. As would be expected the replants in the depressed areas contributed nothing to this yield, on the remainder of the field the average yield per supply was only 0.14 lb. of cacao. Shephard (25) has shown that over the 1934-35 to 1938-39 period, 6 year old supplies had averaged 0.6 lb. of cacao each per year, and it is difficult to explain this divergence.

The most interesting factor arising out of this experiment is the slow rate of growth and high mortality
of supplies planted on unsuitable sites near the river, and
little hope can be entertained for the rehabilitation of
Field 219 was planted 54 years ago and is
these areas. On the remainder of the field the replants
situated on recent river alluvium. It is comparatively
are generally well grown and vigorous, and promise well to
flat and low lying, rising to slightly higher ground to the
contribute an increasing amount to the total yield in future
north and west, and is surrounded on three sides by a river.
years.
Certain areas of the field are of such a character that it
is difficult to avoid waterlogged conditions in a wet season.
This is noticeable on low lying sites near the river, where
the yields of established cacao are very low (see Field Map
XII, Appendix II). Wilson (28) gives the average yield
per picket as 2.6 lb. of cacao over the five years pro-
ceeding 1931-32, which is very high for Trinidad. In that
year one third of the field was accurately recorded and the
average yield was 1.6 lb. per picket. This apparent drop
in yield was attributed to the very wet conditions prevail-
ing during that year. The field was next recorded in 1934-
35 and, under very favourable climatic conditions, a yield
of 2.7 lb. per picket was reaped. Even on such a high
yielding field as this there was a large proportion of the
pickets contributing little to the total yield. 17.6 per
cent. of the pickets were totally unproductive and another
34.6 per cent. were unprofitable before rehabilitation was
commenced at the end of the 1934-35 season.

Removal of trees. The selection of poor bearers was
based on the yield records collected during 1931-32 and
1934-35. The planter decided to cut out all trees 30 or
more years of age, which yielded less than 1.6 lb. of cacao
in 1934-35, and less than 1.0 lb. in 1931-32. This stan-
dard is an exceptionally high one, and much above that rec-
commended by Shephard (24). Other trees, which were either
badly damaged, diseased or produced very small beans, were
also removed. Trees less than 20 years old were cut out.
FIELD 21D.

Field 21D was planted 54 years ago and is situated on recent river alluvium. It is comparatively flat and low lying, rising to slightly higher ground to the north and west, and is surrounded on three sides by a river. Certain areas of the field are of such a character that it is difficult to avoid waterlogged conditions in a wet season. This is noticeable on low lying sites near the river, where the yields of established cacao are very low (see Field Map XIID, Appendix II). Wilson (29) gives the average yield per picket as 2.5 lb. of cacao over the five years preceding 1931-32, which is very high for Trinidad. In that year one third of the field was accurately recorded and the average yield was 1.6 lb. per picket. This apparent drop in yield was attributed to the very wet conditions prevailing during that year. The field was next recorded in 1934-35 and, under very favourable climatic conditions, a yield of 2.7 lb. per picket was reaped. Even on such a high yielding field as this there was a large proportion of the pickets contributing little to the total yield. 17.6 per cent. of the pickets were totally unproductive and another 34.8 per cent. were unprofitable before rehabilitation was commenced at the end of the 1934-35 season.

Removal of trees. The selection of poor bearers was based on the yield records collected during 1931-32 and 1934-35. The planter decided to cut out all trees 20 or more years of age, which yielded less than 1.6 lb. of cacao in 1934-35, and less than 1.0 lb. in 1931-32. This standard is an exceptionally high one, and much above that recommended by Shephard (24). Other trees, which were either badly damaged, diseased or produced very small beans, were also removed. Trees less than 20 years old were cut out
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if they were badly injured as to preclude the possibility of developing into high bearing trees. Other trees over 20 years of age and yielding less than the required standard were retained if it was considered that their performance could be improved. This treatment resulted in the replacement of 19.3 per cent. of the total number of pickets, which had contributed 5.3 per cent. of the total yield in 1934-35. A further 5.4 per cent. of the pickets were heavily pruned or had composite parts removed. The cut portions accounted for 2.4 per cent. of the 1934-35 yield.

This very severe treatment considerably reduced the number of unprofitable pickets in the field. The records for 1937-38 and 1938-39 show the 32.2 per cent. of the total number of pickets were unprofitable, as compared with 45.9 per cent. before rehabilitation. These figures do not include supplies under 5 years old. The number of replants increased from 6.5 per cent. of the field before rehabilitation to 26.0 per cent. after the regeneration scheme.

The effect of this very drastic removal of trees from nearly one fifth of the field, resulted in a severe drop in yield in the year following the rehabilitation programme, 1935-36 (see Table 9.). In fact a far greater adverse effect than would have been expected by the removal of trees and parts of trees, contributing only 7.7 per cent. of the total yield in 1934-35. Whereas the estate yield in 1935-36 dropped to 66.0 per cent. of the 1934-35 yield, the yield of the field decreased to 40.6 per cent. of the former year's total. The recovery of the bearing capacity of the field has been slow and does not appear yet to have fully recovered to its former high yielding state. The average yield per picket of 2.7 lb. of cacao in 1934-35 was exceptionally high, which would tend to accentuate the apparent drop in yield resulting from rehabilitation. The average
annual yield of the field for the 5 years preceding 1931-32 was, however, 2.5 lb. per picket, and yet even in 1939-40, when the climatic conditions were particularly favourable, the field average was only 2.0 lb. per picket. The trend in yield of the pruned trees is seen to follow very closely to that of the pickets on the whole field. The lack of recovery of these trees is exceptional and seems to point to some unfavourable condition within the field.

The removal of one fifth of the trees in a field must have a certain adverse effect on the remaining trees, if only by reducing the canopy considerably. No heavy incidence of thrip damage or any disease in particular has been observed on this field, so that these factors could not account for the reduced yields. A large reduction in the overhead canopy of a field would be liable to increase the range of temperature, lower the relative humidity, increase the rate of evaporation and light intensity at ground level within the field. Furthermore the soil would be more likely to dry out under dry conditions, and suffer conversely in wet weather. All of these factors are associated with bad cacao conditions and may account for the large drop in yield, which was experienced.

History of supplies. Prior to replanting, this field received much the same treatment as did field 21A on the same estate. The draining system was improved, round-ridging was practiced, and overshaoding branches were pruned back. Tannias were planted round the supply sites and bananas were placed in areas where the removal of trees had left large bare patches. The survival of supplies can be seen in Table 9, and the low mortality of replants offers a striking contrast to the adverse effect which was experienced with the total yield after rehabilitation. Only 15, or 4.1 per cent. of the 363 supplied in 1934-35, have failed to
Fig. 1. Well grown 5 year old supply on alluvial soil. Girth at 1 ft. 4.58 cms.

Fig. 2. Poor 5 year old supply on low lying site near river on alluvial soil. Girth at 1 ft. 2.23 cms.

1932-40. It is difficult to estimate mortality (23.6 per cent.) should be as high as 21%, as it is on the same field. The rest of the same treatment, however, the low river are rather extensive than this could not wholly account for the brown earth. On both fields surrounding losses from cuttings wounds were negligible. Figures for all trees on this field for the period 1933-36 to 1958-59, show that 10% of the trees of age was only 2.2 per cent. These casualties have hence been nearly all resupplied.

The growth of the supplies is satisfactory, the replants presenting a healthy and generally more uniform appearance than in the other fields under consideration. The girth measurements of supplies in this field revealed almost identical growth as those of the same age on field section 0). As found on field 21A the areas near the river exhibit a growth than the replants on the remainder of the field. An average girth of 7 supplies on poor soil was only 3.1 cms., compared with 4.5 cms. on the remainder of the field.

Some of the trees growing under these conditions in Figs. 1 and 2, although the result of the good and bad. Fig. 1 is not necessarily a good site and under the supply in Fig. 2 presents an opposite condition. One cannot therefore be satisfied that the
survive up to the end of 1939-40. It is difficult to understand why such a heavy mortality (23.6 per cent.) should have been experienced on field 21A, as it is on the same estate, same soil type and has received the same treatment as field 21D. In the former instance, however, the lower lying areas near the river are rather more extensive than on the latter, although this would not wholly account for the big differences obtained. On both fields arrondeering has been practiced, and losses from cutlas wounds were negligible. The casualty figures for all trees on this field are strikingly low. Over the period 1935-36 to 1938-39, the loss of trees aged 5 to 15 years was 4.5 per cent., and for trees over 15 years of age was only 2.2 per cent. These casualties have since been nearly all resupplied.

The growth of the supplies is satisfactory, the replants presenting a healthy and generally more uniform appearance than in the other fields under consideration. The girth measurements of supplies in this field revealed almost an identical growth as those of the same age on field 21C on Brasso Sand (see section 5). As found on field 21A the supplies on low lying areas near the river exhibit a much slower rate of growth than the replants on the remainder of the field. The average girth of 7 supplies on poor sites near the river bank was only 3.1 cms., compared with 4.1 cms. of 29 supplies on the remainder of the field. The contrast in appearance of trees growing under these conditions are well illustrated in Figs. 1 and 2, although these are possibly extremes of the good and bad. Fig. 1 shows a sturdy well grown supply on a good site and under suitable shade conditions. The supply in Fig. 2 besides being on a low lying site, is overshaded and presents a very spindly appearance. It is extremely improbable that the latter will ever mature into a good tree.

The age at which supplies planted before
1934-35 come into bearing is very slow. The average yield of supplies from 5 to 9 years of age was only 0.1 lb., from 10 to 14 years of age 0.7 lb., and from 15 to 19 years old 1.1 lb. per supply over the period 1935-36 to 1939-40 (see Page 92). The yield of supplies planted in 1934-35 is also disappointing, although it is too early to form any definite opinion. 348 five year old supplies yielded only a total of 2.9 lb. of cacao in 1939-40, which was an exceptionally favourable year.

The most interesting feature arising out of the rehabilitation of this field is the very adverse effect, which the removal of one fifth of the tree population, had on the yield of the remaining trees in subsequent years. The field does not appear to have recovered from the result of this drastic treatment even five years after rehabilitation. It seems to stress the importance of not sacrificing too many trees at a single time. The planter in this case took too high a standard on which to base the selection of trees for removal. Had he been content with the removal of only the most unprofitable trees, and later to gradually increase the standard, the large drop in yield might not have been experienced.

This decrease in yield is, however, only temporary, and the history of these supplies are included in this report. Prior to the first supplies only half of the field was recorded, and although it seems evident that a few trees were cut out, no records are available of any details. Field counts in 1935-36 and 1936-37 showed that these were a large number of unprofitable trees, which start substantially contributing towards the total yield.
FIELD 21C.

Field 21C is an old field planted 79 years ago on Brasso Sand soil, and is situated on the same estate as the previous two fields, 21A and 21D. It is 7 acres in extent, irregular in shape and has one especially interesting feature. As in the two fields already mentioned it lies in the bend of a river and low lying areas round the border are subjected to annual waterlogging. The yield of trees in these border areas are very low and great difficulty is found in establishing supplies. The effect of waterlogging can be seen in Map No. XVIIIC (Appendix II), in which light patches denoting very low yields or blank sites are prevalent all round the banks. As would be expected in such an old field the picket composition is made up mostly of mature and immature supplies, only 8 per cent. of the pickets being original trees. Brasso Sand soil is very liable to dry out during the dry season, this was observed on the field at the end of 1939-40, when the canopy was very bare and presented a somewhat wilted appearance.

Although the field was not actually rehabilitated until 1937, over 10 per cent. of the pickets were supplied in May 1935, and the history of these supplies are included in this report. Prior to the first supplying only part of the field was recorded, and although it seems evident that a few trees were cut out, no records are available of any details. Field counts in 1935-36 and 1936-37 showed that there were a large number of unprofitable pickets in the field. Of the total picket composition over 5 per cent. were blank sites, 25 per cent. were totally unproductive, half of which were supplies under five years old, and a further 30 per cent. yielded less than an average of 1 lb. of cacao each.
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Table 10. Trend in Yields and Survival of Supplies of a 79 year old plantation on Brasso Sand - Rehabilitated in 1937.
Removal of trees. The selection of trees for removal in May 1937 was based on the field records collected in 1935-36 and 1936-37. Only trees yielding less than an average of 0.5 lb. of cacao, during these two years were cut out. A few trees which were diseased with canker or which were badly damaged were also replaced. Considering the high percentage of low bearers present in the field the cutting out programme was not particularly severe. This treatment resulted in the replacement of 6.0 per cent. of the total number of pickets, which had contributed only 0.9 per cent. of the previous year's total yield. At the time of rehabilitation the canopy of the remaining trees was remarkably bare, and it was only found necessary to prune a further 1.0 per cent. of the pickets. The parts cut gave a negligible yield in the previous years.

The trends in yield of the whole field and pruned trees from 1935-36 to 1939-40 are shown in Table 10. The removal of trees on 6.0 per cent. of the pickets cannot be seen to have had no adverse effect on the total field yield in following years, but little would be expected since the treatment was not severe. The total yield in 1937-38 was actually 109.5 per cent. of that in 1935-36. Adverse weather conditions were responsible for the low yield in 1938-39, and particularly favourable climatic conditions for the increase in yield in 1939-40. No explanation can be offered for the drop in the average yield of pruned trees in 1936-37 from 1.4 lb. in the previous year to 0.5 lb., since the average yield per picket on the whole field remained much the same in both seasons. The yield of pruned trees seems to have steadily recovered since 1937-38, although their average yield of 1.1 lb. in 1939-40 compares unfavourably with the average picket yield of 1.9 lb. for the whole field in the same year.
History of supplies. In May 1935 11.2 per cent. of the total number of pickets were supplied, and in the rehabilitation programme in 1937 a further 7.2 per cent. of the pickets were replanted. With the original supplying bananas were planted where additional shade was required, and in 1937 tannias and bananas where necessary were placed round the supply sites. No additional cultivation apart from that normally practiced was given to the field. The percentage number of supplies surviving in each year are shown in Table 10. The mortality of supplies in this field have been high. 28.2 per cent. of the 1935 replants have been lost up to date, but over 20.0 per cent. failed to survive in the first year. Only 78.0 per cent. of the supplies planted in 1937 remained alive at the end of 1939-40. Many of these losses occurred on sites near the river, as found in field 21A. Out of the total number of 69 supplies planted on sites bordering the river 31, or 44.9 per cent., died. On the remainder of the field 59, or 21.2 per cent. of the 277 supplied, were lost. The loss of over 20 per cent. of the replants on the better parts of the field is much greater than should be the case. It is the writer's contention that inadequate ground shade was provided before supplying, and that the high mortality of replants in their first year was due to the very dry conditions, which prevail on this type of soil during the dry season. The establishment of supplies when soil moisture is low is a difficult proposition.

The growth of supplies on this field was found to be identical with same aged supplies on alluvial soil (see section 5). Again a large difference was encountered between the girth of replants on good and bad sites. The average girth of 5 year old supplies was 3.1 cms. and 4.1 cms. respectively for plants on sites bordering the
Fig. 3. Well grown 5 year old supply on Brasso Sand. Girth at 1 ft. 5.56 cms.

Fig. 4. Poor 5 year old supply on low lying site near river on Brasso Sand. Girth at 1 ft. 3.61 cms.
river and on the remainder of the field. Similar figures for 3 year old supplies were 1.7 cms. and 2.2 cms. respectively. Fig. 3 shows a fine 5 year old supply growing on this field. Fig. 4 shows a similar aged supply situated near the river, exhibiting comparatively poor growth.

The age at which supplies come into bearing on this field is even slower than that on field 21D. The average yield per supply of replants aged from 5 to 9 years was only 0.2 lb., from 10 to 14 years 0.5 lb., and from 15 to 19 years of age 0.8 lb. during the period 1935-36 to 1939-40 (see Page 92). The total yield in 1939-40 of the 161 supplies planted in 1934-35 was only 11.4 lb. of cacao, and 2.5 lb. of the total was given by one exceptionally fine tree.

The difficulty of trying to establish supplies on low lying areas near the river is again brought to light in this field. For example all 18 losses of the 1935 supplies on poor sites were planted in 1937, since when 10 have again succumbed to the unfavourable conditions. It is thought that the high mortality of supplies on the remainder of the field was caused through lack of adequate ground shade. The importance of providing sufficient protection for seedlings when planted out, especially on soils as light as Brasso Sand, cannot be stressed too frequently. Field records for 1937-38 showed 37.3 per cent. of the pickets, not including supplies under 5 years old, were still unprofitable. It is recommended that further unprofitable trees should be replaced within the next few years, as the first rehabilitation programme was not particularly severe.
FIELD 257B.

Field 257B is a 52 year old field, 3½ acres in extent, and is situated on high ground, with a gradual downward slope from East to West, on Brasso Clay soil. It is an excellent example of the unsuitability of this soil type to cacao production. The whole field has been subjected to a series of landslides, which readily accounts for its low productivity. Shephard (23) has frequently stressed that such fields can never hope to become profitable unless prices rise to an absurd level, and recommends their abandonment. The futility of trying to rehabilitate such areas can be realised when even mature supplies cannot be expected to yield over an average of 1.0 lb. of cacao.

In earlier years this field had been badly neglected, and the total yield had declined to a very unprofitable level. In 1934-35, which was quite a favourable year for cacao, the average yield of the field was only 0.7 lb. per picket. The tree population consisted of supplies of all ages, only 8.1 per cent. of the originals remained, and the majority of these were unhealthy and misshapen. The field records collected in 1932-33 revealed that 11.3 per cent. of the total number of pickets were blank, 54.1 per cent. of the trees gave no cacao at all, and a further 28.3 per cent. yielded less than an average of 1 lb. of cacao each. Although it seemed unlikely that the rehabilitation of this field would meet with any success, it was attempted at the end of the 1934-35 season.

Removal of trees. The planter originally intended to cut out all trees yielding less than an average of 1 lb. of cacao each, but when it was realised that over ⅔ of the trees in the field would be affected, this was not considered practical. He, therefore turned his attention to the most
<table>
<thead>
<tr>
<th>Year</th>
<th>Yields</th>
<th>Whole Field Supplies</th>
<th>Pruned Trees Supplies</th>
<th>Percent of Survival</th>
<th>Percent of Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934-35</td>
<td>100.0</td>
<td>100.0</td>
<td>0.7</td>
<td>100.0</td>
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</tr>
<tr>
<td>1935-36</td>
<td>74.8</td>
<td>55.1</td>
<td>0.4</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>1936-37</td>
<td>93.5</td>
<td>96.6</td>
<td>0.6</td>
<td>0.3</td>
<td>100.0</td>
</tr>
<tr>
<td>1937-38</td>
<td>77.7</td>
<td>74.5</td>
<td>0.5</td>
<td>0.4</td>
<td>95.8</td>
</tr>
<tr>
<td>1938-39</td>
<td>70.2</td>
<td>72.7</td>
<td>0.7</td>
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</tr>
<tr>
<td>1939-40</td>
<td>123.8</td>
<td>116.3</td>
<td>0.9</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>
unprofitable pickets, basing the selection on the records collected in 1932-33 and 1934-35. Many trees under 20 years of age were removed because they were so badly mis-shapen and unhealthy, as to render them valueless. This resulted in the replacement of 17.4 per cent. of the total number of pickets, which had contributed only 2.1 per cent. of the 1934-35 total yield. 88.5 per cent. of the trees removed had actually yielded no cacao at all in the previous season. An additional 4.8 per cent. of the trees were heavily pruned or had parts removed. The parts cut had only accounted for 1.5 per cent. of the previous years total yield. It is unlikely that the trends in yield of the whole field and pruned trees are shown in Table 11. Unfortunately the field was not counted in 1935-36, so that the first records available after rehabilitation are those in 1936-37. The total yield of the field appears to have suffered to a greater extent than would have been expected by the removal of trees and parts of trees, contributing only 3.6 per cent. of the total yield. In 1937-38 the yield of the whole field was only 77.4 per cent., compared with 93.5 per cent. for the district, both being expressed as a percentage of their 1934-35 totals. The yield, however, seems to have recovered fully by 1939-40, although it is still unprofitable. The trend in yield of pruned trees follows very closely that of all pickets on the field, and no additional recovery has so far taken place, and neglect was responsible for the heavy losses experienced. History of supplies. The supplies planted in May 1935, received little encouragement. No attempt was made to improve the conditions within the field by manuring, liming or roundridging. Although a few bananas were planted in very open patches, no ground shade was provided immediately.
round the seedlings. The removal of 17.4 per cent. of the trees left the canopy very broken, and in subsequent years, the field became foul with weeds, which were not adequately kept in check. It is small wonder then that the mortality of supplies was very high.

No records are available of the number of seedlings actually supplied, for the field was not counted in 1935-36, the year following rehabilitation. In 1934-35, however, 16 per cent. of the total number of pickets were blank and an additional 17.4 per cent. were removed. This left a total of 363 pickets to be resupplied, but only 121 replants on these sites were living in 1936-37. It is unlikely that the original supplying was complete, but even then the mortality in the first year must have been very considerable. Table 11 shows that from 1936-37 to 1939-40 an additional 27.3 per cent of the replants have failed to survive. A second attempt was made to establish supplies in 1937 when 18.7 per cent. of the total number of pickets were replanted. 25, or 13.2 per cent. of the 189 supplied have again succumbed to the unfavourable conditions.

Shephard (23) has shown that tree casualties on Brasso Clay are due more to unsatisfactory soil conditions than to any other factor. It is also likely that many supplies on this field died as a result of cutlas wounds, as no arrondeering was practiced, but there are no available figures to prove this. It is certain, however, that a combination of poor soil and neglect was responsible for the heavy losses experienced.

The growth of 5 year old supplies on this field was very backward (see section 5). The average girth of these replants was only 3.3 cms. compared with that of 4.1 cms. for same aged supplies on Alluvium and Brasso Sand soils, and that of 3.5 cms. for supplies two years younger on Choco-
late soil. The very late age at which supplies come into bearing on this field stresses the unsuitability of Brasso Clay soil to cacao production. During the period 1935-56 to 1939-40 the average yield per supply of trees under 10 years of age was nil, from 10 to 14 years of age 0.2 lb., and from 15 to 19 years old only 0.4 lb. (see Page 92).

The five year old supplies planted in 1935 gave no cacao at all during the 1939-40 season.

The unpracticability of trying to regenerate cacao fields on poor soils, such as Brasso Clay, is well illustrated by the attempted rehabilitation of this field. The mortality of all supplies planted on the field since 1934-35 was as high as 59.3 per cent. Poor soil and neglected conditions were largely responsible for this loss. Even should the replants survive and mature they cannot be expected to give yields sufficiently high to make the field profitable. It is, therefore, recommended that such areas should be abandoned, and that all the planters efforts should be concentrated on the better fields of his estate, which offer a reasonable chance of improvement.

Shepherd (22) has stated that the small patches of low yielding pickets on good soils are almost invariably associated with fallen immortelles. The exceptional fertility of the Chocolate soil is, in a sense, responsible for the high casualty rate, usually experienced, because the immortelles attain enormous dimensions, and are therefore blown down, and each one causes more extensive damage among the cacao trees. Bartley (15) examined the effects of falling immortelles in this field in 1932-33-34 and found that one third of the immortelles fell during this period. He stated that 88.6 per cent. of the total number of cacao trees were either damaged or killed
FIELD 17D.

Field 17D covers an area of 7.5 acres, and was planted 53 years ago on a uniform Chocolate soil. It is completely surrounded by other cacao fields on the same soil type. Two streams run on either side of the field, but are too small to cause any waterlogging near these parts. The undulation of the field and nature of the soil allows free drainage, but artificial ditches are maintained and appear in good order.

The soil is particularly suited to cacao growing, as is shown by the average picket yields, which are greatly in excess of the average for the island. Wilson (29) gives the average picket yield for the five years previous to 1931-32 as 2.4 lb. of cacao. In 1931-32 the field was accurately recorded and the average yield was found to be 2.0 lb. per picket. The high yielding trees are well distributed over the field, but there is a tendency for high yielders at the southerly end (see Map XXC, Appendix II). This may be due in part to the increased water supply which the lower end of the field would receive.

Immortelle damage. Shephard (23) has stated that the small patches of low yielding pickets on good soils are almost invariably associated with fallen immortelles. The exceptional fertility of the Chocolate soil is, in a sense, responsible for the high casualty rate, usually experienced, because the immortelles attain enormous dimensions, and each one causes more extensive damage among the cacao trees. Hartley (15) examined the effects of falling immortelles in this field in 1932-33-34 and found that one third of the immortelles fell during this period. He stated that 22.6 per cent. of the total number of cacao trees were either damaged or killed.
resulting in an estimated loss of 11.3 per cent. of the total yield. Fallen immortelles, apart from direct damage, are bound to have an indirect adverse effect on the yield of remaining trees, through lack of shade, broken canopy and exposure to wind and sun. The average yield per picket of this field actually dropped from 2.4 lb. for the years 1926-27 to 1931-32 to 1.6 lb. for the period 1934-35 to 1939-40.

In 1931-32, the first year that the field was accurately recorded, 16.0 per cent. of the total number of pickets were unproductive, of which 9.1 per cent. were supplies under five years of age, and a further 18.6 per cent. yielded at less than an average of 1 lb. of cacao each. Between 1931-32 and 1935-36, when the programme of rehabilitation was started, falling immortelles had wrought havoc amongst the tree population.

Removal of trees. The selection of trees for removal, was based on previous records collected in the field. All badly damaged trees were cut out, and where only part of the tree was damaged, the injured part was pruned back. Many of the remaining trees were very large and where parts of the trees overshadowed sites to be supplied, they were likewise pruned. Cutting out was undertaken ruthlessly and thoroughly, resulting in the removal of trees on 22.7 per cent. of the total number of pickets, which had yielded only 5.0 per cent. of the total yield in 1934-35. The fact that over one fifth of the trees could be cut out with only an estimated loss of one twentieth of the total yield is surprising on a high yielding field. This field was, however, exceptional in that the damage caused by falling immortelles had been particularly severe in the few years preceding rehabilitation. A further 30 per cent. of the pickets, had parts removed or were heavily pruned. The

<table>
<thead>
<tr>
<th>Year</th>
<th>Estate Whole Field 1934-35</th>
<th>Pruned Trees 1934-35</th>
<th>1936 Supplies Per Tree Free</th>
<th>1936-37 %</th>
<th>1937-38 %</th>
<th>1938-39 %</th>
<th>1939-40 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934-35</td>
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<td>94.7</td>
<td>99.7</td>
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<td>99.2</td>
<td>171.8</td>
</tr>
<tr>
<td>1936-37</td>
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<td>1.5</td>
<td>1.6</td>
<td>1.7</td>
<td>80.1</td>
<td>76.3</td>
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</tr>
<tr>
<td>1937-38</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1938-39</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1939-40</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
yield of the parts cut was 12.5 per cent. of the total yield in 1934-35. Many of the parts removed, however, had been badly damaged and were declining in yield. It would have been expected that this very severe cutting out treatment, affecting over half the trees, would have resulted in a severe drop in yield of the field. This was not found to be the case. The field was not recorded in 1935-36, but in 1936-37 the total yields, expressed as a percentage of the 1934-35 totals, were 70.7 per cent. and 68.9 per cent. respectively for the estate and whole field. The recovery in yield has been very rapid and consistent, even in 1938-39, which was an exceptionally bad year in this district, the total yield of the field was higher than in the previous year. In 1939-40 an average yield of 2.1 lb. per picket was reaped, and it would appear that the field is returning to its former high yielding state. The recovery in yield of pruned trees has been even greater than that of the whole field. In 1939-40 the average yield of pruned trees was 2.4 lb. compared with 2.1 lb. per picket on the whole field, whereas in 1934-35 the average yields had been 1.7 lb. per tree and 1.6 lb. per picket respectively.

History of supplies. Bananas were planted where the removal of trees had left large open areas, but no ground shade was provided immediately round the supply sites. The barrenness of the canopy actually resulted in a very luxuriant growth of weeds, which at times completely engulfed the supplies. Field records of October 1936 revealed that 402, or 17.5 per cent. of the total number of pickets, had been supplied in the previous May. The mortality of supplies has been (exceedingly) great only 307, or 76.3 per cent. of the 1936 supplies, have survived up to the end of 1939-40. Many of these casualties were found to be caused by fallen
immortelles, 12, or 12.6 per cent. of the 97 casualties, being killed outright in this way. A further 32, or 10.4 per cent. of the 307 surviving supplies, had been damaged, and although they will probably recover, they have experienced a severe set back. The exceptionally weedy conditions and lack of protection round seedlings probably resulted in the heavy losses incurred in the first two years following supplying. The planter has resupplied the majority of blank sites every year.

The growth of these replants as revealed by girth measurement of 35 supplies taken at random over the field, illustrates the great fertility of Chocolate soil. The average girth of the 4 year old supplies on this field was 4.3 cms., as compared with that of 4.1 cms. for supplies one year older on Alluvium and Brasso Sand. The age at which supplies start bearing and become profitable is much younger on Chocolate than on other soils. For instance, on this field during the period 1935-36 to 1939-40, supplies aged from 5 to 9 years yielded an average of 0.6 lb., from 10 to 14 years 1.0 lb., and from 15 to 19 years 1.7 lb. of cacao. Only 3 of the 1935-36 replants yielded any cacao in 1939-40, but it is to be expected that within a very few years they will be substantially contributing towards the total yield of this field.

The rehabilitation of this field illustrates that on Chocolate soil a large proportion of low yielding trees can be removed, without having a very adverse effect on the yield, and that the recovery of the yield of the field is very rapid. The great fertility of Chocolate soil is also shown by the early age at which supplies bear and by the rapid growth rate. In this field the mortality of
supplies was greater than need be the case, if good care is taken with supplying and after treatment. The field records for 1938-39 show that 10.9 per cent. of the pickets, not including supplies under 5 years of age, were totally unproductive and that a further 19.7 per cent. yielded less than an average of 1 lb. of cacao each. It is recommended that within the next few years further poor yielders should be replaced. It was observed this year and in previous years that there has been a considerable incidence of thrip damage on this field. The depressing effect on the total yield, caused by thrip attacks, cannot be determined. It is possible that this infestation resulted in part from the reduction in the canopy during rehabilitation.
FIELD 24B.

Field 24B is an old field (84 years of age), whose yields had been very high, but which were steadily declining although the field was still showing good profits. It covers an area of five acres on a good Chocolate soil. A ravine runs throughout the length of the field ending in an extensive swamp, which is prone to flooding in wet weather. The edges of the ravine are for the main part steep and subject to small land slides, but there are also a few low lying areas along its course. The cacao on the banks of the ravine and bordering the swamp is less productive than on the remainder of the field (see Map XXIVA, Appendix II). On the North boundary the cacao was cleared a few years back to make way for the planting of bananas, which has resulted in a slight ‘exposure effect’ on neighbouring cacao trees.

Field records collected in 1935-36 revealed that 13.9 per cent. of the total number of pickets were blank sites, 15.0 per cent. produced no cacao, of which 5.0 per cent. were young supplies, and that a further 19.3 per cent. yielded less than an average of 1.0 lb. of cacao each. The field was not recorded in 1936-37, when the programme of rehabilitation was commenced.

Removal of trees. The 1935-36 records were utilised in determining which trees should be removed. Damaged or diseased cacao and trees which bore numerous but small beaned pods were likewise cut out. In all 14.2 per cent. of the total number of pickets, which had contributed 7.0 per cent. of the 1935-36 total yield, were replaced in May 1937. Of the 199 trees, which were cut out, 67 had produced no cacao, 81 had yielded less than an average of 1.0 lb. each, and 51 had given over 1.0 lb. of cacao per tree during 1935-36. The removal of so many apparently profit-
TABLE 13.  Trend in Yields and Survival of Supplies of an 84 year old Field on Chocolate soil - Rehabilitated in 1937.

<table>
<thead>
<tr>
<th>Year</th>
<th>District 1935-36</th>
<th>Whole Field 1935-36</th>
<th>Pruned Trees 1935-36</th>
<th>Survival of 1937 Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% per picket</td>
<td>% per tree</td>
<td>% per tree</td>
<td>% per tree</td>
</tr>
<tr>
<td>1935-36</td>
<td>100.0</td>
<td>100.0</td>
<td>1.7</td>
<td>100.0</td>
</tr>
<tr>
<td>1937-38</td>
<td>106.6</td>
<td>91.6</td>
<td>1.6</td>
<td>57.8</td>
</tr>
<tr>
<td>1938-39</td>
<td>87.5</td>
<td>108.5</td>
<td>1.9</td>
<td>80.6</td>
</tr>
<tr>
<td>1939-40</td>
<td>144.1</td>
<td>163.6</td>
<td>2.9</td>
<td>112.4</td>
</tr>
</tbody>
</table>
able trees can be explained by the fact that these trees were either damaged by falling immortelles, produced poor quality pods, or had suffered some other casualty during the intervening period. Owing to the great age and fertility of the field many of the trees were large and spreading, and parts of these trees were removed to prevent oversading of the supplies. 7.0 per cent. of the pickets were thus affected, and the yield of the parts cut had been as much as 6.7 per cent. of the 1935-36 total yield. Poor sites, failed to survive. The cutting out of trees and parts of trees, contributing 13.7 per cent. of the total yield, appeared to have a similar depressing effect on the yield of the field in the year following the removal. Table 13 shows that the yields in 1937-38, expressed as a percentage of the 1935-36 totals, were 91.6 per cent. for the whole field, and 106.6 per cent. for the district. The field seems to have recovered amazingly quickly, however, and the yield of the whole field in 1938-39 and 1939-40 was greatly in excess of that of the District. The pruned trees suffered a severe setback, their yield dropped from 3.0 lb. in 1935-36 to 1.7 lb. per tree in 1937-38, but their recovery has been as rapid as that of the whole field.

History of supplies. The field was in such a good general condition that little extra cultivation was necessary before supplying was undertaken. Bananas were planted as additional shade where the canopy was very broken, but the provision of ground shade immediately round the supplies was rather neglected. Although 28.1 per cent. of the pickets, including blanks and replacements, required supplying, only 21.1 per cent. of the total number of pickets were replanted. The remaining sites were either in the ravine or near the swamp and it was not considered that they would ever bear.

Aged from 5 to 9 years was 6.7 lb, 55 supplies from 10 to...
profitable cacao. In a few cases high yielding trees, which occupied more space than one site allowed, were not cut back and supplies were not planted in the immediate vicinity. In those planted before this time, because the planting material was very much greater on low lying areas near the swamp or in the ravine, than on the remainder of the field. 262 of the 298 supplies planted in 1937, were living at the end of 1939-40. The loss of supplies was very much greater on low lying areas near the swamp or in the ravine, than on the remainder of the field. 11, or 24.5 per cent. of the 45 supplied on these poor sites, failed to survive, compared with a loss of only 25, or 9.9 per cent. of the 253 supplied on the remainder of the field. Falling immortelles caused considerable damage amongst the supplies, 6 were killed outright in this way, and a further 20 have been damaged but show signs of recovery. Arron-deering has been practiced on this field and no supplies were lost through cutlas wounds. The growth of the 1937 supplies has been very satisfactory. The average girth measurement of 37 of the 3 year old replants in this field was 3.5 cms., as compared with 2.1 cms. for the same aged supplies on Alluvium and Brasso Sand. Another indication of the fertility of Chocolate soil is shown by the fact that the 3 year old supplies in this field have made better growth than 5 year old supplies on Brasso Clay (see section 5). The difference between rate of growth of supplies on good and bad sites on Chocolate soil was not as great as that experienced on Alluvial and Brasso Sand. The average girth of 10 three year old supplies situated near the swamp or in the ravine was 3.2 cms. compared with 3.6 cms. for the 27 on the remainder of the field.

The early age at which supplies come into bearing on this field can be seen from records collected in 1939-40. The average yield per picket for 56 supplies aged from 5 to 9 years was 0.7 lb, 55 supplies from 10 to
14 years old was 1.4 lb.; and for 52 supplies from 15 to 19 years of age was 2.0 lb. It is to be expected that the supplies planted in 1937 will yield quite as well, if not better, than those planted before this time, because the planting material consisted of specially selected seedlings from exceptionally high yielding trees. It was never put into execution. As will be seen the heavy incidence of Witches Broom disease. Since the initial attempt at rehabilitation in 1936-37, an additional 29 low yielding trees, 2.0 per cent. of the total number of pickets, have been removed, and a further 81 supplies have been planted. The yield analysis of the field for 1939-40 revealed that 10.0 per cent. of the pickets yielded less than an average of 1 lb. of cacao, and that 11.4 per cent. of the pickets were totally unproductive. This latter figure does not include supplies under 5 years of age, which now occupy sites on nearly one quarter of the field. Despite this large number of at present unproductive pickets, an average yield of 2.9 lb. of cacao per picket was reaped in 1939-40, and it is to be expected that the young supplies will play an increasing part in contributing towards the total yield within a few years. Despite the natural drainage is poor, artificial ditches are made up mainly of original trees, over 70 per cent. of the pickets being trees 32 years of age. The original trees present a very unhealthy appearance, many being badly attacked by Witches Broom disease. Canker, dieback and thrip attacks have added to the unsatisfactory conditions and have resulted in a very broken canopy. The lack of a continuous overhead canopy has led to the abundance of weeds during the last few years.

In 1936-37 May (16) carried out an investigation into the incidence of Witches Broom disease in this field, and found that 52 per cent. of the trees had light
Rio Claro District.

In the Rio Claro District only one of the fields (51B2) which have been included in the 1939-40 investigations, has been subjected to a programme of rehabilitation. The planter had also decided to rehabilitate a neighbouring field (51B1) in 1936, but this was never put into execution. As will be seen the heavy incidence of Witches Broom disease in the district has been largely responsible for the failure of the rehabilitation scheme in the case of Field 51B2.

FIELD 51B2.

Field 51B2, some 9 acres in extent, was planted 22 years ago on Princes Town Marl. Outcrops of Green Clay, Alluvium and Colluvium soils occur on 2 acres in the Northern part of the field. These latter areas are rather flat and lowlying and produce poor yielding cacao as is illustrated on Map XXVIIIIB, Appendix II, by the abundance of light patches denoting poor yield. The field is regular in shape gradually sloping down from East to West, and although the natural drainage is poor, artificial ditches are only in evidence on the low lying areas. At the present time the tree population is made up mainly of original trees, over 70 per cent. of the pickets being trees 22 years of age. The original trees present a very unhealthy appearance, many being badly attacked by Witches Broom disease. Canker, die back and thrip attacks have added to the unsatisfactory conditions and have resulted in a very broken canopy. The lack of a continuous overhead canopy has led to the abundance of weeds during the last few years.

In 1936-37 Hay (16) carried out an investigation into the incidence of Witches Broom disease in this field, and found that 52 per cent. of the trees had light
### TABLE 14: Trend in Yields and Survival of Supplies of a 22 year old field on Prince Town Marl - Rehabilitated in 1937.

<table>
<thead>
<tr>
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<tr>
<td>1936-37</td>
<td></td>
<td>100.0</td>
<td>1.2</td>
<td>1.8</td>
<td>0.8</td>
<td></td>
<td>1.0</td>
<td></td>
<td>0.5</td>
<td></td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>1937-39</td>
<td></td>
<td>100.0</td>
<td>2.0</td>
<td>3.8</td>
<td>1.0</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>3.5</td>
<td></td>
<td>57.1</td>
<td></td>
</tr>
<tr>
<td>1938-39</td>
<td></td>
<td>76.8</td>
<td>38.4</td>
<td>93.3</td>
<td></td>
<td></td>
<td>5.0</td>
<td></td>
<td>2.0</td>
<td></td>
<td>57.1</td>
<td></td>
</tr>
<tr>
<td>1939-40</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
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<td>-</td>
<td></td>
</tr>
</tbody>
</table>
infections and that an additional 24 per cent. were heavily infected. In 1938-39 the planter estimated that over 50 per cent. of the pods were badly infected. The planter also stated that systematic pruning had been carried out, but had failed to check the course of this disease. These figures illustrate the seriousness of the disease in this field.

The rehabilitation programme was commenced at the end of the 1936-37 season. Field records for that year revealed that 9.7 per cent. of the total number of pickets were blank sites, only 0.1 per cent. were supplies under 5 years of age, a further 17.8 per cent. were unproductive, and 32 per cent. yielded less than an average of 1.0 lb. of cacao each.

Removal of trees. The selection of trees for cutting out was based on field records collected in 1935-36 and 1936-37. All badly diseased trees were also removed. This treatment led to the removal of trees on 12.7 per cent. of the total number of pickets, which had contributed only 1.3 per cent. of the 1936-37 total yield, and 3.5 per cent. of the 1935-36 total. Of the 254 trees cut out 164 had actually yielded no cacao in 1936-37, and 17 had borne less than an average of 0.5 lb. per tree. 86 of the removed trees had been damaged or were badly diseased. As would be expected heavy pruning was not found necessary on such a young field, and only 1.3 per cent. of the pickets were so treated.

The trends in yield of the whole field, other fields in the district and pruned trees are shown in Table 14. The yields of both the district and the field, expressed as a percentage of the 1936-37 totals, showed phenomenal increases of 227.3 per cent. and 160.3 per cent. respectively in 1937-38. It is difficult to explain this very large increase in yield, except that climatic conditions in the
district were particularly favourable for cacao production in 1937-38. The yield of the rehabilitated field did not increase as much as that of other fields in the district, but it is impossible to say to what extent the removal of 12.7 per cent. of the trees was responsible for this. The yield of the field showed a disastrous drop in 1938-39, a very wet year, to 38.4 per cent. of the 1936-37 total.

The yields of pruned trees do not seem to have recovered from the cutting back treatment in 1936-37.

**History of supplies.** The supplies were not planted in this field until May 1938, a year later than the trees were removed. No additional cultivation, beyond normal practice, was given, very few bananas and no cover crops were planted before supplying. Supplies were planted on 16.6 per cent. of the total number of pickets in 1938 and the survival of these supplies can be seen in Table 14. 208, or 62.6 per cent. of the 332 supplied had died within two years. 28 of these losses were recorded as being killed by Witches Broom disease. The remaining supplies present a very unhealthy appearance and many of them have scarcely made any growth since they were planted. 40 of the surviving supplies were examined in detail in 1939-40 and out of these 13 were attacked by thrips and 11 by Witches Broom disease. Thrips cause continual defoliation, which gradually saps the strength of a young supply, while Witches Broom causes a die back behind the terminal shoot, and only a very vigorous supply will survive such an attack. It is probable that the losses from this disease were more numerous than that actually recorded. Other contributing causes to the high mortality were lack of ground shade, the luxuriant growth of weeds, lack of drainage and the very damp conditions in 1938-39. The latter consideration would greatly hinder the root development of supplies and render them less
able to withstand the ravages of diseases and pests.

The attempted rehabilitation of this field illustrates the dangers and difficulties of carrying out such a policy of regeneration, where Witches Broom disease is prevalent.

The removal of a large percentage of the trees is bound to open up the canopy, and it is thought that this gives a greater chance for the infestation and penetration of disease within the field. The incidence of thrip attacks is generally associated with unhealthy conditions, but the same remarks apply to this pest about the removal of trees as to those on Witches Broom disease. It is recommended that where Witches Broom and thrips are particularly prevalent, a programme of rehabilitation should not be undertaken until these factors have been controlled. The first steps at control should be an improvement in the conditions within the field, which are at present anything but satisfactory. The seriousness of the situation of this field can be realised when the average yield per picket for the period 1936-36 to 1939-40 was only just over 1.0 lb. per picket. A 22 year old field should just be reaching peak production and Princes Town Marl has been shown to be well suited to cacao production (see section 2).
(c) Toco District.

No attempts have been made to rehabilitate fields, which have come under the investigations in this district. Field 33A was, however, extensively supplied in 1938, and this attempt at improvement is described below.

<table>
<thead>
<tr>
<th>Year</th>
<th>% 1937-38</th>
<th>% 1938-39</th>
</tr>
</thead>
<tbody>
<tr>
<td>1937-38</td>
<td>100.</td>
<td></td>
</tr>
</tbody>
</table>

Field 33A, 7 acres in extent, was planted 42 years ago on a Quartz Schist soil. The field is situated on one side of a valley, the upper slopes being bordered by bush and bananas and the lower by a ravine. On the upper slope the cacao is rather exposed and is very unproductive, see Map XXXXI, Appendix II. Certain parts of the field near the ravine are low lying and subject to water logging in wet weather. Shade is inadequate in most parts, and the canopy is generally poor. Soil erosion has resulted in the formation of small gullies here and there, and also tree casualties and low productivity in these areas. Damage from thrips is particularly severe, and marginal leaf scorch is also evident.

The unsatisfactory conditions existing within the field, general neglect and low fertility status of the soil (see section 2) are responsible for the very unproductive state of this field. The field was first recorded in 1937-38, and the investigation revealed that 46.9 per cent. of the pickets gave no cacao whatsoever, and an additional 27.7 per cent. yielded at less than an average of 1.0 lb. of cacao each. Expressed as a percentage of the total number of pickets, the unproductive pickets were composed of 17.7 per cent. blank sites, 0.4 per cent. supplies under 5 years old, and 28.8 per cent. over 5 years of age yielding nothing. No poor yielding trees were removed on this field but in May 1938 17.7 per cent. of the total pickets were supplied, which represented complete supplying on all
Table 15 shows the low average yields per picket on this field for the last 3 years. In 1938-39 a very wet year, the yield of the whole field dropped to 62.1 per cent. of the 1937-38 total. In 1939-40, under favourable climatic conditions, the yield increased to 164.2 per cent. of the 1937-38 total, and the average yield per picket was 1.3 lb. At the end of 1939-40, two years after supplying, only 59.5 per cent. of the 353 seedlings supplied remained alive.

The very wet conditions in 1938-39 were responsible for a high death rate of supplies in the low lying areas in the ravine. Out of 56 replants on these poor sites, 30, or 54 per cent., failed to survive. On the remainder of the field 113, or 38 per cent. of the 297 supplied, were dead at the end of 1939-40. Although bananas were planted in very open areas before supplying, it is probable that lack of shade was largely responsible for this high mortality. In 1938-39 the broken canopy led to a luxuriant growth of weeds and it is possible that cuttas wounds damaged and killed many supplies, for they were often invisible amongst the weeds. The lack of overhead shade was very evident in 1939-40, when 42 supplies taken
at random over the whole field were examined. No fewer than 25 of these were situated on sites unprotected from the direct rays of the sun. The prevalence of thrip damage was also very marked, 12 supplies of the 42 examined were being attacked by thrips, and presented a very wilted appearance. In general the growth of the supplies planted in 1938 is unsatisfactory. Many are very small and stunted and have produced only 3 to 4 leaves, but a few are well grown, generally where the shading is adequate.

This field was planted 47 years ago and covers an area of 4 acres on Maragua Sandy soil. It is sited on this field is very late. In 1938-39 10.6 per cent. of noted on a slope facing north and, although the soil is the total number of pickets were supplies aged from 5 to 19 years old. Supplies were first picked in the fifth growing years. During 1937-38 and 1938-39 the average yield per tree was negligible for supplies from 6 to 9 years of age, in 1932 a severe hurricane swept across the district, causing only 0.1 lb. for supplies from 10 to 14 years of age and considerable damage to cacao trees, and this field is only 0.3 lb. for 15 to 19 year old supplies. It cannot be hoped that supplies planted in 1938 will yield at a much higher rate than those planted previously under the present unsatisfactory conditions. The attempted regeneration of this field stresses the difficulties of raising supplies on poor soils and under neglected conditions.

being blanks, 4.2 per cent. young supplies and 22.3 per cent. trees over 5 years of age), and that an additional 30.9 per cent. yielded at an average rate of less than 1.0 lb. of cacao each.

Only 5 of the 4 acres comprising the field, was rehabilitated in 1939. The remaining acre provides a useful control for studying the effect of the rehabilitation programme on the field yield. The advancement the results total yield, total pickets etc., will be used to refer only to the rehabilitated area in this report.

Removal of trees. The evaluation of trees for control was based on the records collected in 1936-38 and 1938-39. In all 198, or 22.0 per cent. of the total supplies were extirpated,
Up to the present time only one field (28C) has been subjected to a programme of rehabilitation in the Moruga District. This field was not rehabilitated until May 1939, but particulars concerning the trees cut out and apparent effect on yield are given below.

FIELD 28C.

This field was planted 47 years ago and covers an area of 4 acres on Moruga Marly Silt soil. It is situated on a slope facing North and, although the soil is free draining, it has cross draining ditches. These drains tend to prevent erosion of the light and loose sandy soil. In 1933 a severe hurricane swept across the district, causing considerable damage to cacao trees, and this field is only just recovering from its effects. In 1931 and 1932 the average yield per picket on the field was 1.7 lb., but since 1933 it has dropped to below 1.0 lb. The field was first recorded in 1937-38, which revealed that 39.3 per cent. of the total pickets were wholly unproductive (12.7 per cent. being blanks, 4.2 per cent. young supplies and 22.4 per cent. trees over 5 years of age), and that an additional 30.9 per cent. yielded at an average rate of less than 1.0 lb. of cacao each.

Only 3 of the 4 acres comprising the field were rehabilitated in 1939. The remaining acre provides a useful control for studying the effect of the rehabilitation programme on the field yield. For convenience the words total yield, total pickets etc., will be used to refer only to the rehabilitated area in this report.

Removal of trees. The selection of trees for removal was based on the records collected in 1937-38 and 1938-39. In all 198, or 22.0 per cent. of the total pickets were cut out,
<table>
<thead>
<tr>
<th>Year</th>
<th>Yields</th>
<th>Survival of 1939 Supplies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Unrehabilitated</td>
<td>Rehabilitated</td>
</tr>
<tr>
<td></td>
<td>% 1938-39</td>
<td>% 1938-39</td>
</tr>
<tr>
<td>1937-38</td>
<td>104.8</td>
<td>97.1</td>
</tr>
<tr>
<td>1938-39</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1939-40</td>
<td>126.5</td>
<td>139.4</td>
</tr>
</tbody>
</table>
and these trees had contributed only 4.3 per cent. of the total yield in 1938-39, and 5.6 per cent. of the total in 1937-38. 126 of the removed trees had actually yielded no cacao at all in 1938-39, and 47 had given less than an average of 0.5 lb. each. 10 trees, which had given an average yield of 1.7 lb. per tree during the previous two years, were removed because they had become badly damaged. An additional 146 trees (16.4 per cent. of the total pickets) were heavily pruned or had composite parts removed, where these parts yielded badly or overshadowed the supply sites. The parts cut had contributed only 3.4 per cent. of the total yield in 1938-39.

It might have been thought that the removal of over one quarter of trees would have had an indirect adverse effect on the remaining trees on a light sandy soil, but this was not found during 1939-40, the year following the treatment. The yield trends of the untreated and rehabilitated parts of the field are compared in Table 16. The rehabilitated section actually increased in yield to a greater extent than did the remainder of the field during 1939-40. The pruned trees were also found to suffer no ill effects from their treatment.

Supplying. Supplying in 1939 was not complete. 199 seedlings were planted on 22.1 per cent. of the total number of pickets, but this left 85 blank sites, which have not yet been supplied. Bananas were planted to provide additional shade in barren patches, but no ground shade was placed immediately round the supplies. During 1939-40 10 of these supplies have died. Arrondeering has been practiced, which has prevented cutlas damage on the young replants. At the end of the 1939-40 season, the supplies presented rather a wilted appearance, following a very dry season, but there is no reason why they should not pick up well after the rains.
The rehabilitation of this field shows that over one quarter of the total number of pickets have been replaced by supplies, without in any way impairing the total yield. The age at which supplies come into bearing on this field has been disappointing in the past. Over 80 supplies between the ages of 15 and 19 years yielded only an average of just over 0.1 lb. each during 1937-38 and 1938-39. It has been pointed out in section 2 that Moruga Marly Silt soil should be capable of good productivity if suitably manured. It is probable that the supplies and mature trees would greatly benefit for applications of suitable potassium and phosphatic manures, which is not at present practiced. Considerably reduced by the use of improved methods, the loss of revenue puts this operation beyond the means of the majority of planters to-day. On the other hand the cost of rehabilitation is very small by comparison, and this method of improvement can well be carried out on all estates with little extra expenditure.

Replanting.

As the operations in field 2151 have not been discussed in this report, it is thought advisable to give a short account of the procedure adopted for the replanting of this field. In May of 1934 all cocoa and other trees were felled and three months later selected seedlings were planted. At the same time immortelles, bananas, hemp, and cassava were planted, as permanent and temporary ground shade. The close planting of cassava and tannins round the seedlings necessitated arroudeering, and the value of this work weeding can be judged when it is realised that only one supply was damaged by cutlass wounds in the whole field.
Comparison Between Costs of Rehabilitation and Replanting.

Detailed costs have been kept for the rehabilitation of field 24B (see page 57). In this field 14 percent of the trees were removed in 1937 and a further 13 percent of the pickets were blank before rehabilitation and required supplying. Another field (24B1) on the same estate and on the same Chocolate soil type was completely replanted in 1934, and the cost of these operations are compared with those of the rehabilitated field. The costs for 1939-40 in both fields have been added to those for the years 1934 to 1938 given by Shephard (25a). The comparison shows that although the cost of replanting has been considerably reduced by the use of improved methods, the loss of revenue puts this operation beyond the means of the majority of planters to-day. On the other hand the cost of rehabilitation is very small by comparison, and this method of improvement can well be carried out on all estates with little extra expenditure.

Replanting.

As the operations in field 24B1 have not been discussed in this report, it is thought advisable to give a short account of the procedure adopted for the replanting of this field. In May of 1934 all cacao and shade trees were felled and three months later selected seedlings were planted. At the same time immortelles, bananas, tannias and cassava were planted, as permanent and temporary ground shade. The close planting of cassava and tannias round the seedlings necessitated arronjeering, and the value of this hand weeding can be judged when it is realised that only one supply was damaged by cutlas wounds in the whole field.

<table>
<thead>
<tr>
<th></th>
<th>1934</th>
<th>1935</th>
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<th>1937</th>
<th>1938</th>
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<th>Totals</th>
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<td>Felling cacao and shade trees</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.33</td>
</tr>
<tr>
<td>Planting and supplying</td>
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<td>1.90</td>
<td>5.71</td>
<td>6.39</td>
<td>4.76</td>
<td>5.46</td>
<td>56.60</td>
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<td>Pruning bananas</td>
<td>-</td>
<td>3.98</td>
<td>7.34</td>
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<td>4.76</td>
<td>2.86</td>
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<tr>
<td>Arrondeering</td>
<td>-</td>
<td>3.33</td>
<td>3.81</td>
<td>3.05</td>
<td>2.90</td>
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<td>14.99</td>
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<td>9.07</td>
<td>9.52</td>
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<td>9.03</td>
<td>4.61</td>
<td>54.22</td>
</tr>
<tr>
<td>Draining androundridging</td>
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<td>0.75</td>
<td>3.15</td>
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<td>11.98</td>
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<td>5.71</td>
<td>5.26</td>
<td>1.73</td>
<td>22.22</td>
</tr>
<tr>
<td>Pests and Diseases</td>
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<td>0.95</td>
<td>0.95</td>
<td>2.09</td>
<td>2.86</td>
<td>-</td>
<td>6.47</td>
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<tr>
<td>Reaping bananas, tannias, cacao</td>
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<td>5.24</td>
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<td>10.55</td>
<td>9.06</td>
<td>6.41</td>
<td>42.54</td>
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<td>5.67</td>
<td>12.73</td>
<td>10.11</td>
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<td>47.41</td>
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<td>59.79</td>
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<td>51.89</td>
<td>31.16</td>
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<td>13.39</td>
<td>13.53</td>
<td>13.69</td>
<td>15.12</td>
<td>14.33</td>
<td>90.29</td>
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<td><strong>Total Expenditure</strong></td>
<td>70.55</td>
<td>50.18</td>
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<td>74.05</td>
<td>67.01</td>
<td>46.09</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bananas</td>
<td>-</td>
<td>54.18</td>
<td>68.37</td>
<td>72.15</td>
<td>58.10</td>
<td>37.06</td>
<td>299.38</td>
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<td>Tannias</td>
<td>-</td>
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<td>2.40</td>
<td>-</td>
<td>1.43</td>
<td>0.53</td>
<td>5.32</td>
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<tr>
<td>Cacao</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.99</td>
<td>4.24</td>
<td>5.23</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>-</td>
<td>55.14</td>
<td>70.77</td>
<td>72.15</td>
<td>60.52</td>
<td>42.15</td>
<td>300.73</td>
</tr>
<tr>
<td><strong>Excess Expenditure</strong></td>
<td>70.55</td>
<td>-</td>
<td>2.55</td>
<td>1.90</td>
<td>6.49</td>
<td>3.94</td>
<td>80.47</td>
</tr>
<tr>
<td><strong>Excess Revenue</strong></td>
<td>-</td>
<td>4.96</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Open pollinated seedlings from selected parents, combining high yield with large bean size, were used for planting material. On the whole the results from these trees have been disappointing. Many trees have failed to show the promise of the parents capabilities, but it is yet early days to form any definite conclusions. Some trees, on the other hand, have shown themselves already to be superior to the parents both in size of bean and yield. The value of these trees now that methods of vegetative reproduction have been made practical is very great. The planter is in fact replacing his unsatisfactory seedlings by cuttings from these high yielding trees (mostly from the parent I.C.S.1).

Costs of Replanting. The costs of replanting this field are shown in detail in Table 17. All figures in this report refer to the costs per acre. The total expenditure for the first six years was $381.20 per acre, or $63.53 per year. 'Working' expenses amounted to $290.91 of this total, or an annual average of $48.48, the remainder of the costs being accounted for by overhead charges such as management and estate charges. This expenditure was over three times that of the normal costs on this estate, advantage of this. The total revenue for the six years ending 1939 was $300.73 or $50.12 per year, and was made up almost entirely by the sale of bananas. The returns from cacao were only $1.00 in the fifth year, and although they were four times as great in 1939, they still contributed less than one tenth of the total expenditure. The total expenditure showed an excess of $80.47 for the six years or $13.41 per year over the revenue. As would naturally be expected by far the greatest loss was sustained in the first year ($70.55), the average annual excess expenditure amounting to only $2.00 for the succeed-
The importance of the part played by bananas in the financial role was considerable. Over the six years ending 1939 the revenue from bananas alone met the total working expenditure for all but $1.03. The use of bananas as a means of reducing the expenditure of replanting was made possible by the Government's contract with the United Fruit Company in recent years. The Gros Michele variety was planted for this purpose, but in the last two years has sustained very heavy losses from the ravages of leaf spot disease (Cercospora Musae). This disease largely accounts for the 50 per cent. decrease in revenue from bananas in 1939 compared with the previous four years.

The use of the Gros Michele banana in future replanting schemes cannot be recommended because of the prevalence of leaf spot disease. Other more resistant varieties can be grown but these have no export value, and the local demand is very limited.

The revenue obtained from tannias and cassava was remarkably small. The latter providing no income and the former less than $1.00 per annum. It seems surprising that no greater effort has been made to take fuller advantage of this source of revenue. It is possible, now that bananas will have to play a smaller part in the provision of revenue, that more attention will be paid to the use of suitable varieties, handling and marketing of ground crops.

The greatest single item of expenditure was that of weeding and arrondering. The latter is essential in avoiding damage to the young plants by cutlas wounds, but this cost will be greatly reduced when the trees form an effective canopy over the ground. The expenditure of $3.70 per year on manuring was high considering that Choco-late soil is the most fertile cacao soil in Trinidad, but
the increased use of manures is to be encouraged amongst planters.

In the past most cacao estates in Trinidad were established on the contract system; the planter paying the contractor 24 cents per full bearing tree. Under this system it would have cost the planter $50.00 per acre (spacing at 14' x 14') to replant this field; and in addition he would have had to bear the cost of felling the trees, digging the main drains and overhead expenses. If these additional charges are deducted, the actual expenditure for the six years ending 1939 was only $30.00 per acre, which is a considerable saving on the old system, although many of the trees have not yet reached full bearing. The new method has many other advantages namely: the use of only the best planting material, greater control in the management and supervision of the field, and the considerable revenue which can be obtained from subsidiary crops.

Costs of Rehabilitation. For details of the methods used in the rehabilitation of this field the reader is asked to turn to page 57, where these are fully described. It is very difficult in estimating the cost of rehabilitation to differentiate between the extra costs incurred and the normal expenditure. This has been attempted, and in Table 18 the additional expenditure caused by removal of trees, pruning, supplying, arrondeering, draining, manuring, etc., have been separated from the normal expenses. The increase in normal expenditure in 1937 and 1938 after rehabilitation compared with the previous three years was due almost entirely to a rise of $4.14 per acre per annum in the current estate expenses since 1937. This figure was obtained from fields which had not been subjected to any special treatment. The low normal expenditure in 1939 is due in part to the low yields in that year. The average annual costs of reaping
### TABLE 18. Cost per acre of rehabilitating* Field 24B.

<table>
<thead>
<tr>
<th></th>
<th>1937</th>
<th>1938</th>
<th>1939</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Expenditure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal of trees</td>
<td>1.46</td>
<td>-</td>
<td>0.14</td>
<td>1.60</td>
</tr>
<tr>
<td>Pruning</td>
<td>1.74</td>
<td>1.69</td>
<td>3.04</td>
<td>6.47</td>
</tr>
<tr>
<td>Supplying</td>
<td>3.91</td>
<td>0.41</td>
<td>2.36</td>
<td>6.68</td>
</tr>
<tr>
<td>Arrondéering</td>
<td>9.85</td>
<td>0.34</td>
<td>1.43</td>
<td>2.62</td>
</tr>
<tr>
<td>Draining, Manuring</td>
<td>-</td>
<td>-</td>
<td>1.90</td>
<td>1.90</td>
</tr>
<tr>
<td>Total extra Expenditure</td>
<td>7.96</td>
<td>2.73</td>
<td>8.97</td>
<td>19.56</td>
</tr>
<tr>
<td>Total normal Expenditure</td>
<td>24.30</td>
<td>23.15</td>
<td>9.72</td>
<td>57.17</td>
</tr>
<tr>
<td>Total Expenditure#</td>
<td>32.26</td>
<td>25.88</td>
<td>18.59</td>
<td>76.73</td>
</tr>
<tr>
<td>Revenue:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cacao</td>
<td>89.92</td>
<td>42.94</td>
<td>21.80</td>
<td>154.66</td>
</tr>
<tr>
<td>Bananas</td>
<td>9.32</td>
<td>12.48</td>
<td>18.76</td>
<td>40.56</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>99.14</td>
<td>55.32</td>
<td>40.56</td>
<td>195.02</td>
</tr>
<tr>
<td>Profit</td>
<td>66.88</td>
<td>29.44</td>
<td>21.97</td>
<td>118.29</td>
</tr>
</tbody>
</table>

* 14% of the trees were removed and 13% of the pickets were blanks.

+ Estimation only.

# The total average annual expenditure for this field for the years 1934 to 1936 was $18.64 per acre. The similar figure for revenue (entirely cacao) was $38.66 giving an annual profit of $20.02 per acre.
manufacture and transport dropped from $11.74 per acre in 1937 and 1938 to $2.71 in 1939. The overhead expenses were also much reduced in 1939.

The total extra expenditure resulting from the rehabilitation programme in field 24B was only $19.56 per acre for the three years ending 1939, or an average annual expenditure of $6.62. The comparatively high expenses for 1939 were due to the removal of further low yielding trees, which had been missed in 1937, heavy pruning, draining and considerable resupplying of dead supplies and blank pickets. The main items of the extra expenses were pruning and supplying, amounting to a total annual expenditure of $4.48 per acre, whilst arrondeneering accounted for a further $0.87 yearly per acre. Manuring was not considered necessary on this exceedingly fertile Chocolate soil. After the third year the extra cost entailed should be considerably reduced, although it will never completely disappear for the policy of rehabilitation must be maintained continuously if full benefits are to be realised.

The revenue from bananas planted round the supplies totalled $40.56 per acre for the three years ending 1939. This revenue more than paid for any extra expenditure incurred through the rehabilitation programme over the same period. It is significant to note that bananas in this rehabilitated field have not suffered from leaf spot disease, which was so prevalent on the neighbouring replanted field. The exceptionally large revenue of $89.82 per acre obtained from cacao in 1937 was due to a sudden and temporary rise in cacao prices, the field yield being very similar in 1937 and 1938. The revenue from cacao despite the cutting out of 14 per cent. of the trees in 1937 has been maintained in subsequent years. The average annual revenue from cacao in the three years preceding 1937 was $38.66 per acre, as compared with a similar figure of $51.49
per acre for the period 1937-1939. Seasonal fluctuations in climate and prices have a great effect on the revenue obtained for cacao and the increase after 1937 cannot be attributed to rehabilitation; but this scheme has not in any way impaired the profits.

Discussion. The comparison between the costs of replanting and rehabilitation are interesting. Had field 24E been replanted it would have shown a total excess expenditure of about $80.47 per acre over the six year period 1934-1939, as it was the field showed a considerable profit of $178.35 per acre over the same period. The difference of $258.82 between these two figures is the total loss that the planter would have sustained had the field been replanted. It is true that the resultant yield on the replanted field will probably be considerably better than on the rehabilitated one, but the initial loss of revenue and increased expenditure as a result of replanting is far in excess of that which could be afforded by the majority of planters to-day. Whereas it is hoped that through a rehabilitation programme the yields of a field may be markedly increased with little loss in revenue and only a slight increase in expenditure, as is the case in field 24E.

The costs of rehabilitation in this particular case on a Chocolate soil are considerably smaller than can be expected, on a soil of less fertility. Very little expense was incurred through cultural improvements, whereas on poorer soils the need of manuring, draining and round-ridging will greatly increase the expenditure. At the same time the returns from bananas will be less, and a slight drop in the field yield for 2 to 3 years after rehabilitation can usually be expected. It may be anticipated, however, that the trees in a rehabilitated field will ulti-
<table>
<thead>
<tr>
<th></th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of Trees</td>
<td>$2.00</td>
<td>$1.50</td>
<td>$1.00</td>
<td>$2.00</td>
</tr>
<tr>
<td>Pruning</td>
<td>$1.20</td>
<td>$1.20</td>
<td>$1.20</td>
<td>$3.60</td>
</tr>
<tr>
<td>Supplying, shading, etc.</td>
<td>$4.77</td>
<td>$4.77</td>
<td>$4.77</td>
<td>$9.17</td>
</tr>
<tr>
<td>Manuring</td>
<td>$1.00</td>
<td>$1.00</td>
<td>$1.00</td>
<td>$3.00</td>
</tr>
<tr>
<td>Arronoeering</td>
<td>$0.50</td>
<td>$0.50</td>
<td>$0.50</td>
<td>$1.50</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$1.00</td>
<td>$1.00</td>
<td>$1.00</td>
<td>$2.33</td>
</tr>
<tr>
<td>Total Expenditure</td>
<td>$12.00</td>
<td>$6.50</td>
<td>$5.50</td>
<td>$24.00</td>
</tr>
</tbody>
</table>

* Replacements: 20% of Trees to be removed and 10% are blanks.
mately benefit from the improved cultural operations and manurial policy.

The cost of rehabilitating 1 acre of cacao in the Moruga District has been estimated and is shown in Table 19. The total expenditure of $24.00 per acre for the first three years is probably on the high side, but is nearer the average cost for rehabilitation on the poorer soil types than the $17.66 figure obtained on field 24E, as the best indication of growth rate. Between 25 and 40 supplies were measured in each field for different and has allowed for manuring and miscellaneous (including draining, etc.). The figure for pruning is approximately $2.50 less than that obtained a field 24E, and the cost for supplying and provision of shade is similarly greater. These differences would be expected on a less fertile soil than the Chocolate type. In this estimation no allowance has been made for the revenue that would be obtained from bananas, planted for shade. On field 24B it was shown that the revenue from bananas was double the extra expenditure, and it is probable that they would more than pay for the expenses of rehabilitation in the Moruga District.

Bananas used for shade on a replanted field suffered to a great extent from leaf spot disease, which inhibits their future use as a source of revenue on a large scale, but this disease was not apparent in the rehabilitated area on field 24E. Both the maximum and the minimum girth was measured on each supply and an average of the two was taken for the final estimate.
(5) Growth of Supplies.

As the supplies planted, since the rehabilitation experiments were started, have not yet come into bearing to any appreciable extent, it was thought that a good indication of the progress and health of supplies could be obtained by measuring their growth. For this purpose the girth measurement of a large number of supplies was taken as the best indication of growth rate. Between 35 and 40 supplies were measured in each field for different aged supplies where this was possible. At the same time the suitability of the sight and overhead shade of each picket was noted. The difficulty of determining the extent of shading by eye was apparent, and for this reason only extremes of shading were noted. Even so the figures for shading cannot be taken as being very accurate for a supply marked as being overshaded in a field which has generally an open canopy, might not be so marked in comparison with a supply of similar shading in a field with a very dense canopy.

The girth was taken at a height of 1 foot above ground level. At this point the trunk has attained a uniform girth, and is not affected by the increased girth of the trunk just above the ground, not by the effects of low branching (very few supplies branch below the 2 feet level). Both the maximum and the minimum girth was measured on each supply and an average of the two was taken for the final estimate.

The supplies selected to be measured were taken at random from the field sheets, being evenly distributed over the whole field. This method obviated the tendency to choose trees in the field, which were not truly representative of the conditions under which they were growing.
**TABLE 20.** Average girth measurement in cms. of supplies in a replanted and rehabilitated fields.

<table>
<thead>
<tr>
<th>Field</th>
<th>Soil Type</th>
<th>Age of Supplies in 1939-40</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>24Bi*</td>
<td>Chocolate</td>
<td>9.2</td>
</tr>
<tr>
<td>21A</td>
<td>Alluvial</td>
<td>5.5</td>
</tr>
<tr>
<td>21D</td>
<td>Alluvial</td>
<td>-</td>
</tr>
<tr>
<td>21C</td>
<td>Brasso Sand</td>
<td>-</td>
</tr>
<tr>
<td>257B</td>
<td>Brasso Clay</td>
<td>-</td>
</tr>
<tr>
<td>17D</td>
<td>Chocolate</td>
<td>-</td>
</tr>
<tr>
<td>24B</td>
<td>Chocolate</td>
<td>-</td>
</tr>
</tbody>
</table>

* Replanted in 1934

---

**TABLE 21.** Comparison of average girth measurements in cms. between supplies on good and bad sites.

<table>
<thead>
<tr>
<th>Field</th>
<th>5 &amp; 6 year old Supplies</th>
<th>3 year old Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field Average</td>
<td>Good Sites</td>
</tr>
<tr>
<td>21A</td>
<td>5.5</td>
<td>5.8</td>
</tr>
<tr>
<td>21D</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>21C</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>24B</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Bad sites situated in low lying areas near river.
+ 6 year old supplies.
For a purpose of comparison all aged trees were also measured in a field on Chocolate soil, which was replanted in 1934, and which has been constantly resupplied in each succeeding year. These trees give a fair indication of the maximum growth which can be attained for cacao seedlings.

The results show a marked difference between rate of growth of supplies on different soil types, and these differences are shown in Table 20. As would be expected the trees on the replanted field (24B1), on Chocolate soil, show a marked superiority to same aged supplies on Chocolate soil and other soil types in rehabilitated fields.

On Alluvial soil 6 year old supplies measured 5.5 cms., compared with 9.9 cms. for the replanted trees. The average girth of 5 year old supplies on both Alluvial and Brasso Sand soils were markedly similar, being 4.1 cms. This figure is considerably better than that for similar aged supplies on Brasso Clay, measuring 3.3 cms., but by contrast 5 year old plants in the replanted field measured 7.2 cms.

Four year old supplies on field 17D on Chocolate soil, with an average girth of 4.3 cms., just exceeded that of replants one year older on Alluvial and Brasso Sand soils, but were 1.9 cms. smaller than same aged supplies on the replanted field. The average girth of 3 year old supplies both on Alluvial and Brasso Sand soils was 2.0 cms., as compared with 4.1 cms. on the replanted field, and 3.5 cms. exceptionally large. Mature trees under these unsuitable conditions seldom produce such cases, and it cannot be expected that supplies will do otherwise.

A fair indication of the growth rate of supplies on different soils is given by an estimation of the age at which supplies have the same average girth on various soils. For example a 3 year old supply on Chocolate soil would be equivalent to a 4 year old supply on Alluvial or Brasso Sand, and a 5 year old supply on Brasso Clay. The growth rate on Alluvial and Brasso Sand have been found to be practically identical, these figures have been grouped together.
rate of growth of replanted cacao ([6 years of age]) on Chocolate soil, appears to be 40 per cent. greater than that of same aged supplies on Alluvial.

On many of the fields there were low lying areas near a river, as explained in the field reports. A striking difference was found between the average girth of supplies on these poor sites compared with those of the remainder of the field, termed good sites, which is shown in Table 21. On the fields in question 7 to 10 of the supplies measured were in these low lying areas. The average girth of 6 year old supplies on field 21A was 4.6 cms. on the bad sites compared with 5.8 cms. on the remainder of the field. A marked similarity was again shown between the growth rate on both Alluvial and Brasso Sand soils, the girth measurement of the 5 and 3 year old supplies on both the good and bad sites being identical. The average girth of 5 year old supplies on both fields 21D and 21C measured 4.5 cms. and 3.1 cms. for the good and bad sites respectively. An average girth of 1.7 cms. on the low lying sites and 2.2 cms. on the remainder of the field was recorded for the 3 year old supplies on both fields 21A and 21C. On field 24B the difference between the average girths of 3 year old supplies on good and bad sites was not so marked, being 3.6 cms. and 3.2 cms. respectively. Besides the slow rate of growth of replants on these low lying areas, it has been pointed out that the mortality of supplies planted on these areas is exceptionally large. Mature trees under these unsuitable conditions seldom produce much cacao, and it cannot be expected that supplies will do otherwise.

Shading. The difficulties pertaining to the assessment of shading by eye have already been stated. The results taking extremes of over and undershading compared with suitable conditions are shown in Table 22. Since the growth rate on Alluvial and Brasso Sand have been found to be practically identical, these figures have been grouped together.
<table>
<thead>
<tr>
<th>Fields</th>
<th>Soil</th>
<th>Age of Supplies</th>
<th>Average No. of Girth Cms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21A, 21D</td>
<td>Alluvial</td>
<td>6, 5</td>
<td>3.9</td>
</tr>
<tr>
<td>21C</td>
<td>Brasso Sand</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>17D</td>
<td>Chocolate</td>
<td>5</td>
<td>4.0</td>
</tr>
<tr>
<td>257B</td>
<td>Brasso Clay</td>
<td>5</td>
<td>3.2</td>
</tr>
<tr>
<td>21A</td>
<td>Alluvial</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>21C</td>
<td>Brasso Sand</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>24B</td>
<td>Chocolate</td>
<td>3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Effect of Shading on Girth of Supplies:**

- **Over Shaded:**
  - 21A, 21D: 4, 5, 6, 5
  - 21C: 4, 5
  - 17D: 5
  - 257B: 5
  - 21A: 3
  - 21C: 3
  - 24B: 3

- **Under Shaded:**
  - 21A, 21D: 4, 5, 6, 5
  - 21C: 4, 5
  - 17D: 5
  - 257B: 5
  - 21A: 3
  - 21C: 3
  - 24B: 3

- **Normal:**
  - 21A, 21D: 4, 5, 6, 5
  - 21C: 4, 5
  - 17D: 5
  - 257B: 5
  - 21A: 3
  - 21C: 3
  - 24B: 3

**Average Girth Cms.:**

- 21A, 21D: 4.6
- 21C: 4.4
- 17D: 4.5
- 257B: 3.5
- 21A: 4.1
- 21C: 2.4
- 24B: 3.8
The results show marked differences under varying shade conditions. The differences have been further accentuated on fields 21A, 21D and 21C in that overshading most frequently occurs on the low lying sites near the river. General observations indicate that overshaded supplies are usually tall but spindly, whereas those on very open sites generally present a very stunted appearance.

The figures show that for 5 and 6 year old supplies on Alluvial and Brasso Sand soils, the average girth for over and undershaded supplies were 3.9 and 3.8 cms. respectively, compared with 4.6 cms. under favourable shading.

On field 17D, on Chocolate soil, the canopy was rather open and no badly overshaded supplies were encountered. The undershaded trees showed a slightly smaller girth by 0.4 cms. than those under suitable conditions. On Brasso Clay, field 257B, overshading seemed to have a much greater depressing effect on rate of growth than undershading.

The average girths of supplies over and undershaded being 2.4 cms. and 3.2 cms. respectively, compared with 3.5 cms. for the remainder of the supplies.

For the 3 year old supplies on Alluvial and Brasso Sand, the decrease in girth as a result of both extremes of shading was similar, and represented a 17 per cent. reduction over suitably shaded trees.

On field 24B, the average girth of 2.4 cms. for supplies on open sites was very small compared to those under suitable shading of 3.8 cms., but only 2 trees were available under the former conditions. The average girth of overshaded supplies on the same field was 3.0 cms.

Although the above figures cannot be taken as extremely accurate of differing shading conditions, large differences were obtained, and it is the opinion of the writer that degree of shading has a very marked effect on the rate of growth of supplies. The greater growth rate...
of supplies on a replanted field can largely be accounted for by the lack of overshaded conditions. The planter's dislike of cutting out trees and heavy pruning has resulted in the past in the very slow progress in growth of supplies, and the removal of parts of trees and whole trees must accompany any rehabilitation scheme. It is also apparent that the other extreme is almost as bad in slowing up growth, and the provision of ground shade and overhead shade is essential. The latter hinders to some extent the influx of disease and pests and also the young supplies against large changes in temperature and humidity within the field, which are deleterious in growth. The regulation of shade must depend to a certain extent on the existing conditions in the field.

The writer recommends that a further investigation into the effect of varying shade conditions should be carried out. The assessment of the degree of shading could be accurately determined by the use of a photoelectric cell.

The results of this investigation can be summarised as follows:

1. Young trees in a replanted field show a much greater growth rate than those in a rehabilitated area.
2. Soil types are found to have a great effect on the rate of growth of supplies. This is greatest on Chocolate, next in order come Alluvial and Brasso Sand, and finally Brasso Clay.
3. Trees on poor sites are markedly inferior to those on good.
4. Both extremes of shading appear to have a depressing effect on the girth measurement of supplies. This aspect of the subject should be further investigated.
(6) General Discussion and Summary.

The findings obtained for each individual field have been fully described in the field reports, the results have been grouped together here so that a more general picture of the progress of rehabilitation can be formed.

The execution of the rehabilitation programme in the present series of experiments cannot be regarded as ideal in many respects.

Recent investigations by the Department have shown that the yielding capacity of a tree cannot be accurately judged as a result of one year's records. They show that the percentage of trees averaging over 1 lb. of cacao over a number of years, which will yield less than 0.5 lb. as a result of rehabilitation, is as high as 26.3 per cent. This figure is reduced to 6.2 per cent, with trees yielding less than 0.5 lb. in two consecutive years.

This finding is rather borne out by an examination of Table 23, which shows the average percentage frequency before and after rehabilitation and the percentage frequency of the trees removed on fields 21A, 21D, 21C, 257B and 24B in the Montserrat District. All frequencies are expressed as a percentage of the total number of pickets. Before rehabilitation records for 1931-32, 1934-35 and 1935-36 were used (according to when fields were counted and when rehabilitated) and after rehabilitation records for 1937-38 and 1938-39.
TABLE 25. Percentage frequency of pickets before and after rehabilitation, and of trees removed.

<table>
<thead>
<tr>
<th>Class</th>
<th>Before Rehabilitation</th>
<th>After Rehabilitation</th>
<th>Difference</th>
<th>Trees cut out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanks</td>
<td>6.0</td>
<td>4.5</td>
<td>-1.5</td>
<td>-</td>
</tr>
<tr>
<td>1 - 4 years</td>
<td>8.9</td>
<td>20.4</td>
<td>+11.5</td>
<td>-</td>
</tr>
<tr>
<td>Yielding 'O' over 5 yrs</td>
<td>14.6</td>
<td>12.9</td>
<td>-1.7</td>
<td>5.2</td>
</tr>
<tr>
<td>&quot; 0.1 - 1.0</td>
<td>26.6</td>
<td>22.0</td>
<td>-4.6</td>
<td>5.0</td>
</tr>
<tr>
<td>&quot; over 1.0</td>
<td>44.3</td>
<td>40.1</td>
<td>-4.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The decrease in percentage frequency of trees over 5 years of age and yielding nothing was 1.7 per cent., as a result of rehabilitation. Actually 5.2 per cent. of this class were cut out so that the decrease was very much below what would have been expected. The records available for the recognition of low yielders were, however, only available for the one year immediately preceding rehabilitation. These figures are complicated by the difference between seasons on which the percentage frequencies were based. The yields for 1937-38 and 1938-39 were 18 per cent. lower than those for the seasons prior to rehabilitation, which would tend to lower the number of high yielders and increase the percentage of low yielders, making the difference for the latter, as a result of rehabilitation, smaller than it should have been. This is borne out by the figures, for the decrease in percentage frequency for trees yielding over 1 lb. was 4.2, whereas only 2.3 per cent. were removed. Table 23 does nevertheless show certain beneficial effects resulting from rehabilitation. Blank pickets have been reduced and the number of supplies under 5 years of
age, on the fields in question, have been increased, until on an average over one fifth of the fields are now occupied by supplies under 5 years of age. The figures also show that even though a large number of unprofitable trees removed from a field, many others will remain. Rehabilitation should, however, be a continuous process once started, and the steady replacement of unprofitable trees over a number of years should greatly increase the total yield when the supplies come into bearing.

Now that several years records are available for the fields, which have been rehabilitated, no difficulty should be experienced in recognising poor yielders in the future. For the average planter no such records are available and the cost of obtaining them on a large scale would be prohibitive. In this case a system of marking poor yielders at the time of picking should be introduced, and should be carried out over a two year period before removal. Obviously unproductive, damaged or diseased trees should be replaced at once. The planter is recommended to replace only the most unprofitable trees at first, and to gradually increase the standard for cutting out in each succeeding removal.

(b) **The effect of rehabilitation on total yields.**

The effect of cutting out and heavy pruning of a large number of trees on the field yield is complicated by the fluctuating trend in yields from year to year. It would appear that the cutting out of over 12 per cent. of the total pickets results in a depression in the field yield, greater than would be accounted for the yield of the removed trees, in the year immediately following the removal. Recovery in yield usually takes place within one or two years. Recovery is very much quicker on Chocolate than
Trends in Yield of Heavily Pruned Trees

Graph I. Alluvial Soil

Field 11 A (1934)
Field 21 B (1935)

Graph II. Chocolate Soil

Field 110 (1934)
Field 146 (1935)

Graph III. Brasso Sand

Field 21 C (1937)

Graph IV. Brasso Clay

Field 257 B (1936)
The removal of over one fifth of the trees on field 17D on Chocolate soil had no apparent depressing effect on the total yield. On field 21D on Alluvial soil, the removal of a similar number of trees depressed the yield by over one half of the former level, and recovery is not complete after 5 years. On field 28C on Moruga Marly Silt, the cutting out of 22.0 per cent. of the total pickets had no apparent adverse effect on the total yield in the following year. On nearly every field recorded by the Department over one fifth of the total pickets could be removed, which contributed only about one twentieth of the total yield. The writer does not recommend the removal of more than 20 per cent. of the total pickets at a time, on soils other than Chocolate, because it may have an adverse effect on the total yield in subsequent years.

Vegetative propagation by budding or use of cuttings. The yield trends of heavily pruned trees and yield per picket for the whole fields are shown in Graphs I, II, III, and IV. In all fields and on all soil types, the trend in yields per tree of heavily pruned trees were found to follow very closely the trend in yields per picket of the whole field. The yield of pruned trees usually drops to a greater extent than the yield of the field in the first year, but no exceptional recovery such as that found by Van Hall (27) has yet taken place. The trees do not, as a whole, show any loss in yield over the period after considered. The disinclination of planters to subject trees to severe pruning is unfounded on the grounds of any deleterious result on the tree yield. The importance of the regulation of shade for the growth of supplies has already been stressed, and any parts of mature trees, which heavily overshadow the site to be planted should be removed.
Planting Material. The planting material used in the present series of rehabilitation experiments were selected estate seedlings. It is probable that within a few years better planting material will be available on a large scale and at a comparatively small cost. Pound (19) has shown the great variation which exists between trees in the number of beans per pod, the weight of individual beans and the number of pods produced. Following this investigation Cheesman and Pound (4) selected 100 high yielding cacao trees from a variety of soils and districts. Harland (14) has shown, however, that a high yielding tree may fail to transmit its desirable characters to its seedling progeny. Nevertheless, until vegetatively produced plants are available, planters are advised to use selected seedlings from high yielding and good quality trees only.

Vegetative propagation by budding or use of cuttings, provides a means whereby the desirable properties of a parent can be transmitted to its progeny. Pound (20) has found that the variability in bearing capacity was less among budded clones than among seedling trees from the same parent, and that the rootstock has a marked influence on bearing capacity. There are, however, two disadvantages to budded cacao. One that if the tree is required to be replaced by a sucker the latter will be of the stock and not scion variety, and two that fan buds result in low spreading branches and absence of a main trunk. The latter objection can be overcome by either budding high with a fan bud or low with a chupon bud.

Whereas budding has been practised in a limited way for many years, the use of cuttings has only been made possible in comparatively recent years, on account of the difficulties of establishment. Cheesman (3) (5) and Pyke (22) have successfully established both fan and chupon
cuttings, although special propagators have to be used. Initial differences in type of rooting of these cuttings was not found to persist after two years. Fan cuttings branch and spread obliquely close to the ground, whereas chupons tend to put up a vertical leading shoot more akin to a seedling.

Recently investigations have been carried out into the importance of compatibility in cacao. Voelcker (28) and Cope (7) have found that self compatible trees give significantly higher yields than self incompatibles. The full practical importance of this discovery is not yet known. Much of the work on improved planting material is yet in the experimental stage, but it is hoped that before long uniform material for growing under varying conditions will be available to the planters. The planter should not, however, rely on all his problems to be solved by improved planting material, without improving the unsatisfactory and neglected conditions now existing within the majority of cacao fields.

Mortality of Supplies. One of the most striking features of this investigation is the very high mortality amongst supplies. Graph V shows the percentage number of supplies living in the 4 years following the year in which they were planted. The total average loss for the fields in question was found to be 22 per cent. for the first three years. As would be expected the greatest loss occurred in the first year following supplying, amounting to an average of 13 per cent., but the mortality continued to an appreciable extent over the succeeding 3 years.

No valid reason can be given for the great difference between loss of supplies on fields 21A and 21D, both are situated on Alluvial soil, are on the same estate and
### TABLE 24. Mortality of Supplies on Good and Bad Sites.

<table>
<thead>
<tr>
<th>Field</th>
<th>Year Supplied</th>
<th>TOTAL</th>
<th>Poor Sites*</th>
<th>Good Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Supplied</td>
<td>No. Dead</td>
<td>%</td>
<td>No. Supplied</td>
</tr>
<tr>
<td>21A</td>
<td>1934</td>
<td>63</td>
<td>15</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>1937</td>
<td>80</td>
<td>19</td>
<td>23.7</td>
</tr>
<tr>
<td>21C</td>
<td>1935</td>
<td>223</td>
<td>62</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>1937</td>
<td>123</td>
<td>28</td>
<td>22.3</td>
</tr>
<tr>
<td>24B</td>
<td>1937</td>
<td>298</td>
<td>36</td>
<td>12.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>787</td>
<td>162</td>
<td>163</td>
<td>40.0</td>
</tr>
</tbody>
</table>

* Mainly low lying areas near the river.
have received the same attention. Yet on field 21D, only 4 per cent. of the supplies were lost over the first four years, compared with 24 per cent. on field 21A. The records available fail to show any cause for the high mortality of supplies in most cases, which can be pruned and trimmed, to be recommended in future planting schemes.

Poor Sites. It is possible that the cut out trees were low yielders on account of some deficiency or unsuitability of the soil or sites they occupied. It is unlikely in this case that the supplies will thrive any better in such sites. In several of the fields low lying areas near the river have never produced good cacao and the supplies planted on these sites have been subject to a far greater loss than on the remainder of the field. The actual figures obtained are shown in Table 24.

The total loss of supplies on the fields 21A, 21C and 24B was 20.5 per cent. On the low lying sites near the river the mortality was as high as 40.0 per cent., as compared with only 15.5 per cent. on the remainder of the field. In each field the death of supplies on poor sites was found to be surprisingly high and this accounts in part for the very high mortality of supplies on these fields. When it is also considered that the supplies surviving in these areas grow at a relatively slow rate (see section 4), the rehabilitation of such areas cannot be recommended.

The same reasoning applies to unsuitable soils as the Brasso Clay type. Disease. The removal of a large percentage of the area population and heavy pruning undertaken during

Casualty Factors. On Chocolate soil falling immortelles were found to account for 12.1 per cent. of the death of supplies, and to have damaged but not killed a further 9.5 per cent. of the surviving supplies. This immortelle damage on Chocolate soil is very considerable, and it is recom-
mended that exceptionally large and insecure trees should be cut down before the rehabilitation programme is commenced. In this way their fall can be controlled and any damage caused can be repaired at once. The use of the Dadap species of immortelle, which can be climbed and pruned, is to be recommended in future planting schemes.

On others fields a variety of causes have contributed to the high casualty rate of supplies. In one case (field 51B2) Witches' Broom disease caused extensive damage. In several instances thrip attacks have been very marked in rehabilitated fields. The lack of adequate provision of ground shade, the lack of sufficient weeding and arrondeering, and general neglect of supplies after planting has caused the high mortality in others.

It is of paramount importance that supplies should not only receive careful treatment at the time of planting but also in subsequent years. Young supplies must be protected by ground shade and should always be arrondeered as a prevention against cutlas damage. It is recommended that 3 or 4 plants of cassava or tannia should be planted about 18 inches around the supply site, not only to provide ground shade, but also as a protection against cutlas wounds. Bananas should be planted to provide light overhead shade, where the removal of trees have left large open areas.

Pests and Diseases. The removal of a large percentage of the tree population and heavy pruning, undertaken during a rehabilitation programme, results in a considerable opening up of the canopy and makes conditions favourable for the advent of pests and diseases, particularly thrips. Fields 17D, 51B2 and 33A are all suffering from thrip infestations. It is likely that on field 51B2 (see page 63)
<table>
<thead>
<tr>
<th>Field</th>
<th>Soil Type</th>
<th>Yield of Rehabilitated Supplies in 1939-40</th>
<th>Average Yield of Supplies from 1935-36 to 1939-40 Aged:</th>
<th>Field</th>
<th>Soil Type</th>
<th>Yield of Rehabilitated Supplies in 1939-40</th>
<th>Average Yield of Supplies from 1935-36 to 1939-40 Aged:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age</td>
<td>No.</td>
<td>Total Yield in lb.</td>
<td>5 - 9 Years</td>
<td>10 - 14 Years</td>
<td>15 - 19 Years</td>
</tr>
<tr>
<td>21A</td>
<td>Alluvial</td>
<td>6</td>
<td>48</td>
<td>5.9</td>
<td>133 0.7</td>
<td>71 1.4</td>
<td>61 1.3</td>
</tr>
<tr>
<td>21D</td>
<td>Alluvial</td>
<td>5</td>
<td>348</td>
<td>2.9</td>
<td>224 0.1</td>
<td>91 0.7</td>
<td>66 1.1</td>
</tr>
<tr>
<td>21C</td>
<td>Brasso Sand</td>
<td>5</td>
<td>161</td>
<td>11.4</td>
<td>160 0.2</td>
<td>75 0.5</td>
<td>76 0.4</td>
</tr>
<tr>
<td>257B</td>
<td>Brasso Clay</td>
<td>5</td>
<td>88</td>
<td>-</td>
<td>20  -</td>
<td>75 0.2</td>
<td>76 0.4</td>
</tr>
<tr>
<td>17D</td>
<td>Chocolate</td>
<td>4</td>
<td>307</td>
<td>0.9</td>
<td>230 0.6</td>
<td>183 1.0</td>
<td>186 1.5</td>
</tr>
</tbody>
</table>
thrip damage has resulted in the death of many young supplies, and the same was probably the case on the other two fields. On field 51B2 much damage has also been caused by Witches’ Broom disease.

Where supplies are badly attacked by thrips hand spraying with Bordeaux Mixture is an effective method of control. There is also a possibility that the spread of the thrips parasite Dasycapus Farvipennis (1) may reduce the incidence of this pest. It is recommended, however, that where any pest or disease, such as Witches’ Broom, is particularly prevalent, rehabilitation should not be attempted until these factors are under control.

Age of Bearing of Supplies. The yield of supplies planted since the rehabilitation experiments were commenced, and the yields of various aged supplies planted previously are shown in Table 25. The rehabilitated supplies have so far given a negligible yield, despite the fact that 1939-40 was a particularly favourable year for cacao. The fact that supplies can be quickly brought into production on suitable soils is shown on fields 21A and 17D, in which supplies aged 9 to 14 years yielded at an average rate of over 1.0 lb. of cacao over a number of years. On field 257B on Brasso Clay the average yield of 15 to 19 year old supplies was only 0.4 lb. of cacao, which again stresses the impracticability of attempting to rehabilitate such areas. The late age at which supplies come into bearing on fields 21D and 21C is typical of the majority of fields in Trinidad. It is hoped that better methods of management and in future, improved planting material will hasten and increase the yielding capacity of supplies. In contrast to the above figures, the average yield of field 24E1, which was replanted in 1934, was 0.3 lb. per picket in 1938-39 and 0.6 lb. per
picket in 1939-40. Although it is early yet to form any definite opinion it is hoped that the rehabilitated supplies will play an increasing part in enhancing the total yield of fields within a few years. In every 3 or 5 years is advised.

General. Although it will be some years before the full benefit of rehabilitation will be felt in the present series of experiments, their progress cannot be regarded as completely satisfactory. Apart from cutting out unprofitable trees, pruning and supplying, the experimental fields have not received as much attention as they should. On no field was a suitable manurial policy adopted at the time of rehabilitation. Draining and roundridging, where necessary, have often been left undone. The regulation of shade has often not been thoroughly supervised. Some supplies have been badly overshadowed and others left in too exposed conditions. The provision of ground shade immediately round supplies has frequently been inadequate or unpractised. General neglect in cultivation after planting has added to the lack of measures, which should be taken if full benefits are to accrue from a programme of rehabilitation.

A planter will tender lavish care on replanting a field, whereas supplying on an old field is liable to be forgotten. Although there is practically everything to be said for replanting, it has been shown in section 4 that replanting, involving total loss of revenue and increased expenditure, cannot be undertaken by planters under present circumstances. Rehabilitation provides the only means by which the yields of fields can be restored, and the serious situation of the moment saved. As much, if not more, careful supervision should be given to the establishment of supplies in a rehabilitation programme as in replanting. It is recommended that only part of an estate should be rehab-
ilitated at one time to ensure that this part is thoroughly treated under close supervision. The division of an estate into 5 or 6 sections and the repeated execution of a rehabilitation programme on each section once in every 5 or 6 years is advised.

2. On all, except the worst soil types, such as Brasso Clay, there is no reason why unprofitable trees in a field should not be replaced by supplies, with a potentially greater yielding capacity.

3. Whereas the loss of revenue and increased expenses make the cost of replanting prohibitive, rehabilitation could be carried out extensively with little extra expenditure.

4. The execution of a programme of rehabilitation in a number of experiments has been reviewed and was not found to be ideal.

5. The cutting out of trees on up to 30 per cent. of the total pickets appears to have an adverse effect on the total yield in the year immediately following the removal, but recovery takes place in two to three years. The effect was less marked on Chocolate soil.

6. Heavy pruning did not generally have an adverse effect on the yield of pruned trees in subsequent years.

7. The mortality of supplies has been high. General neglect, weedy conditions, lack of ground shade, pests and diseases (and immortelle damage on Chocolate soil) are the main factors responsible for the high casualty rate.

8. On poor soils, such as Brasso Clay, and on unsuitable sites, such as low-lying sites near the rivers, the mortality of supplies has been excessive, and the growth rate of supplies very slow. The rehabilitation of such areas cannot be recommended.

9. 5 and 6 year old supplies planted during the rehabilitation programme have given no appreciable yield up to date.

10. It is recommended that a programme of rehabilitation should not be attempted where pests and diseases (thrips and Witches' Broom) are particularly prevalent, until effective control measures have been taken.

11. It is recommended that the experimental areas should be subjected to a further programme of rehabilitation.
SUMMARY AND RECOMMENDATIONS.

11. On the majority of fields in Montserrat, Rio Claro, Moruga and Toco Districts, a large proportion of the yield is contributed by a comparatively small percentage of the total pickets.

12. On all, except the worst soil types, such as Brasso Clay, there is no reason why unprofitable trees in a field should not be replaced by supplies, with a potentially greater yielding capacity.

13. Whereas the loss of revenue and increased expenses make the cost of replanting prohibitive, rehabilitation could be carried out extensively with little extra expenditure.

4. The execution of a programme of rehabilitation in a number of experiments has been reviewed and was not found to be ideal.

5. The cutting out of trees on up to 20 per cent. of the total pickets appears to have an adverse effect on the total yield in the year immediately following the removal, but recovery takes place in two to three years. The effect was less marked on Chocolate soil.

6. Heavy pruning did not generally have an adverse effect on the yield of pruned trees in subsequent years.

7. The mortality of supplies have been high. General neglect, weedy conditions, lack of ground shade, pests and diseases (and immortelle damage on Chocolate soil) are the main factors responsible for the high casualty rate.

8. On poor soils, such as Brasso Clay, and on unsuitable sites, such as low lying sites near the rivers, the mortality of supplies have been excessive, and the growth rate of supplies very slow. The rehabilitation of such areas cannot be recommended.

9. 6 and 5 year old supplies planted during the rehabilitation programme have given no appreciable yield up to date.

10. It is recommended that a programme of rehabilitation should not be attempted where pests and diseases (thrips and Witches' Broom) are particularly prevalent, until effective control measures have been taken.

11. It is recommended that the experimental areas should be subjected to a further programme of rehabilitation.
in the near future, as the percentage of low yielding trees is still high on many of the fields.

12. It is thought that both over and under shaded conditions are deleterious to the growth of supplies. The importance of the regulation of shade should be further investigated.

13. It is recommended that future rehabilitation experiments should be given closer supervision and that part of the field should be left untreated to act as a control.

14. The importance of manuring on growth of supplies should also be investigated.
The writer wishes to express his indebtedness to Mr. A.L. Jolly for suggestions and criticisms offered in connection with this work. He would also like to take this opportunity of thanking Professor C.Y. Shephard, the Planters, on whose estates the work is being conducted, and the staff of the Department of Economics for their assistance and co-operation.


# APPENDIX I. List of Fields Used in Analyses for Part I.

## MONTSERRAT DISTRICT

**Chocolate Soil:** Age and Analyses for 1931-32

- 17E and 17D - 45 years old
- 17C - 50 "
- 17B - 60 "
- 17A - 70 "

**Brasso Clay:** Age and Analyses for 1932-33

- 56A and 56B - 20 years old
- 56C and 56D - 25 "
- 56E and 56F - 30 "
- 56G and 56H - 40 "
- 257A and 257B - 45 "


- 51B1a, 51B1b and 51B2 - 21 years old
- 51A1 and 51A2 - 43 "


- 28B and 187A - 26 years old
- 28A - 31 "
- 192A and 192B - 41 "
- 197A and 243B - 41 "
- 25A - 46 "
- 243A - 60 "


- 33A, 101A and 259A - 41 years old
<table>
<thead>
<tr>
<th>Map No.</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>XIIID.</td>
<td>21A</td>
</tr>
<tr>
<td>XIID.</td>
<td>21D</td>
</tr>
<tr>
<td>XVIIIC.</td>
<td>21C</td>
</tr>
<tr>
<td>XIC.</td>
<td>257B</td>
</tr>
<tr>
<td>XXC.</td>
<td>17D</td>
</tr>
<tr>
<td>XXIVA.</td>
<td>24B</td>
</tr>
<tr>
<td>XXVIB.</td>
<td>51B2</td>
</tr>
<tr>
<td>XXVIII.</td>
<td>XXXII.</td>
</tr>
<tr>
<td>XXXI.</td>
<td>XXXIII.</td>
</tr>
<tr>
<td>XXXII.</td>
<td>28C</td>
</tr>
</tbody>
</table>
MAP No. XIIIId.

YIELD OF INDIVIDUAL PICKETS

JULY 1937 to JUNE 1938

FIELD 21A

SOIL: ALLUVIAL

AGE OF FIELD: 82 YEARS

Planting distance: 12 ft. by 12 ft.

Note: Each square represents a picket or tree-site, and each circle an "extra," "middle" or "false" tree. See key for yield of each picket.

KEY

YIELD IN LB.

OVER 6.2

3.8-6.2

2.3-3.7

1.3-2.2

1.2-2.1

0.7-1.2

0.4-0.7

0.3-0.4

Unc

X Subplots under 7 years at age (1939-40)
MAP No. XIII.
YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 21D
SOIL: ALLUVIAL
AGE OF FIELD: 52 YEARS
Planting distance: 12 ft. by 12 ft.
Note: Each square represents a picket or tree-site, and each circle an "extra," "middle" or "false" tree. See key for yield of each picket.

KEY
YIELD IN LB.
OVERT 6.2
3-8-2
2-3-7
1-3-2
8-1-2
4-7
0-3

x Sites under 6 years of age
(1939-40)
MAP No. XVIII.

YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 21C
SOIL: BRASSO SAND
AGE OF FIELD: 77 YEARS
Planting distance: 12 ft. by 12 ft.
Note: Each square represents a picket or tree-site, and each circle as "para," "middle" or "falta" tree. See key for yield of each picket.

KEY
YIELD IN L.B.

- Supplies under 6 years of age (1939-40)
YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 257B
SOIL: BRASSO CLAY
AGE OF FIELD: 50 YEARS
Planting distance: 12 ft. by 12 ft.
Note: Each square represents a picket or tree-site, and each circle an 'extra,' 'middle' or 'false' tree. See key for yield of each picket.

KEY
YIELD IN LB.

OVER 62
38-62
25-37
13-22
9-12
6-7
4-3
0-2

* Supplies under 6 years of age (1933-40)
MAP No. XX c.
YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 17D
SOIL: CHOCOLATE
AGE OF FIELD: 51 YEARS

Planting distance: 12 ft. by 12 ft.

Note: Each square represents a picket or tree-site, and each circle an "extra," "middle" or "false" tree. See key for yield of each picket.

KEY
YIELD IN LB.

OVER 6.2
3-8 -6-2
2-3-3-7
1-3-2-2
-8-1-2
•4-7
0-3

x Supplies under 6 years of age (1937-40)
MAP No. XXIV A.
YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 24B
SOIL: CHOCOLATE
AGE OF FIELD: 82 YEARS

Planting distance: 12 ft. by 12 ft.

Note: Each square represents a picket or tree-site, and each circle an "extra," "middle" or "false" tree. See key for yield of each picket.

KEY
YIELD IN LB.

OVER 62
38-62
25-37
15-22
9-12
6-7
3-0

X Supplies under 6 years of age (1935-40)
MAPS Nos. XXVIa, XXVIIa, XXVIIIa

YIELD OF INDIVIDUAL PICKETS

YIELD IN LB.

Note: Each square represents a plot of two acre and each color or shade represents one throw. Numbers at the bottom of each column indicate yields.

KEY

- Supplies under 6 years of age (1929-40)

Field 51B2 only one rehabilitated.
MAP No. XXXXI.

YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 33A
SOIL: QUARTZ SCHIST
AGE OF FIELD: 40 YEARS

Note*: Each square represents a plot of 10 x 10 ft. and each circle an "extra," "middle," or "full" tree. See key for yield of each plot.

Note: This field is a continuous one but for convenience of printing has been subdivided at "A."
MAP No. XXXII.
YIELD OF INDIVIDUAL PICKETS
JULY 1937 to JUNE 1938
IN
FIELD 28C
SOIL: MORUGA MARLY SILT
AGE OF FIELD: 45 YEARS

Planting distance: 12 ft. by 12 ft.
Note: Each square represents a picket or tree-site, and each circle an "extra," "middle" or "false" tree. See key for yield of each picket.

KEY
YIELD IN LB.

- OVER 6.2
- 3.8-6.2
- 2.3-3.7
- 1.3-2.2
- 0.8-1.2
- 0.7-1.2
- 0.1-0.7
- 0.0-0.1

X Supplies under 6 years of age (1939-40)