A SURVEY OF BANANAS IN TRINIDAD

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D.T.A. Report

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PART I
SECTION A

General Introduction

Departments of Agriculture frequently find it necessary to collect information about areas under their care, indeed paucity of information often limits the efficiency of agricultural officers in the tropics.

Recurrents available to a department are always limited and information is therefore needed to ensure that they are used to the best possible advantage. For example low yields of an important crop would indicate a research programme but before the potential value of such a programme would become apparent both the importance of the crop and the occurrence of low yields would have to be known. Again the appearance of an unknown disease in a cash crop would require that information about how far production was limited and how widespread the disease was before expensive research was undertaken.

Information is also necessary for administrative reasons, for example knowledge of population density, crop yields and degree of fragmentation in an area might indicate that a land settlement was required. Such a finding would create a need for even more information about proposed settlement areas, the occurrence of diseases of humans and stock, the rainfall and its distribution, the water supplies and the possibility of erosion would all have to be known before action could be taken.

Sometimes such information can be collected from records already existing, for example the total production of arrowroot in Saint Vincent could be found from export
records or the production of sugar cane in Barbados found from factory records.

In underdeveloped countries it is often found that even the most simple records are not kept and that other methods of obtaining desired information must be employed. Examples in this case are that it might be necessary to know the population of an area, the proportion of cultivated land to fallow, the average yield of a crop or the average size of families. A complete survey would, in many cases, cost so much that it could not be considered but a sample survey would cost far less and would yield results of an accuracy sufficient for the purposes to which they were to be put. In addition the accuracy of the results may be computed from the data themselves.

As well as cheapness sample surveys offer several other advantages, in the first place they are relatively quick, a full scale survey may take so long to prepare and execute that the findings may be out of date before they can be used. In the case of a run of bad yields, for example, a possible famine might be suspected and only a sample survey could measure the food reserves of an undeveloped country rapidly enough for counter measures to be taken if these were required. Sample surveys also allow the collection of extremely detailed information, this is because a large range of facts may be collected about a small number of farms, if this were attempted on all farms costs and administrative difficulties would be prohibitive.

From this short introduction it can be seen that the sample survey, in the hands of the agriculturalist, is a tool of great importance.
PART I

SECTION B

Particular Introduction

A survey conducted by a group of students during a one year course is, to a large extent, artificial. In the first place a sample survey is not undertaken because it is the best tool with which to collect certain required information but rather a sample survey is undertaken and the information gained is of secondary importance. In this sample survey an attempt was made to decide upon a subject which would yield interesting and useful results but it should be remembered that this was done within the framework of the sample survey as an academic exercise. The real results of a survey such as this are to be measured by the training in the use of the technique received by the student group rather than in terms of the value of their findings.

Other factors also limit the possible choice of subject to some extent, for example the enumeration can only be done at Christmas because the enumerators are available only at that time. Thus crops at an unsuitable stage of growth at Christmas cannot be surveyed, an example here is rice.

The whole survey must be planned and prepared before Christmas and this leaves little time for the testing of methods and procedures which is of particular importance and in addition lack of knowledge of local conditions and crops tends to lead to uninformed discussion in the early stages.

The students taking part in the survey were required to choose, plan and execute a sample survey under the general director of Dr. A.L. Jolly. G.E. Hodnett, Esquire advised
upon statistical matters. Initially there were seven students doing the survey as their main project and in addition about 30 post graduate students were available for one week in December to act as enumerators.

After initial discussions three of the above seven students withdrew leaving J.W. Auckland, J.R. Bird, G. Farley and A. Denness. The last named was particularly interested in the statistics of the survey.

The following surveys seemed possible and were examined by the group:

1. A survey of some aspect of cocoa production in Trinidad. Including the Cocoa Improvement Scheme.
2. A survey designed to estimate future production of citrus in Trinidad.
3. A survey to find some of the reasons why the production of export bananas in Trinidad is uneconomic.

The first subject was dropped as it proved impossible to find a suitable facet of production to investigate and the choice between 2 and 3 decided by a show of hands, thus the final choice lay in the personal preference of the majority.

The survey adopted by the group was at that time outlined as follows:

1. **Purpose.** To detect and estimate certain factors which cause the collection of bananas for export by the Marketing Board to be uneconomic.
2. **Population.** Those producers who at present supply, or have supplied, the Marketing Board.
3. **Information to be collected.** Informed opinion as to what constitutes the main limiting
factors is on record. It is suggested that the choice of questions be guided by this. The following are put forward as possibilities.

(a) What is the ratio of stools of exportable to non-exportable types.
(b) Distance of plot from place of collection.
(c) Are bananas the main crop grown on the holding.

4. Collection. Visits to holdings by students enumerators supervised by the survey team.

5. Frame. A suitable frame, a list of producers is known to exist.

6. Choice of sample etc. - Left over for further discussion.

7. Isolated or repeated survey. Isolated.
PART I

SECTION C

Background to the Banana Industry

The group, having decided to do a survey of export bananas set out to acquire a through working knowledge of the industry in Trinidad. The following remarks are a summary of their findings and are based on the Caribbean Commission Pamphlet No. 33 (1957).

The export of bananas first started in 1932 but was discontinued on the outbreak of hostilities in 1939. In 1953 some Gros Michel bananas were exported to the United States but in 1955 the Marketing Board of Trinidad and Tobago signed a contract with an English firm to supply bananas of the Gros Michel and Cavendish type and supplies to the United States ceased.

The Marketing Board has certain powers, one of which is to regulate and control the export of bananas to places outside the Caribbean territories. In addition it can establish depots and agencies, enter into contracts for the sale, purchase and transport of bananas and grade the fruit. The Board may also regulate the price for bananas delivered at its depots.

The Marketing Board has an agreement with Union International Company Ltd. which requires the company to purchase all export bananas of the Gros Michel and Cavendish varieties restricted to bunches of a minimum of seven hands f.a.s. in Port of Spain and on quay, alongside lighter in Tobago. This contract was fixed at 5.8¢ B.W.I. per pound naked fruit for the first five years with revision at the end of that time and at the end of each subsequent three year period.

The method of working is as follows, the Marketing Board issues cutting notices to the growers some four to six days before a slip is expected.

The island is divided into a number of areas under the control of a supervisor, within these areas vehicles, accompanied by collectors, travel along definite routes and stop as necessary to select, weigh and pay for bunches offered by growers at points along the road. The growers receive 4½ per pound, the balance of 1¾ being used to meet expenses in marketing and to build up a reserve.

The bunches accepted at the roadside are weighed on the lorry and placed in polythene bags, the load is packed with banana trash and taken to the Wharf. Loading of the ship usually takes place at night and at this point bunches may be rejected.

Bananas in Trinidad are but rarely grown in pure stand, the bulk of the fruit being produced from plants intercultivated with cocoa. The export varieties are not the most suitable type for this purpose so the overall picture is one of various varieties of bananas and plantains, with a variable (and usually small) percentage of export types, grown among cocoa as a secondary and unimportant crop. As such the banana plants receive little care and work on cocoa takes precedence over their culture.

Farrel is also of the opinion that the strong local demand for the fruit offers strong competition to the Marketing Board.

The theoretical grounds for retaining an organisation for the export of bananas would appear to be that

cultivation: (Farrel 1958).

1. Could provide year round employment.
2. Could give high output per acre and per annum.
3. Could give a year round income.
4. Could provide a further source of income for the Colony.

These advantages would appear to be extremely desirable and indicate that an export banana industry would be of real value to Trinidad and Tobago.

...
SECTION a
PART a.

The Preparation of the Frame

In order to select a sample to be surveyed it is necessary to have a complete list of the units which in total constitute the population to be examined. Such a list forms one of the possible types of frames, in this case it can be seen that the frame required was a complete list of producers of export bananas. Other types of frames for example those obtained by the use of random co-ordinates on a map, were ruled out as not all the farms in Trinidad produce bananas for export, and only a very small percentage of the land area is occupied by bananas.

The preparation of a frame provided an important part of the work of the survey team. No suitable ready made frame existed so one had to be compiled.

The objects of the survey restricted the frame to those banana growers who sold all or part of their produce to the Marketing Board so the financial records of the board of payments to each producer provided a suitable starting point. These records had not, of course, been designed with frame preparation in view and it was necessary to consolidate them.

Members of the group examined these records and found that they were in the form of a file for each shipment. The sheets in the file were a record compiled at the roadside of all purchases made and showed the names of the vendors and

(a) The number of stems purchased.
(b) The weight of the stems.
(c) The payment made.

In addition a record was kept of the number of stems rejected;
<table>
<thead>
<tr>
<th>Purchase Slip No.</th>
<th>Supplier</th>
<th>Rate</th>
<th>Lbs.</th>
<th>Number of Stems</th>
<th>$ /</th>
<th>REJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20232</td>
<td>S. Dass</td>
<td>4¢</td>
<td>54</td>
<td>1</td>
<td>2.16</td>
<td>-</td>
</tr>
<tr>
<td>20233</td>
<td>V. Ledec</td>
<td>4¢</td>
<td>93</td>
<td>2</td>
<td>3.92</td>
<td>-</td>
</tr>
<tr>
<td>20234</td>
<td>M. Mendoza</td>
<td>4¢</td>
<td>30</td>
<td>1</td>
<td>1.20</td>
<td>-</td>
</tr>
<tr>
<td>20235</td>
<td>M. Estrada</td>
<td>4¢</td>
<td>92</td>
<td>3</td>
<td>3.68</td>
<td>-</td>
</tr>
</tbody>
</table>
the district in which the collection was made was noted at the top of each sheet. (Districts are administrative divisions, their approximate whereabouts are indicated by the name e.g. Toco, Sangre Grande). A short extract of the record for shipment seventy-two appears opposite.

The component parts of the complete shipment records were found to be records of the fruit collected by one lorry in one day and it was known that the lorries travelled over the same roads when collecting for each shipment.

This route travelled by a lorry in one day's collecting came to be known by the group as a 'Truck route'. The number of truck routes in each district varied; for example the Maracas district had only one truck route while Toco district had several.

It will be seen from the specimen record that the address of the producer is not given. The group considered this problem and decided that this difficulty could be overcome by various means which are later discussed (Part 4 Section A), the frame was therefore prepared from the records of the Marketing Board.

It has already been stated that the form of the records required modification before they were suitable for use as a frame. For example the use of the record for one shipment only was not possible as it was known (Farrel 1958) that many producers did not supply bananas for every shipment and that some growers who had supplied the Board in the past had ceased to do so while new ones had come in. In order to ensure that the frame covered all producers and not merely a section of them a consolidated list covering several shipments had to be made.
Identification of Truck Routes

In order to prepare as complete a frame as possible and at the same time to reduce the work involved, it was decided that a frame covering a period of six months would be desirable, but that one covering three months would be less adequate.

Work was accordingly started on the records of the most recent three month period available to the team (17.4.58, 16.5.58, 27.5.58, 9.6.58, 28.6.58) if time permitted it was intended to extend the list backwards in time and thus prepare a frame covering a six month period. By this means the group ensured that an adequate frame would be produced, and at the same time guarded against the possibility that if a 'six month' frame was attempted from the start the limited time available might mean that it would not be completed and would be useless. In fact it was only found possible to prepare the frame from a three month period.

The work of compiling a consolidated record for the whole of Trinidad would have been very great so a two stage sampling technique was employed to reduce it. Two stage sampling is more completely discussed in the next section but stated briefly it meant that the initial sample could be selected in terms of truck routes, the second stage sample only being picked in terms of producers. Thus the consolidated lists were only required for half the truck routes so reducing the work involved in consolidation. An additional and important advantage was that the sample forms would be in groups or clusters on the ground and not scattered randomly over Trinidad.
Identification of Truck routes.

It was necessary to gather together the records covering a three month period for each truck route, this was done in the following manner. (In order that the files might be recounted correctly each individual sheet was stamped with a serial number and the files then split down.) The records for each district for five collections (71, 72, 73, 74, 75) were then placed in separate piles. A long wooden beech was used for this work and in order to avoid confusion spaces were given for work in various stages of completeness, e.g. there were separate piles for complete truck routes, suspected truck routes, incomplete truck routes, etc.

The methods of identifying truck routes were various, in the case of small districts like Maracas and Cedros it was found that there was only one truck route per district. In larger districts with several truck routes all records signed by a certain collector were gathered together and examined. In some cases the name of a larger producer was found to figure on all five of the shipments even though the collector varied.

By using these means sets of five records were built up and tested to see whether they were in fact the five records of one truck route in the following manner. The five 'suspected' records were laid on a table in such a way that the names showed, a search was then made to see if any of these names appeared on all five sheets and if a number of named appeared on at least three or four sheets, if this occurred then the records were held to represent a truck route. It was frequently found that only three or
four of the shipment records matched, the incorrect sheet was then substituted by another from that district to try to obtain agreement with the other four.

In this manner a total of thirty two truck routes were built up for the whole of Trinidad. They were designated by the district in which they occurred and by a letter. Thus the three truck routes in the Biche district were known as Biche A, Biche B and Biche C.

Consolidation of the selected truck route records.

The first stage sampling procedure resulted in the selection of sixteen truck routes and these were consolidated. Clip-cards were used for this purpose because the alternative method, a list on paper, was unwieldy. Clip-cards may be considered as a piece of paper, the lines of which may be arranged in any desired order and, if required, sorted into sections.

The method used was to prepare a card for each producer whose name appeared on the record for the truck route. The card showed the following data:

(a) The producer's name.
(b) The number of shipments made.
(c) The number of stems shipped in each shipment.
(d) The total stems shipped in the period.

In addition a code number representing the name of the truck route was stamped on each card.

The frame when prepared could by no means be considered perfect and it is proposed to discuss its defects under headings given by Yates (1953 4. 8.)(1)
1. Inaccurate. The frame did not suffer from this defect except for the possibility of people who were not producers selling stolen bananas or people acting as agents and giving their own names. (For example if a labourer on an estate sold bananas from the estate his name would not represent the producer).

2. Incomplete. As export bananas may only be sold through the Marketing Board the frame may be considered to be complete in respect of the period covered.

3. Subject to duplication. There is a strong possibility that a number of holdings appeared more than once on the frame due to agents of the owner giving their own names for some shipments and the owners names being given on other shipments.

4. Inadequate. The frame cannot be considered inadequate as all export banana producers appeared on the original lists.

5. Out of date. As it was intended to survey those holdings which produced bananas in the period covered by the frame it could not be considered to be out of date.

Other defects which applied to the frame are as follows:

1. The address of the producer was not given and location proved to be extremely difficult.

2. The acreage of the holding was not given, the number of bunches shipped in the period was used as a basis for stratification but this was not entirely satisfactory.

The frame, although known to be subject to some defects, was nevertheless used as these could not, by their nature, be corrected.

The preparation of the frame, even though it was realised that this would be extremely laborious, look far longer than was expected. When the final sample was drawn only two weeks remained for the location of the sample holdings and this time was insufficient.

In this survey a two-stage sample was used, the first stage consisting of a selection of half the truck routes and the second stage sampling the producers on the selected truck routes. This had two advantages:

1. The work of preparing consolidated lists of truck routes was reduced by half, thus affecting a great saving of time.

2. The sample holdings were thereby concentrated in selected truck routes, thus made location and enumeration cheaper and less time consuming.

In order to select truck routes these were assigned odd numbers and half discarded by the use of a table of random numbers. Thus the selection was not biased as each truck route had an equal chance of inclusion in the final sample.

The selection of the second stage of the sample was not completely random, restrictions on randomers in the form of stratification were used. This device is commonly employed in sample surveys as a form of insurance, if nothing is gained by its use nothing can be lost. The advantages
PART 2

SECTION B

The Selection of the Sample

The proper selection of a sample in a sample survey is of extreme importance as figures obtained from it are raised to give figures for the whole population. All possible measures must be taken to make it truly representative and at the same time to keep it sufficiently large to obtain a small error and sufficiently small to economise in the amount of work to be done.

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which it was hoped to gain were:

1. A variable sampling fraction could be used for different strata. This, it was hoped, would enable those groups where wide variation might be expected to be intensively sampled and a less intensive sampling fraction used for groups were less variation might be expected.

2. Those producers who, though numerically small, produced a large volume of fruit could be intensively sampled.

It will be remembered that the frame provided no indication of the acreage cultivated by a given producer, the group therefore adopted total production over the period covered by the frame as a basis of stratification. It was felt that this would reflect acreage. Examination of the frame showed that producers could be divided into three major groups.

1. Those producing 1 - 5 stems in the period.

2. Those producing 6 - 51 stems in the period.

3. Those producing 51 + stems in the period.

The first group was by far the largest numerically, the second group was intermediate and the third group contained very few producers. No previous survey had been done on this subject so the choice of sampling fraction was arbitrary. The following were chosen:

1 - 5 group 1/45

6 - 50 group 1/15

51 + group Complete.

Each truck route was divided into the strata and cards selected by means of a table of random numbers, each truck route being sampled separately.
Planning the Field Work

While the work on the frame was in progress two members of the group attended to the field work, their objects were as follows:

1. To see if the survey could be carried out in its original form and if not what modifications were required.

2. To devise enumeration techniques.

In this part of the report it is intended firstly to describe the difficulties met with in the field and how they were overcome and later to discuss the enumeration methods which were evolved.

The first major difficulty encountered was that it was practically impossible to recognise a banana plant of an export variety unless it bore a fairly mature bunch; it was certainly impossible to train enumerators in such work. This meant that no direct count of export varieties was possible and that some method of obtaining an indirect count had to be considered. It was found that export varieties could be recognised fairly easily when in bearing and that by counting the suckers (pseudostems) the idea of the standard of cultivation employed could be obtained. With regard to this last point the recommended method is to cut out all suckers except one that is in process of bearing, one smaller 'follower' and one very small sucker - the 'peeper'. In this way a succession of large bunches are obtained (More suckers produce more bunches but these have a strong tendency to be too small for export). Thus if the average number of suckers was found to be about three standards of
cultivation could be described as good while more suckers would indicate low standards and provide a possible reason for uneconomic collection. 

The disease is well advanced. Leaf spot It was therefore decided that to record all the export bananas in bearing and to note their standard of cultivation would be desirable. In order to reduce the size of the unidentified group plantains were also to be separately recorded - these again being easily identified by their fruit.

Thus some idea could be built up of: 

(a) The density of planting of bananas.

(b) The percentage of export varieties. 

(c) The standard of cultivation of export varieties.

Other crops varied and 

The possibility of asking the cultivator direct questions was considered but this was ruled out as it was felt that the answers, due to suspicion or poor memory, would not be accurate. In addition it is difficult to access answers objectively, the answer 'Yes! to the question 'Do you use fertilisers? could mean that:

(a) Fertilisers were applied at planting only.

(b) Fertilisers were applied at planting and at later intervals.

(c) Fertilisers were applied once but this was not normal practice on the holding.

It was also felt (wrongly) that the cultivator would seldom be available to answer questions.

The incidence of disease was also, at one time, thought to be of importance, enquiries however revealed that it would be impossible to measure in the field how far disease limited expansion of production, e.g. one could not measure what would happen on a given holding if bananas were planted in pure stand if they were not so planted when enumeration
took place. In the case of Panama disease it is also impossible to state whether or not the plant is infected without certain tests unless the disease is well advanced. Leaf spot disease is known to occur but in this case it is difficult to enumerate objectively the effects on a given plant; infection in the early stages is again difficult to detect.

It was known that bananas are generally considered as a secondary crop in Trinidad and are intercultivated with other crops. These other crops are of interest as any expansion of bananas must take place, in most cases, at their expense. For these reasons it was decided to record these other crops. Visits to holdings showed that these crops were varied and could usefully be grouped together in some cases—an example here is the group of food crops—tannia, dasheen, mlaze, cassava, topee tamboo, etc. Separate recording would be cumbersome and provide results of little value. In other cases a single crop, due to its importance, was worth recording separately. E.g. cocoa, citrus, coffee. It was also found that some holdings where bananas were growing were not completely cleared of bush and it was felt that this should be recorded.

At this stage the following modified objects of the survey were accepted by the group.

1. To measure the density of planting of all types of bananas and plantains.

2. To gain some idea of the percentage of export varieties and the standard of their cultivation, and indirectly to measure the numbers of non-export bananas and plantains.
3. To record the crops with which bananas occurred.

The population was defined as being those producers who had supplied the Marketing Board with bananas during the period covered by the frame and the survey was considered as an isolated one and was not designed for repetitive sampling.

(a) Account of all plants on a sample square.
(b) Use of a line transcept.
(c) Use of a broad strip method.

Method (a) was discarded because it was felt that it would be impossible to ensure that the sample square was completely random and because large numbers would be needed to cover the variable material, it would also be difficult and time consuming to lay out an exact square in the thick vegetation liable to be encountered. In the same way the use of a line transcept was ruled out as thick vegetation would not allow its accurate use.

The final method adopted (c) is fully described in Appendix I (Instructions for Field Enumeration). In brief it consists of a strip three yards wide running along the holding. The direction being chosen in a random manner to eliminate bias, and the correct direction being adhered to by the use of sighting poles, three yards apart, placed in position by a method of no parallax. Plants were recorded, on the form shown, as they occurred in each square yard covered by the strip.

The method is not totally accurate, the line may not be exactly straight but deviations are not due to definite bias, for example a tendency to avoid a patch of thick undergrowth.
Methods of recording on the field

It was impossible to record all the vegetation on any given holding as the vegetation was mixed and, in some cases, the holdings extremely large. It was therefore necessary to work out a method of sampling the vegetation.

Three methods were considered by the group:

(a) Account of all plants on a sample square.
(b) The use of a line transect.
(c) The use of a broad strip method.

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The method is not totally accurate, the line may not be exactly straight but deviations are not due to definite bias, for example a tendency to avoid a patch of thick undergrowth.
This method is capable of giving an intensive picture of the vegetation of a small or medium sized holding but would be time consuming and tedious in the extreme if used on a large estate where very long strips would have to be recorded.

After discussion it was decided to adopt this method by recording a twenty-five yard strip and then merely measuring the distance along the sample line until a definite change in the vegetation occurred, a further twenty-five yard strip would then be recorded. Thus much time could be saved, one form could be used for recording and the slight change of method did not involve extra equipment or the instruction of the enumerators in two distinct methods.

The final crop groups chosen were as follows:

B  Unidentified banana/plantain.
E  Identified export variety banana.
F  Identified non-export banana, fig or plantain.
(C  Citrus.
D  Coffee.
F  Ground provisions and food crops.
A  Cocoa.
D  Other food trees.
M  Cleared undergrowth - non crop.
N  Cleared undergrowth - non crop.

This classification was designed to give accurate counts of all major crops and to group the others together.

The final layout of the form used is shown in Appendix I (From F) it is compact to cut down the number of
forms used and has the recording key at the top for the convenience of enumerators. The space at the bottom allows easy totalling in the office.

The method was considered to have worked well in the field and to have been readily grasped by the enumerators.

It was stated in the account of the construction of the frame that no address was known of the producers beyond an indication of the district in which they sold their bananas to the Board. When the sample was drawn it was necessary to locate the selected holdings. This section describes the procedures used.

The sample was divided into two parts, Red Division and Blue Division, as follows:

**RED**

Maracas
Montserrat
Toco 'F', 'H', 'J', 'I', 'G'
Salparo

**BLUE**

Tamana 'G'
Mayaro & Cayagnayara
Sangre Grande 'X'
Rio Claro
Bible
Sangre Grande 'A', 'B', 'I', 'X'.

The purpose of this division was to ensure that the group members had equal distances to travel and that one division was not at a great distance from the College. It should be noted that basic organization was adhered to in the supervision of enumerators.

The procedure used in Blue Division was to hand to the Assistant Agricultural Officers in whose district the selected truck routes lay (Sangre Grande and Rio Claro) lists of names of the occupiers of those farms it was desired to find. After consultation with their junior staff, these officers arranged for the group members to be shown to any
PART 4
SECTION A

Location of the Sample Farms

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**RED**
- Maracas
- Montserrat
- Toco 'F' 'E' 'J' 'I' & 'G'
- Talparo

**BLUE**
- Tamana 'S'
- Mayaro & Guayaguayare
- Sangre Grande 'Y'
- Rio Claro
- Biche
- Sangre Grande 'A' 'B' & 'X'.

The purpose of this division was to ensure that the group members had equal distances to travel and that one division was not at a great distance from the College. It should be noted that this organisation was adhered to in the supervision of enumerators.

The procedure used in Blue Division was to hand to the Assistant Agricultural Officers in whose district the selected truck routes lay (Sangre Grande and Rio Claro) lists of names of the occupiers of those farms it was desired to find. After consultation with their junior staff these officers arranged for the group members to be shown to any
BANANA SURVEY

 Enumerator: A.M. Other
 Location: Atkins, T.
 District: Maracas.
 Type: I-5

 Location Notes:

 Opposite 2½ mile post on the Ancono road. Plot behind house.

 Sketch of Area.

 Approx. area: 2 acres.
farms on the lists which were known to them. In Red Division a similar method was used but direct contact was made with the junior agricultural staff and a system of enquiries from local people employed.

When a holding was located a sketch map was made of it, if the holding was found to be fragmented only that part on which export bananas were produced was recorded. For this purpose form L which is shown opposite was used. A farm of two acres owned by T. Atkins and on the Maracas truck route would be filled in as shown opposite. The farm number was firstly the truck route number followed by a stroke and a number corresponding to the order of location of that particular farm in terms of others in the same truck route.

It frequently happened that the cultivator showed a group member round the holding and in this case there was no difficulty in establishing where the boundaries were or the size of the cultivation. Where the cultivator was not available a member of the agricultural staff was usually able to show the member where the holding was and point out the boundaries represented by Cordyline terminalis (1) planted upon them.

It was the location of the sample farms which proved to be one of the weak points of the survey, in retrospect it seems that had more time been available and had the help of the Marketing Board been enlisted more farms might have been located.

(1) Red rayo = Elephant plant = Boundary plant =

Ti plant = Red dragon.
PART 4

SECTION B

Instruction of Enumerators

The most careful planning and preparation of a survey is totally wasted if the enumerators employed do not understand what is required of them. In this survey the enumerators were postgraduate students and their high standard of intelligence made it easy for them to grasp the techniques involved. The main problem was therefore to capture the interest of the enumerators.

It was decided that a seminar was the most suitable method with which to instruct the enumerators, this being backed up by intense supervision in the field.

The programme, together with explanatory notes, is given below.

(a) The Principles of Survey Sampling in General. A. Denness

This talk consisted of a general introduction to the principles of a sample survey.

(b) The Background of the Banana Industry in Trinidad and Problems Arising. J.R. Bird

This was substantially similar to the section earlier written on this subject (Part I Section C).

(c) Drawing the Sample for the Survey. A. Denness

A brief description of how the frame was prepared and the sample drawn.
(d) Limitations of the Problems in the Field. G. Farley
This was a description of how the difficulties found in the field had been overcome and why the techniques used had been selected.

(e) Identification of Bananas and Plantains by their Fruit. J.N. Auckland
A lecture-demonstration to teach enumerators to recognise export bananas when in bearing.

(f) The Methods of Field Enumeration and Recording. G. Farley.
A talk on the methods described in Part III.

In addition enumeration instructions were handed out (Appendix 2) and enumerators were invited to inspect a demonstration of the various crop classes.

Apart from this instruction it was intended that close supervision would itself enable a certain amount of teaching to be done in the field while enumeration was taking place.

The method appeared to work well in the field but had all the sample farms been located it is highly probable that there would have been insufficient time to enumerate them all.
PART 4
SECTION C

Enumeration - Organisation and Execution

It was necessary to make full use of the enumerators for the week they were available and to give intensive supervision to ensure that instructions were carried out. With this in mind the following organisation was used.

Approximately thirty enumerators were available and these were required to work for two days and in some cases three. The Red and Blue Divisions were retained and each of the two group members in each division supervised two enumeration teams. Transport to the previously located and mapped sample farms was by private cars and on arrival each enumeration team was shown the boundaries of the holding and the exact whereabouts of the sample line. When enumeration of a holding was complete the supervisor moved the team to the next holding and the process was repeated. The fact that only two enumeration teams were working under any one supervisor made possible a high level of supervision and the loss of very little time in moving from one holding to the next.

The method appeared to work well in the field but had all the sample farms been located it is highly probable that there would have been insufficient time to enumerate them all.
Reasons for Failure to Obtain Complete Enumeration

In neither red nor blue district was the enumeration of the sample farms completed. This section deals with the reasons for failure in blue district, for the reasons applicable to red district the reader is invited to refer to the reports of G. Farley and A. Denness.

The main reasons were:

(1) Lack of Time. The preparation of the frame took far longer than expected and only two weeks were left to locate the sample farms. More time to locate the sample would have resulted in many more farms being found.

(2) Difficulty of Location. It will be remembered that the frame provided no indication of the address of the producers beyond showing the district where they were to be found. This was a greater difficulty than originally expected, it was found to be easy to find the large estates but the small, often non-residential holdings frequently some considerable distance away from the roads, were extremely difficult to locate.

It is considered that the best method of finding the sample would have been to ride with a collection truck and ask the vendors where the sample producers were to be found. In addition had a list been submitted to the Marketing Board (as originally planned) it is highly possible that they could have supplied the addresses of many of the sample holdings.
Breakdown of Cars. Both the cars owned by the students working in blue district proved to be extremely unreliable. One car was used once to contact the Officers of the Department of Agriculture and then broke down and, due to lack of spares, was not available for further use during the period of the field work. This meant that the two students could not work independently, the two working together could find and map no more farms than one working alone.

The other car was roadworthy for only part of the fortnight, after two days work a spring was broken and the shock absorber linkage lost. Location of farms ceased and the rest of the day was spent getting it back to College. Repairs took the rest of the week as a new or second hand linkage could not be obtained and one had to be made. Other breakdowns occurred during the second week, one day was lost when the car refused to start and time was lost due to repairs to electrical circuits and fuel lines.

It was intended to use this car to find more farms after the main enumeration had taken place but this was impossible as the transmission rod dropped off and part of the starter motor entered the clutch housing.

It is concluded that the use of very unreliable cars was a considerable factor in the failure to locate sufficient farms. During the location period it was impossible to forecast the availability of the cars and this, combined with the fact that it was sometimes possible to find a number of farms quickly and at others a day's work would yield few farms,
made it impossible to estimate, at any given time, the progress of the location process.

From the experience gained it is concluded that the use of a frame which does not show the addresses of the sample is attended with great difficulties, if such a frame has to be used it is essential to allow a great deal of time, for location and to ensure the availability of reliable transport.

The proximity to the college, location, enumeration and processing of the results by the student group would have revealed:

(a) The difficulties of location and thus pointed out the desirability of limiting the survey to fewer truck routes.

(b) The fact that some of the results obtained were of no value and thus allowed the modification of the type of information to be collected.

In addition greater insight into the practical difficulties of organisation would have become apparent.

Due any information collected in a pilot survey can be used if it is found that the survey can be carried out as planned and because a pilot survey may prevent complete or partial failure it is concluded that pilot surveys form an essential part of the planning of sample surveys. This is the case even where results are not required to determine suitable sampling fractions.
The various failures of this survey have been pointed out in the relevant sections, it is intended here to suggest how many of these could have been avoided.

Shortage of time was a great factor but nevertheless a pilot survey would have been of great value. This could have been done on the Maracas truck route which is suitable by reason of its close proximity to the College. Location, enumeration and processing of the results by the student group would have revealed:

(a) The difficulties of location and thus pointed out the desirability of limiting the survey to fewer truck routes.

(b) The fact that some of the results recorded were of no value and thus allowed the modification of the type of information to be collected.

In addition greater insight into the practical difficulties of organisation would have become apparent.

As any information collected in a pilot survey can be used if it is found that the survey can be carried out as planned and because a pilot survey may prevent complete or partial failure it is concluded that pilot surveys form an essential part of the planning of sample surveys. This is the case even where results are not required to determine suitable sampling fractions.
The method of calculation used by the group are given in Appendices 2-5. Only the first stages were done by the group the rest, being performed by A. Denness working alone, for a full description of this work the attention of the reader is invited to his report.

Not all the truck routes were enumerated so the results are not as complete as could be wished. In addition not all the crop groups have been worked out, this is partly due to lack of time and partly to the fact that in some cases the results would have meant little. For example where the group of food crops are concerned the occurrence of many plants might mean that the land was used to grow food or merely that much of the original ground shade used to establish cocoa had persisted. In the same way figures for uncleared and cleared bush have not been given as these have no meaning.

The results for the various Musa groups have been given separately but it is considered that these figures have no value and cannot be compared. A collection of export bananas occurred while enumeration was in progress and thus the number of export types identified might have varied between holdings in a way unconnected with density. For the same reason the sucker count is of no value and was not worked out.

Thus only the figures for all Musa species can be used and the survey fails to give reliable results to show the number of export types or the standard of their cultivation and also fails to give the proportion of the total Musa species which the export types form.
### TABLE 1.

**Totals for all Producers.**

<table>
<thead>
<tr>
<th>CROP</th>
<th>TOTAL</th>
<th>% S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Musa species</td>
<td>12,074,186</td>
<td>± 3,986,000</td>
</tr>
<tr>
<td>Unidentified bananas</td>
<td>8,396,366</td>
<td>± 1,378,000</td>
</tr>
<tr>
<td>Identified export bananas</td>
<td>2,952,652</td>
<td>± 140,000</td>
</tr>
<tr>
<td>Identified non export bananas</td>
<td>692,037</td>
<td>± 1,000,000</td>
</tr>
<tr>
<td>Cocoa</td>
<td>16,456,477</td>
<td>± 5,411,000</td>
</tr>
<tr>
<td>Coffee</td>
<td>7,500,500</td>
<td>± 2,345,000</td>
</tr>
<tr>
<td>Citrus</td>
<td>764,276</td>
<td>± 176,100</td>
</tr>
</tbody>
</table>

### TABLE 2.

**Density Results for each Truck Route.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>16 ± 1</td>
<td>69 ± 1</td>
<td>211 ± 18</td>
<td>73 ± 29</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>23 ± 2</td>
<td>65 ± 1</td>
<td>32 ± 5</td>
<td>57 ± 18</td>
<td>101 ± 42</td>
</tr>
<tr>
<td>P</td>
<td>51 ± 1</td>
<td>2 ± 0.12</td>
<td>11 ± 5</td>
<td>0</td>
<td>00</td>
</tr>
<tr>
<td>B+E+P</td>
<td>91 ± 1</td>
<td>135 ± 10</td>
<td>256 ± 25</td>
<td>129 ± 10</td>
<td>101 ± 23</td>
</tr>
<tr>
<td>C</td>
<td>3 ± 2</td>
<td>1 ± 0.2</td>
<td>13 ± 5</td>
<td>210 ± 26</td>
<td>-</td>
</tr>
<tr>
<td>O</td>
<td>10 ± 5</td>
<td>88 ± 9</td>
<td>18 ± 0.42</td>
<td>331 ± 60</td>
<td>232 ± 36</td>
</tr>
<tr>
<td>A</td>
<td>292 ± 8</td>
<td>244 ± 9</td>
<td>254 ± 43</td>
<td>260 ± 54</td>
<td>17 ± 6</td>
</tr>
</tbody>
</table>
Table 1 opposite shows the total could for all the producers of export bananas. It will be seen that the standard errors are very large and the only information that can safely be deduced from this is that export bananas are produced on holdings where other crops are grown, these other crops are mainly other Musa species, cocoa and/or coffee and/or citrus.

Table 2 shows the density results for each truck route. It can be seen here that many more plants of the Musa species are grown in Montserrat than in the after four truck routes and that the greater number of Musa species do not occur at the expense of cocoa. Citrus occurs only to a small extent in the Maracas, Talpero and Montserrat truck routes but is important in the Rio Claro truck route, the figures for Tamana have not been worked out.

Cocoa is widely grown in all truck routes except Tamana where fewer cocoa trees are not accompanied by an increase in plants of Musa species. Coffee is not much grown in the Maracas and Montserrat truck routes but assumes some importance in the Tamana and Rio Claro truck routes.

Figures for the strata within each truck route (Table 3) yield little extra information of any real value, the density of plants of Musa species varies greatly between holdings of different size groups but no pattern is apparent. In addition the strata are based on production of export bananas and it is doubtful if total acreage is sufficiently strongly reflected to allow fine comparison of figures. It is also impossible to say if differences in planting density of Musa species conceal varying proportions of export banana types and even if these differences were known comparison would be difficult as some export types might be sold on other markets, for example to hucksters.
TABLE 3

Figures for strata within each truck route

<table>
<thead>
<tr>
<th></th>
<th>Maracas</th>
<th></th>
<th></th>
<th>Talparo</th>
<th></th>
<th></th>
<th>Montserrat</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>1-5</td>
<td>6- 50</td>
<td>51 +</td>
<td>B</td>
<td>72</td>
<td>61</td>
<td>6</td>
<td>60</td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>0</td>
<td>85</td>
<td>E</td>
<td>54</td>
<td>0</td>
<td>117</td>
<td>E</td>
<td>32</td>
</tr>
<tr>
<td>E</td>
<td>19</td>
<td>572</td>
<td>233</td>
<td>36</td>
<td>P</td>
<td>0</td>
<td>7</td>
<td>P</td>
<td>0</td>
</tr>
<tr>
<td>P</td>
<td>60</td>
<td>54</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Musa</td>
<td>79</td>
<td>626</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citrus</td>
<td>0</td>
<td>0</td>
<td>C</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>C</td>
<td>0</td>
</tr>
<tr>
<td>Coffee</td>
<td>7</td>
<td>11</td>
<td>11</td>
<td>0</td>
<td>92</td>
<td>226</td>
<td>24</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Cocoa</td>
<td>310</td>
<td>92</td>
<td>23</td>
<td>A</td>
<td>225</td>
<td>47</td>
<td>12</td>
<td>A</td>
<td>163</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Rio Claro</th>
<th></th>
<th></th>
<th>Tamana</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>92</td>
<td>39</td>
<td>-</td>
<td>B</td>
<td>0</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>E</td>
<td>46</td>
<td>26</td>
<td>81</td>
<td>E</td>
<td>103</td>
<td>47</td>
<td>102</td>
</tr>
<tr>
<td>P</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>B</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B E P</td>
<td>138</td>
<td>3</td>
<td>113</td>
<td>B E P</td>
<td>103</td>
<td>47</td>
<td>102</td>
</tr>
<tr>
<td>C</td>
<td>311</td>
<td>176</td>
<td>0</td>
<td>C</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>O</td>
<td>489</td>
<td>175</td>
<td>0</td>
<td>0</td>
<td>319</td>
<td>50</td>
<td>79</td>
</tr>
<tr>
<td>A</td>
<td>350</td>
<td>117</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
</table>
In the medium sized producer strata in Rio Claro a pure stand of export bananas seems to occur, when it is seen that this density would give a planting distance of about 20 x 20 feet it will be seen that these figures must conceal some other crop (the normal spacing for bananas in pure stand is 8 x 8).

In three cases, Maracas, Montserrat and Talparo citrus was not produced on holdings in the 1 - 5 strata but was produced in the truck routes on the larger holdings, in the Rio Claro truck route however the 1 - 5 group did produce citrus. No general pattern emerges either with this crop or with cocoa and coffee.

The difficulties encountered in this survey are themselves a reflection of the condition of the export banana industry in Trinidad and it is useful to compare this industry with that of Saint Vincent. In April, 1959 the writer visited Saint Vincent and saw much of export banana production, many pure stands of export bananas were seen and even where mixed cultivation occurred (for example bananas under coconuts or as initial shade for cocoa) a high planting density of bananas was obtained. The bananas were cultivated well, spraying, pruning, propping and fertilising were general practice; this is certainly not the case in Trinidad.

In direct contrast to Trinidad the bananas in Saint Vincent are grown close to the docks and are not transported long distances on frequently poor roads, the farms producing bananas are not scattered over the island, but close together in district areas. Shipments take place weekly and thus no bananas become over ripe.

A survey of bananas in Saint Vincent would have been far easier for these reasons and it would seem that the
successful industry in Saint Vincent is based largely on well cultivated pure stands of bananas grouped closely together and at no great distance from the docks. On the other hand the uneconomic Trinidad industry depends on low intensity, scattered production frequently carried out at great distances from the docks.

2. ALLOCATION OF RESPONSIBILITIES

Field enumerators will be issued with their days for field recording at least 24 hours beforehand, at the same time they will be allocated a field supervisor who will arrange personally the hire of daily transportation and collection of meals from the hotel. Record keeping will be ordered centrally.

All enumerators should be completed during the period of December 15th - 20th inclusive.

3. LOCATION OF SAMPLE FARMS

Field enumerators will be taken in pairs to the sample farms by their field supervisors. We will also arrange the details of the day's work. There will be continuity of supervision, one person will be on one place, periodic visits to each supervisor will be made to them. This should ensure that any irregularities are dealt with in the field.

The start of the day and the farm location will be given by note card with the number of farm and the farm number, district and location. In addition the sample farms to be recorded must be

4. FIELD ENUMERATION

Field enumerators will be responsible for final reports, and, although their work will be supervised, they must develop and maintain interest.

(a) Line Layout

(b) Sample size

6. METHOD OF LINE DELIVERY

This method was proposed on the recommendation of the Joint Committee.
INSTRUCTIONS FOR FIELD ENUMERATION

1. GENERAL.

The general and statistical background of the survey will be fully covered in the lectures given on Friday, 12th December, 1958. It should, however, be remembered that the primary aim of the survey is to estimate the density of all the plants of the genus Musa on those estates and holdings contributing bananas for export through the Marketing Board Scheme in Trinidad.

Information is also required on other associated problems. These may be summarised as:

(i) An estimation of the percentage of Musa plants suitable for export, by an identified "export" fruit and an identified "non-export" fruit count.

(ii) An investigation of crop associations in which plants of the genus Musa are found.

(iii) An indication of the standard of cultivation of export banana varieties, by a shoot per stool count.

2. ALLOCATION OF ENUMERATORS.

Field enumerators will be informed of their days for field recording at least 24 hours beforehand. At the same time they will be allocated a field supervisor who will arrange personally the time of daily departure and collection of meals from the Hostel. Packed lunches will be ordered centrally. All enumeration should be completed during the period of December 15th - 20th inclusive.

3. LOCATION OF SAMPLE FARMS.

Field enumerators will be taken in pairs to the sample farms by their field supervisors, who will also arrange the detail of the day's work. Although field supervisors will not be present continuously during field enumeration at any one place, periodic visits to each working site will be made by them. This should ensure that any practical problems can be dealt with in the field.

The shape of the farm and its location will be given by notes and sketch on Form L. This form also gives the farm number, district and type to identify it exactly. In addition the sample lines to be taken will be nominated.

4. FIELD ENUMERATION.

Field enumerators will work in pairs in the field, and although their duties fall into two district types, familiarity with both duties will facilitate interchange and maintain interest. These two duties are:

(a) Line delineation by the line marker.

(b) Sample recording by the crop enumerator.

5. METHOD OF LINE DELINEATION.

This method may appear cumbersome at first, but has been developed to minimise equipment, simplify method and provide a system which will be practicable under the wide range of conditions
Equipment to be used consists only of three standard survey poles. This equipment will be provided each day by the field supervisors.

The line will be laid in the general direction nominated by the field supervisor on Form L, and which he will indicate in the field.

This is done by placing the first pole, A, at the starting point and the second pole, B, 3 yards away in the direction of the line. The third pole, C, is then placed in line with A and B, 3 yards beyond B, by method of no parallax. While the line marker is placing C in position the crop enumerator will be recording from A to B. During the time he enumerates from B to C the line marker removes pole A and places it 3 yards beyond C in line with B and C by the method of no parallax. Thus enumerator and marker work stage by stage along the line together.

The placing of the poles as close as 3 yards is required to facilitate ease of the crop enumerator’s job, and to ensure working accurately in thick growth. The enumerator’s measuring pole may be used at first to measure the 3 yards, but practice will soon develop accurate marker estimation.

6. METHOD OF SAMPLE RECORDING.

Crop enumeration falls into four categories:

(a) Recording of genus MUSA occurrence.
(b) Banana/plantain fruit type identification.
(c) Associate crop record.
(d) Shoot per stool count of identified export variety bananas.

All recording will be done on Form F.

The sample line will be laid out as in section 5, with poles at 3-yard intervals. Carrying the 3-yard measuring pole at right angles to the line, it will be possible to record a 3-yard width, so that between two adjacent poles there are 9 squares of 1 square yard area each. It will be easy after practice to estimate mentally the division of the between-poles 3 yards into yards, but for accuracy the width of the sample line must always be measured with the measuring pole.

These squares on the ground correspond to the squares on Form F, so that each column of squares on Form F represents a sample line length of 25 yards, and the whole sheet of four columns 100 yards of sample line. By using the crop enumeration code given at the top of Form F, it is possible to record the occurrence of plants in any one square yard. Occurrence of a plant within a square yard is defined by shoot at ground level. Should a plant occur on a line it should be placed in that square in which most of the shoot at ground level occurs. A similar definition is to be applied in case where doubt arises as to whether the plant occurs in the sample width. Occurrence of the plant within the square yard is to be recorded only, not the number of such plants. Any one plant must not be recorded as being in more than one square.

7. USE OF CROP ENUMERATION CODE.

A copy of the code will be found on the attached Form F. It is a letter code designed to simplify the categories (a), (b) and (c) of crop enumeration.

For bananas and plantains, E and P should only be used if the plant carries identified fruit of an export banana variety (E) or an identified non-export banana or plantain (P).

Letters C, O and A are self explanatory. F covers such crops as cassava and tannia commonly grown in peasant holdings, and D for other food trees such as tonka bean and bread fruit.

In the case of non-crop association M and N are given to indicate undergrowth density and management. M indicates cut and cleared undergrowth, while N represents uncontrolled growth of weed plants.

Bare ground is represented by a blank square on the recording form.

8. **SHOOT PER STOOL RECORDING.**

This is carried out on identified export banana stools only. Where E is entered on Form F to represent such a plant the number of stools is counted and entered alongside the letter E. Thus an identified export banana stool of 7 shoots is recorded as "7 E".

9. **PEASANT AND ESTATE RECORDING.**

On Form L the holding will be defined, on an area basis, into Peasant Holding or Estate, under the heading TYPE. To avoid much arduous work on estates the system of using Form F has been adapted for the two types of holding.

For a Peasant Holding the whole of the sample line, or lines, are recorded. Starting at the foot of column I and working upwards with progress of the line, 25 yards are covered. Having completed column I, the next 25 yards is recorded from the foot of column II, and so on until the 100 yards is completed at the top of column IV. Should the sample line be greater than 100 yards, it is continued on a second sheet, again working from bottom to top. On any Peasant Holding the sample lines will be numbered, and this number must be entered at the top of Form F. If any line requires more than one Form F these must be numbered with a sheet number consecutively for each line. So that on any Peasant Holding line, sheet and farm numbers (from Form L) should be entered on all sheets used.

An Estate type does not require all the sample line, or lines, to be recorded. The first 25 yards are recorded as in Peasant Holding, from bottom to top of column I on Form F. The enumerators then continue marking the line in the given direction but not recording the crops until a distinct change in vegetation type occurs. At this point a note is made at the foot of the next column of the unrecorded distance covered. Another 25 yards of the new vegetation type is then recorded in this next column. During movement through the unrecorded area of crop, the 3 yard spacing of line poles can be much increased, according to crop conditions, to allow greater speed of work. In a similar way to the Peasant Holding lines a number of sheets make up a given line, and number of lines a given farm number. Consecutive numbers must be maintained.
10. FORM F AND L COLLECTION.

At the end of a day's work the line and sheet numbers should be sorted into order and all recorded work handed to the field supervisor.
**BANANA SURVEY**

**CROP ENUMERATION CODE.**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B.</td>
<td>Unidentified banana/plantain.</td>
<td>F.</td>
<td>Ground provision/food crop.</td>
</tr>
<tr>
<td>E.</td>
<td>Identified export variety banana.</td>
<td>A.</td>
<td>Cocoa.</td>
</tr>
<tr>
<td>P.</td>
<td>Identified non-export banana, fig or plantain.</td>
<td>D.</td>
<td>Food tree not otherwise designated.</td>
</tr>
<tr>
<td>C.</td>
<td>Citrus trees.</td>
<td>M.</td>
<td>Cleared under-growth. NON-CROP.</td>
</tr>
<tr>
<td>O.</td>
<td>Coffee.</td>
<td>N.</td>
<td>Thick undergrowth. NON-CROP.</td>
</tr>
</tbody>
</table>

I.  

II.  

III.  

IV.
To estimate the total number of cocoa trees and its sampling error

\[
\begin{align*}
1 & \quad \text{Size groups} & \quad \sum_{i} T_i & \quad \text{Number of trees} \\
1 & \quad 1-5 & \quad x/45 & \\
2 & \quad 6-50 & \quad x/15 & \\
3 & \quad 51+ & \quad 1 & \\
\end{align*}
\]

Trees estimated for farms from the measured areas

Let

- \( Y_{it} \) = total (estimated) number of trees on all holdings within strata \( i \) and within each truck route \( t \).
- \( Y_{it} = \sum_{i} Y_{it} \) for \( t \).
- \( Y_{it} = g_{it} S_i \) (\( Y_{it} \)) for \( t \).

Then

\[
Y_{it} = \frac{t \times A}{a} \quad \ldots \ldots (1)
\]

Let

- \( Y_{it} \) = total (estimated) number of trees on all holdings within strata \( i \) and within each truck route \( t \).
- \( Y_{it} = g_{it} S_i (Y_{it}) \) for \( t \).

Then

\[
Y_{it} = \sum_{i} g_{it} S_i \quad \ldots \ldots (2)
\]

Where

- \( G_{it} = \) working second stage raising factor
- \( G_{it} = 1/f_{it} \)
- \( f_{it} = \) working second stage sampling fraction.

But

\[
Y_{it} = \frac{t \times A}{a}
\]

Therefore

\[
Y_{i} = G_{i} S_{i} \frac{t \times A}{a} \quad \ldots \ldots (3)
\]

\[
\sum Y_{it}
\]

\[
\begin{array}{c}
\text{Truck route} \\
1 \\
2 \\
3 \\
4 \\
\vdots \\
\vdots \\
\vdots \\
\text{'}n' \\
\end{array}
\]

\[
\begin{array}{c}
Y_{it} \\
\vdots \\
\vdots \\
\vdots \\
\end{array}
\]
\[ Y = g' \cdot y \text{it} \]

\[ g' = \text{exact first stage raising factor} \]

\[ f' = \frac{1}{f'} \]

\[ f' = \text{exact first stage sampling fraction} \]

But \[ Y_{i} = \left( \frac{X_{i} - X_{i+1}}{X_{i+1} - X_{i}} \right) \]

\[ Y = g' \cdot Y_{i} \cdot S_{i} \]

\[ (Y_{i}, X_{i}) = S_{i} \cdot \left( \frac{t \cdot x}{a} \right) \]

\[ Y = g' \cdot Y_{i} \cdot S_{i} \cdot \left( \frac{t \cdot x}{a} \right) \]

\[ Y = \left( \frac{g}{i} \cdot S_{i} \right) \]

\[ V(Y) = g^{2} \cdot V(S_{i}, y) \]

\[ V(S_{i}, y) = \frac{N_{i} \cdot g^{2} \cdot (1 - f_{i})}{S_{i}^{2}} \]

Substituting \( S_{i}^{2} \) (estimate of \( g^{2} \))

\[ V(S_{i}, y) = \frac{N_{i} \cdot S_{i}^{2} \cdot g^{2} \cdot (1 - f_{i})}{S_{i}^{2}} \]

\[ \therefore V(Y) = \frac{N_{i} \cdot S_{i} \cdot g^{2} \cdot (g_{i} - 1)}{S_{i}^{2}} \]

Which is the formula used in the calculations.

The mean weight \( x \) as in the ratio method is an example of a weighted mean since

\[ x = \frac{b_{i}x_{i}}{a_{i}x_{i}} \]

and one can therefore substitute \( Y \) for \( x \) and \( g' \) for \( a \).

Formulas (7,8) give all approximate formulae for the estimation of the variance in the ratio, the true estimated variance at the stage can then be calculated.
APPENDIX 3

Method

Add sheets

Reduce to (a) Total per holding
(b) Total per acre.

where the variance between \( Y_1 \) and \( Y_2 \) is denoted by

\[ \frac{t}{A} = \text{Number of trees as measured} \]

\[ A = \text{Total acreage of the holding} \]

\[ a = \text{Number of square yards sampled per farm} \]

The mean ration \( \bar{r} \) used in the ratio method of

is an example of a weighted mean since

\[ \bar{r} = \frac{S(y)}{S(x)} = \frac{S(xr)}{S(x)} \]

and one can therefore substitute \( y \) for \( r \) and \( w \) for \( x \).

Yates (7.5) gives an approximate formulae for the
standard error of the ration of the two estimates
whose sampling errors are independent.
\[ V = \left( \frac{Y_1}{Y_2} \right) = \left( \frac{Y_1}{Y_2} \right)^2 \left( \frac{V(Y_1)}{Y_1^2} + \frac{V(Y_2)}{Y_2^2} \right) \]

The estimates \( Y_1, Y_2 \) etc. are not independent of the densities so the concept of covariance must be introduced, that is

\[ 2 \text{ cov} \left( \frac{Y_1 \ Y_2}{Y_1 \ Y_2} \right) \]

where the covariance between \( Y_1 \) and \( Y_2 \) is denoted by \( \text{cov} \ (Y_1 \ Y_2) \).

Therefore to calculate the variance of \( \bar{r} \) in 3 above one has the following formula derived from 7,5k with an allowance for covariance and a finite population.

\[ V(\bar{r}) = \frac{1 - \frac{\bar{r}^2}{n}}{\sum \left( \frac{V(y)}{\bar{y}^2} - \frac{2 \text{ cov} (xy)}{\bar{x} \bar{y}} + \frac{V(x)}{\bar{x}^2} \right)} \]

The dots represent the \( x \) and \( y \) values of the sample units. The point \( M \) is the sample mean \((\bar{x}, \bar{y})\). The line OMD through the origin and the mean represents the ratio given by the sample. If \( Q \) denotes the sum of squares of the deviations of the \( Y \)'s from the values given by the ratio line OMD one has

\[ Q = S(y - \bar{y})^2 \]
\[ = S\left( (y - \bar{y}) - \bar{y} \ (x - \bar{x})^2 \right) \]
\[ = S(y^2) - 2 \bar{y} S(xy) + \bar{y} S(x^2) \]
Which is the formula used in the computations.

If $S_q^2$ represents the estimated mean square deviations from the true ratio line one has

$$S_q^2 = \frac{\bar{q}}{n-1}$$

then

$$V(\bar{x}) = \frac{1 - f}{n\bar{x}^2} \quad S_q^2 = \frac{1 - f}{(x)^2} \quad N S_q^2$$

which is equivalent to

$$V(\bar{y}_w) = \frac{1 - f}{n S_w^2}$$
### APPENDIX IV

#### CALCULATION SHEET FOR TOTALS

<table>
<thead>
<tr>
<th>Size Group</th>
<th>f_1''</th>
<th>N_1''</th>
<th>S_1(Y)</th>
<th>( \bar{y}_1 )</th>
<th>G_1 N_1''</th>
<th>Y = G_1'' S_1(Y)</th>
<th>N - 1</th>
<th>S_1(Y - \bar{y})^2</th>
<th>S_1</th>
<th>N ''S_1</th>
<th>( \bar{v}(Y) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Density calculation sheet.

1. \( \xi \)  
2. \( \xi Y^2 \)  
3. \( \xi X \)  
4. \( \xi (X^2) \)  
5. \( \xi (X)^2 \)  
6. \( \xi \)  
7. \( \xi^2 \)  
8. \( \xi^2 (X^2) \)  
9. \( \xi (Y) \) \( \xi^2 (X^2) \)  
10. \( \xi (XY) \)  
11. \( 2\xi \)  
12. \( 2\xi (XY) \)  
13. \( Q \)  
14. \( n-I \)  
15. \( s_q^2 \)  
16. \( n \cdot s_q^2 \)  
17. \( (I - \xi \xi) \)  
18. \( (I - \xi \xi) n \cdot s_q^2 \)  
19. \( \sqrt{V(\xi)} \)  
20. \( \xi \sqrt{V(\xi)} \)