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REPORT ON CARDAMOM CULTIVATION  
IN SOUTH INDIA

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Research

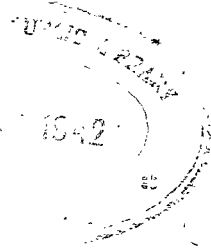


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## INTRODUCTION

**T**HE present report comprises an account of observations made during the survey of cardamom cultivation financed by the Imperial Council of Agricultural Research and carried out in September, October and November 1940. During the survey, cardamom estates and small holdings were visited in the Madura, Tinnevely, Coimbatore and Malabar districts of the Madras Presidency, the Cardamom Hills and adjacent areas in Travancore, a small area in Cochin State adjoining the Malabar district, Coorg, the Hassan and Kadur districts in the Mysore State and the North Kanara district in the Bombay Province.

The purpose of the survey was two-fold. On the one hand, it was considered that a survey of the growth and cultural conditions in the various cardamom growing districts might prove of assistance to producers in pooling information and experience. On the other hand, a survey was felt to be a necessary preliminary to the formulation of any research scheme, if this was to take into consideration the requirements of the industry as a whole. In this report, it is hoped that both purposes have been kept in view. In the light of the experience gained during the survey, an attempt has been made to put forward certain suggestions as to the way in which technical assistance can best be given to this industry.

The extent of cardamom production has proved to be much greater than was suspected and it seems certain that over 1,00,000 of acres are cultivated under this crop. The value of the produce, based on such figures as I could obtain, cannot be less than Rs. 50,00,000 per annum, even when calculated on a price figure well below that of the last two or three years.

The industry is one which deserves assistance for several reasons. It affords a valuable source of revenue from evergreen forest lands, which can be cultivated with this crop with the minimum of disturbance of the soil. This is a matter of considerable value and importance in view of the extreme necessity of avoiding the degradation of hill lands in the wet tropics by erosion, the almost inevitable accompaniment of opening such areas to most types of cultivation. The value of the produce, for its bulk, is high and this renders cardamoms a suitable crop for areas where transport facilities are restricted and has permitted the development of an agricultural industry in localities which would otherwise have never been opened up. It must be pointed out, however, that efficient communications would be of considerable assistance in raising standards of cultivation in certain areas where they are at present lacking. Finally, cardamoms represent a valuable money crop for cultivators living in areas where such crops are not very numerous.

As will appear in the report, recent years have been marked by a considerable increase in cultural difficulties owing to pests and diseases and bad seasons and existing technical institutions are largely unable to afford adequate assistance. This is not due to any lack of desire to assist but to the fact that facilities for technical work in the cardamom areas are absent or, at the very most, extremely limited. The outlay required for adequate assistance is probably more than any individual administration could consider in view of the

many calls made on available funds by more widely cultivated and important crops. Work on cardamoms seems therefore eminently of the type for joint action of the several administrations involved. This is further supported by the fact that the industry cuts across state and provincial boundaries in many ways and the protection of lands brought under cultivation in the hill regions of South India is a matter of concern not only to the administrations in which they lie but also to those of the plains at their feet.

It is hoped that the situation revealed by the survey may be of value in devising means of providing the technical help of which the industry undoubtedly stands in need.

During the survey, I have been greatly assisted by very many individuals, both officials and planters. I should like to make grateful reference to the assistance in planning my tour in Travancore rendered by Mr K. R. Narayana Iyer, Director of Agriculture, and to Mr Siva Rama Pillai of the Travancore Department of Agriculture who accompanied me throughout my tour in the Cardamom Hills. To Mr K. M. Thomas and Mr M. C. Cherian, of the Madras Department of Agriculture, I am indebted for much assistance in planning my tour in Madras districts and for several fruitful discussions. In Coorg, I was greatly helped by the Chief Commissioner, Mr J. W. Pritchard, I.C.S., and members of his staff, in arranging for visits to representative cardamom holdings. In Mysore State Mr K. H. Srinivasan, the Senior Assistant Director of Agriculture was of great assistance in arranging visits and in supplying valuable statistical information. My visit to the small but interesting cardamom area in North Kanara was made of special-interest by the help of Mr. C. V. S. Habbu, Rural Development Inspector, Karwar.

In every district, cardamom planters showed the utmost interest in the survey and gave me every assistance in their power. Without the unbounding hospitality which met me wherever I went, it would have been quite impossible to have covered the ground in the time available and the survey would have been considerably more difficult and strenuous than it was. My most grateful thanks are due to all those planters whose hospitality I enjoyed and from whose experience, I was able to gather so much of the information which is contained in this report.

#### CULTIVATED AREA

Cardamoms are cultivated in the western hill tracts of South India from the North Kanara District in the Bombay Presidency to the Tinnevely district in the extreme south of Madras. Owing to the various systems of cultivation, it is extremely difficult to get any very accurate figures of the acreage under this crop. In Table I an attempt has been made to give a rough estimate of the area under cardamoms in different districts. The figures vary greatly in accuracy and can only be considered as a rough guide. I believe that in the aggregate they do not over-estimate the area.

It is impossible to arrive at any accurate figure for the actual area under cardamoms in Coorg. I was supplied with a figure of 35,590 acres for the area under cardamoms in that province, but at least two-thirds of this area is held under the system known as geni-males, in which only a small proportion

## INTRODUCTION

### TABLE I

*Area under cardamom cultivation*

Locality	Acres
North. Kanara . . . . .	900
Mysore State . . . . .	21,800
Coorg . . . . .	10,000
Madras . . . . .	15,000
Travancore . . . . .	60,000
Cochin . . . . .	700
Total	1,08,400

of the land is actually planted at any one period, the rest being left under the natural forest vegetation. A rough estimate of production in Coorg during 1939-40 was given at about 7,500 maunds of 28 lb. each, a figure which suggests that it is unlikely that more than about 10,000 acres are planted with cardamoms.

It appears therefore that there are rather more than 1,00,000 acres under this crop in South India.

It is even more difficult to get any estimate of the total production, but I was supplied with a figure of 1,58,000 maunds of 28 lb. each as a rough approximation. This gives an average figure for production per acre of about  $1\frac{1}{2}$  maunds. Observations made during the tour in conjunction with information given me on yields, suggests that this is not an unreasonable figure.

There has been a considerable extension of the area under cardamoms in recent years, especially in the last five or six years. This is due to several causes and in order to examine the position, it is necessary first to consider the situation as it was some time ago. As a primary crop, either in large scale plantations or smaller peasant owned areas, cardamoms were restricted to the Cardamom Hills in Travancore and to a lesser extent to the Kodaikanal, Anamallai and Nelliampathy Hills in Madras, some western hill areas in Coorg under the special system of land tenure known as geni-male and a few areas in the Munzerabad taluk in the Hassan district of Mysore. There was a substantial acreage also in Mysore in coffee estates, where ravines and other moist situations were planted with cardamoms and a small acreage in North Kanara where cardamoms were planted as a secondary crop under areca nuts. This last system also occurs to some extent in the areca gardens of the Shimoga district of Mysore.

The extension noted in recent years has been determined by a number of factors. In Travancore, the opening of the road from Munnar to the west coast, has rendered accessible a considerable area of jungle suitable for cardamoms and some 10,000 acres of land have been leased or are available for lease for this crop. In Mysore and Coorg, the disastrous fall in coffee prices and increasing difficulties of the smaller growers, led to the search for alternative sources of income. The success of cardamoms in parts of the coffee areas and the satisfactory price level of the commodity led to considerable extensions of cardamom cultivation, either at the expense of coffee or interplanted with it. Finally, to a smaller extent, large tea interests with areas of jungle at their



disposal which they were unable to open in tea owing to restriction, have turned their attention to cardamoms as a means of utilizing such idle lands. In addition, a certain amount of fresh jungle land has been planted with cardamoms in other areas, growers being attracted by the comparative ease of cultivation and the satisfactory market position.

On the other hand, production has shown signs of a serious falling off in some of the older areas, the reasons for which will be considered in later sections of the report. Here it may be said that the major causes probably lie in increasing age of the older plantations, a succession of climatically unfavourable years, the appearance of thrips as a major insect pest and the damage done by mosaic disease.

#### CONDITIONS OF CULTIVATION

##### *Climate*

The cardamom areas all lie in the Western Ghats—the extensive series of hill ranges which run parallel to the west coast of South India. The climate of this area is determined by the monsoons and the year can be divided into four fairly well marked seasons. Those are the cold weather, the hot weather, the south-west rains and the north-east rains. The first of these consists of the first three months of the year and is characterized by relatively dry weather with fairly moderate temperatures although with a wide diurnal range. Temperatures rise towards the end of the period and are accompanied by increases in humidity and the onset of the first hot weather showers. The hot weather comprises the month of April, May and the first part of June and is marked by high temperatures and showery weather. The south-west rains set in in June and continue until early September. In the more westerly portions of the hills, the rains at this period are very heavy and continuous, but they decrease considerably in more easterly areas which experience strong west winds, much cloud and fairly frequent showers. After a short inter-monsoon period, the north-east rains commence and continue up to December. This is a bright showery period in the more northerly and westerly areas, but is marked by heavier rains and overcast skies in the south and east.

Proceeding from north to south, it may be said generally that the dry seasons are less dry and more liable to occasional showers and the north-east rains are more reliable. In Table II are given rainfall figures for a number of places in or close to cardamom growing areas which illustrate the rainfall distribution. It can be seen from these figures that cardamoms are grown in South India under rainfall conditions ranging from about 60 inches to over 230 inches. It may be noted that most of the heavier rainfall districts are in the north, where the distribution through the year is less regular. In these areas, cardamoms are less dependent on rainfall for their moisture supplies, which are ensured more by careful selection of sites. It seems that some of the extension of cardamoms to be seen in Mysore and to a lesser extent in Coorg is likely to suffer from a lack of realization that successful growth of cardamoms in situations with especially favourable soil moisture conditions is no criterion of their success in neighbouring areas where the plants must depend entirely on rainfall.

## INTRODUCTION

TABLE II  
*Rain-fall at selected points in cardamom districts from north to south (in)*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Sirsi— North Kanara .	0·03	0·00	0·44	1·69	2·31	22·28	34·37	22·59	7·73	7·11	2·00	0·23	100·78
Hanbal— South Mysore .	0·03	0·04	0·80	3·00	6·07	28·35	49·20	28·96	13·76	10·50	1·98	0·59	143·28
Bhagamandla— Coorg .	0·05	0·26	1·43	3·34	11·05	52·40	79·95	41·33	22·58	17·17	4·09	0·42	234·07
Seetagundy— Malabar District .	1·42	0·44	1·22	2·51	7·43	23·25	35·86	23·68	10·16	11·98	8·00	2·39	128·34
Valparasi— Coimbatore Dis- trict	0·79	0·27	1·61	4·59	9·15	22·03	27·20	22·03	12·14	12·66	6·96	1·00	120·43
Sathurangapara— Cardamom Hills .	2·33	2·23	3·36	4·92	2·66	6·19	7·90	5·64	3·99	12·94	6·89	4·09	63·14
Pambadampara— Cardamom Hills .	0·85	0·73	1·09	3·27	6·13	11·98	15·65	12·82	6·31	8·58	5·50	1·23	74·14
Kardana— Madura District .	3·59	2·86	1·99	4·55	2·47	8·78	11·19	5·15	5·85	12·65	12·83	8·22	80·13
Manjolai— Tinnevely District	11·62	4·94	2·58	4·62	6·59	7·34	5·47	5·46	6·43	15·34	21·56	19·85	111·80

Temperature records for these districts are not readily available but they are probably generally similar to those of adjacent coffee and tea areas, of similar elevation. The maximum temperatures will normally occur from March to May. The former is rarely likely to rise above 95°F. The lowest minimum temperatures will occur in December and January and may fall to 50°F. These figures correspond to those recorded at the Mysore Coffee Experiment Station which is at about 3,000 ft. above sea level, in the Western Ghats of Mysore. They will vary somewhat with elevation and with latitude.

### *Elevation*

All the cardamoms seen during this survey were grown at elevations between 2,000 and 5,000 ft. These appear to be about the limits for successful cultivation. In the few areas where cardamoms were seen above 4,500 ft. their growth was slow and crops were small. Apart from the exceptional area in North Kanara, I saw no cardamoms below 3,000 ft. and from conversations with experienced planters, it seemed that at lower elevations although vegetative growth was satisfactory, cropping was extremely poor. In North Kanara plants had been planted at sea level, where they grew but gave no crop.

It is frequently difficult to separate the effects of altitude from other factors. In illustration of this point, a case may be quoted of an area fairly recently developed in cardamoms, where they do very poorly below 3,500 ft., whereas indications from another district strongly suggested that this was the most favourable elevation for cardamoms. It was clear from such scanty rainfall records as were available, from the topography of the land and from the natural vegetation, that there was a marked falling off in rainfall in the areas at this elevation compared with those higher up the valleys. In this case, the rainfall was the major determining factor.

The upper limits are probably largely determined by temperature but also depend on the maximum elevations in the locality. Cardamoms are extremely susceptible to wind and areas the least liable to exposure to high winds are quite unsuitable for cardamoms.

### *Soils and vegetation*

In discussing soil conditions for cardamoms it is quite impossible to separate this discussion from a consideration of the natural vegetation of suitable sites. Excepting for the moment the cardamoms planted with areca nut and coffee, almost all successful cardamom plantations have been established in evergreen jungle land. The exceptions to this are very few and consist of areas which have been opened up on land formerly under coffee which had been allowed to lapse back to jungle for some years. The soils most favourable for cardamom growth and development are those of the evergreen forests. Such soils usually owe more to the climate and the vegetative cover they carry than to the mineral composition of the parent material. Further, cardamoms only appear to flourish when these soils receive the minimum of disturbance so that the degenerative changes associated with extensive clearing of the natural vegetation are avoided. In those cases where cardamoms have succeeded on soils formerly opened up



in coffee, there has usually been a considerable period during which some regeneration of the soil has taken place.

During the survey, cardamoms were found growing on soils of considerable variety within the limits of evergreen jungle soils. While the best cardamoms seen anywhere were on a deep chocolate coloured forest loam which appeared to extend for a considerable depth below the humus horizon, very nearly as fine growth was noted on a soil which, beneath a comparatively shallow zone of humus accumulation consisted of a white quartz gravel. Other fine cardamoms were to be found on extremely stony soils, with rock outcrops, the finer particles being light and sandy.

The common feature in all areas where cardamom development was good, was the presence of a well developed mulch and a well marked layer of humus accumulation. There could be no question that this condition is of primary importance for good cardamom growth. The importance attached to the protection of mulch by growers and the response to organic matter applications all bear out this conclusion.

The second factor of importance was the presence of adequate moisture supplies. It was noticeable that good cardamoms on light gravelly or sandy soils were in districts where rainfall was well distributed. Where distribution was less even, good cardamoms were usually only to be seen where soils were deeper and finer in texture.

One of the most noticeable features of any extensive area under cardamoms is the rapidity with which one passes from areas of luxuriant growth into other areas where plants make the poorest of development. This is associated with quite small variations in topography; slight ridges, where there is any tendency for leafy debris to slip or be washed into depressions, or where soil moisture conditions are slightly less favourable show up immediately in the growth of cardamoms, in a way which is much more marked than with crops like tea or coffee. This variability was naturally most marked on the soils which would normally be classed as poorer. Soils, which with adequate mulch and organic matter and satisfactory soil moisture conditions will support excellent cardamoms without any great depth or richness below, are almost useless if any of these requirements are deficient.

It follows from these remarks that any tendency to soil erosion is fatal for cardamoms and great care must be exercised on steep land. Although some very fine cardamoms were seen on steep slopes, the utmost care was obviously essential. Substantial protection against erosion is of course provided by the overhead canopy of shade and by the mulch and it is necessary to avoid their disturbance. On the whole, the best cardamom lands seen were those of comparatively gentle contours where the problem of ensuring an even accumulation of mulch and the preservation of the soil moisture holding capacity is less difficult.

In the more northerly districts, where the rainfall distribution is less equable, individual areas under cardamoms are less extensive than in the south. This must be considered as the direct consequence of the more limited occurrence of the suitable combination of organic matter accumulation and soil moisture.

In Mysore, under ravine cultivation, and in the areca gardens of North Kanara, the soil moisture position is guaranteed by ground water supplies. In the latter district, where there is little, if any, mulch supply from the shade, great importance is attached to the addition of organic matter and all the gardens have areas of jungle land which are used as sources of green manure.

Cardamoms are very intolerant of inadequate drainage and provision of drains is always essential when swamps in ravines are planted up.

### *Shade*

All cardamoms are grown under conditions of shade which means in most areas, that the plants receive the reduced light filtered through a continuous overhead canopy provided by the top storey of the original evergreen jungle. In Coorg, however, under the 'male' system plants receive the full sunlight for a few hours of the day and are in the deep shadow cast by surrounding untouched jungle for the remainder of the daylight hours. In the areas where coffee and areca nuts are grown, the shade is provided by the coffee shade and when the two crops are interplanted, by the coffee itself and by the areca nut palms.

Considering the main cardamom types, most growers agreed that the smaller cardamom is more light sensitive than the larger cardamom. At the same time, the former types can stand several hours of full sunlight without harm in the Coorg males and often appear to do quite well under comparatively light coffee shade, provided the soil and the root system is well protected. This is very strikingly shown in Mysore where the smaller cardamom interplanted with coffee develops very much better than it does in the absence of the coffee. In such cases the leafy shoots are usually exposed to higher light intensities than are usual in the plantings of the larger cardamom types in the southern districts, but the soil and roots are heavily shaded by the coffee. In the larger cardamom plantings, gaps in the shade canopy are almost always associated with marked signs of leaf scorch in the shape of rim burning and streaks of dead tissue. Under similar conditions of shade and topography, the smaller cardamom is liable to show even more marked symptoms of unfavourable conditions.

The explanation of these phenomena appears to lie in the inter-relation of shade from the sun and the moisture supply. The larger cardamom is able to thrive under rather less favourable soil moisture conditions provided the shade is satisfactory. The smaller cardamom requires an ample soil moisture supply and if this is assured can stand comparatively light shade conditions. In the Coorg 'males,' great emphasis is placed on the necessity of an eastern or northern facing so that the period when the plants get the full sunlight does not fall in the afternoon hours, when evaporation rates are at their highest. In Mysore, until recently, the cultivation of cardamoms has always involved the planting of smaller cardamom types in situations of especially favourable soil moisture conditions. It seems doubtful whether some of the extension now in progress into drier sites is likely to be a success.

*General remarks*

It must be concluded that the cultivation of cardamoms is only likely to be successful on evergreen forest soils or on sites which owing to favourable local conditions permit an adequate moisture supply, a plentiful development of humus and a permanent mulch cover. Land opened up for other crops in evergreen forest areas will grow cardamoms if it has had a period of natural regeneration and there is sufficient tree growth to provide a shade canopy. In some parts of Mysore, cardamoms interplanted with coffee seem fairly successful, but the observations made suggest that the coffee is a vital element in the association and its disappearance would result in the rapid deterioration of the cardamoms.

## I. THE CARDAMOM PLANT

*General description*

The cardamom plant (*Elettaria cardamomum* Maton) consists of a perennial rhizome throwing up leafy shoots, which bear at their bases one or more flowering panicles. The leafy shoots and flowering panicles have a comparatively short life of one to three years and new shoots arise from the bases of the older ones and by the growth of their bases, extend the rhizome system. This habit of growth results in the gradual formation of a large clump of leafy stems, often arranged around an empty central area, which finally breaks up into separate clumps as older portions of the rhizome decay. °

The leafy shoot consists of a central stem, bulbous at the base and bearing the sheathing leaf bases of the alternate leaf blades. These blades are elongate, tapering to the base and to the apex, and measuring one to three feet long and two to six inches broad at the centre. The size of the leafy shoots varies considerably and may reach 15—18 feet in the most vigorous varieties. The upper leaf surface is smooth, while the lower may be either smooth or softly hairy according to the variety.

The flowers are borne on lax panicles, usually called racemes by planters, one or more of which arises from the bulbous base of the leafy shoot. These panicles may be erect, flexuous or prostrate according to variety. Each panicle consists of a main rachis which may extend to four feet in length, bearing short alternate lateral racemes. These racemes bear the flowers on short peduncles which are closely set alternately on one side of the axis. The flowers open in succession from the base towards the tip and the raceme may continue to expand new flower buds for a considerable period from its apex.

The flowers are handsome, about  $1\frac{1}{2}$  inches long by  $\frac{3}{8}$  inches across, each consisting of a tubular calyx and three pale green, strapshaped petals. The most conspicuous feature of the flower is the large central lip which is white streaked with violet. This is a transformed stamen. There is a single functional stamen and a thread like style terminating in a funnel shaped stigma in the centre of the flower.

The fruit which follows the flower is a small trilocular capsule containing 15—20 hard brownish-black seeds with a thin mucilaginous coating. When ripe the capsule is pale green to yellow in colour and the fruit wall is firm and smooth. The shape of the capsule is variable according to the variety.

The underground portions of the plant consist of the rhizome and the roots. The rhizome is stout, branched and covered with a tough corky skin. The roots are stout and fleshy when under cover, but tend to become green and hard if exposed. They are usually very superficial and may extend for considerable distances without branching on the soil surface.

### Varieties

In systematic literature, the genus *Elettaria* is considered to consist of one species, *Elettaria cardamomum* Maton, with one variety, var. *majus*. Some authorities raise the variety to specific rank. The main difference between the two types is the size and vigour of the plant. Most accounts of cardamom cultivation speak, of three main varieties—the Mysore, the Malabar and the Ceylon indigenous. The first of these appears to correspond to the variety *majus*, while the other two are forms of the species. The naming is most unfortunate and has led to great confusion, in South India. The form described as 'Mysore' is not indigenous to Mysore and has only been grown there on a very small scale during recent years. It is always called 'Ceylon' in Mysore, and judging by all reports this name is much more appropriate since most of the areas planted with it in South India derived their seed from Ceylon estates. The type commonly planted in Mysore and Coorg is undoubtedly the Malabar cardamom, and this is the type which is indigenous in the wet jungles of these areas.

In the course of the survey it became clear that the range of variability among cultivated cardamoms is very considerable, giving ample scope for selection and breeding work. It was not possible in the time available to make a detailed study of the range of types and varieties but a list of characters noted to show marked variation will serve to indicate the extent of variability. These are given in the following table:—

<i>Character</i>	<i>Types</i>
Vigour . . . . .	High, low
Leaves :	
Texture . . . . .	Smooth, hairy (lower surface)
Shape . . . . .	Broad, narrow
Petiole . . . . .	Short, long
Panicles . . . . .	Simple, compound (one plant only seen)
Fruits :	
Cross-section . . . . .	Round, three angled
Shape . . . . .	Spherical, ovoid, fusiform
Peduncles . . . . .	Short, long

On the whole, the clearest primary division of types appears to be that based on size and vigour. The smaller type, leafy shoots of which rarely, if ever exceed about 10 ft. is also characterized by prostrate panicles. This is the Malabar cardamom. It is cultivated in Mysore and Coorg, where it is usually characterized by almost spherical fruit, although other capsule forms do occur. The fruit are yellow in colour when fully ripe. A similar type is commonly cultivated in small holdings in the Cardamom Hills though the fruit is rather longer. The cultivated type in North Kanara seems also to belong to this group but the capsules here are three angled in cross section and more ovoid in shape.

The wild type in the Anamallai hills also belongs to this group but, like the form in Travancore, has rather elongate fruit. In Coorg, they distinguish two types, the 'male' cardamom and the Munzerabad but the only difference appears to be in the size of the fruit. It is probable that the Munzerabad is the result of selection from the wild type.

The larger types show much greater variation. They can be most conveniently divided on the basis of their panicle habit. The most commonly cultivated type on the larger holdings in Travancore and the hilly districts of the Anamallais, Nelliampathies and Madura has smooth leaves and erect panicles and longish fruits with a more or less circular cross section. This is the type commonly referred to in these areas as the Mysore cardamom. As has already been pointed out this name is very unfortunate as this type has apparently no connection with Mysore whatever, and has certainly never been cultivated there until quite recently.

A second type of high vigour is characterized by flexuous panicles which commence growing upwards but soon bend over. The fruit is variable but is usually ovoid and three angled and the leaves are usually, though not always, smooth. This type is found in the Gandamanayakkanur area in Madura, in the area recently developed in Tinnevely and to some extent in the Travancore hills. In the Tinnevely area, it appears to occur wild or to have been introduced before extensive cultivation was undertaken. In Travancore it is known as 'Mixed Mysore', 'Vallakai' or 'Hybrid'.

There are several types with prostrate panicles which belong to the more vigorous group. They differ from the Malabars in that they are little if any inferior in development to the Mysore and that fruit shape is nearly always either three angled and ovoid or very elongate. In the Gandamanayakkanur area, a type with prostrate racemes, very long peduncles and long fruit appears to occur as the wild type. In Travancore, a type with prostrate panicles and fruit usually ovoid and three angled is known as 'Tara'.

At the Mysore Coffee Experiment Station, a beginning has been made on a collection of types. It seems there that fruit shape is a very useful character for classification of the types so far collected but only the fringe of the subject has been touched and the selections come only from a comparatively restricted area.

### *Biology*

The growth and flowering of cardamoms are closely bound up with weather conditions, especially rainfall and soil moisture supply, so that there is considerable variation in different districts. Generally speaking, the main growth period is in the hot weather months from March to May with a second growth period after the south-west monsoon. The flowering panicles begin to show themselves quite early in the year from the bases of the vegetative shoots of the previous year's growth. Flowering commenced in most areas about April and May and continues through the south-west monsoon months and to a variable extent in the latter part of the year. In the more northerly areas of Coorg, Mysore and North Kanara there is little, if any, flowering activity after September but in the more southerly areas flowers continue to form up to the end of the

year and there may be some production of new flowering panicles in October and November.

The period of development of fruit appears to be about  $3\frac{1}{2}$  months in the smaller varieties grown in Coorg, Mysore and North Kanara and about four months with the larger varieties commonly grown in the more southerly districts. In the few areas planted with the larger types in Mysore, it appears that these types are rather later in ripening than the smaller ones, indicating that the difference is varietal rather than climatic.

The life of a flowering panicle is variable. In the southerly districts, it may go on producing flowers for two or three seasons, but in the northerly areas, it usually dies off in the dry season. This seems to be due to the much more extreme drought conditions in the northern districts.

The flowers are produced one or two at a time on branches of the panicle. They are invariably cross pollinated and are presumably dependent on insects. Observations show that they are commonly visited by bees.

After the panicles have flowered and died, the vegetative shoots bearing them also die off. It is interesting to note the contrast in the number of living vegetative shoots on clumps in the southern districts and in the more northerly districts, even when the annual crop production is more or less similar. It seems that the smaller types in the northern districts tend to produce more panicles per vegetative shoot in a season but that they die off sooner.

Detailed work of a comparative nature on the growth and development of the different types has not been carried out but it is obvious that comparisons made at various points in the cardamom growing areas would greatly assist in selecting the most suitable types for varying conditions. At present it is often difficult to decide whether differences are the result of inherent varietal characteristics or of differing climatic conditions, since the main cultivated types are different in the northerly and southerly areas.

### *Distribution*

Cardamoms occur wild in the evergreen jungles of Travancore, Madras, Coorg and Mysore. On lightening the shade canopy in these jungles, cardamom seedlings will frequently spring up spontaneously, presumably from seed lying dormant in the soil. This spontaneous development does not occur in every area which has been opened up in cardamoms but has occurred commonly in all districts where cardamoms are grown except North Kanara. The type of cardamom growing wild seems, with one exception, always to be the smaller variety with prostrate flowering panicles. The one exceptional area is in the Tinnevely district, where apparently wild cardamoms are of the hybrid type. There seems to be some doubt whether these are truly indigenous in this area as it was stated that it only occurs in the jungle areas which have previously been entered for the extraction of timber. Further into the hills, where the forest has been practically untouched, it does not occur.

The erect variety appears to have been introduced from Ceylon in comparatively recent times and does not occur truly wild in South India. Of course, escapes are quite likely to be met with in jungles in proximity to the

areas where this variety has been planted, and it is probable that natural hybridization has taken place

The genus appears to be indigenous to South India and Ceylon. Capsules of species of *Amomum* appear to a small extent in the spice market from Nepal and from Cochin-China and Thailand, and are sometimes confused in accounts of cardamom with the true cardamom.

## II. CULTURAL METHODS

The cultural methods employed in the production of cardamoms show considerable variations. They can be conveniently classified into four types as follows:—

1. The Coorg 'Male' system
2. The North Kanara system
3. The Southern system
4. The Mysore system

The first two of these are quite distinct and stand as the opposite poles of agricultural development while the last two approximate to one another and no sharp line of demarcation is really possible. It must be remembered that although cardamoms have been an article of commerce for a very long time, it is only in comparatively recent times that their cultivation has become an agricultural industry. At first, as with all crops, the collection of cardamoms from the jungles sufficed to meet the requirements for consumption and trade. Even at the present time, a certain amount of cardamoms is obtained in this way. The next step involved the encouragement of the growth of cardamoms in the jungles in which they were known to occur. This was done by felling a few large trees in suitable sites and waiting for cardamom seedlings to spring up. These may have been thinned out and bare patches supplied up with the seedlings. Occasional weeding and the harvesting of the crop comprised the remainder of the work required.

The 'Male' system in Coorg practically amounts to this type of cardamom production. In a suitable area of jungle, plots of a size varying between 16 and 25 cents are cleared of jungle growth and planted up with cardamoms, either by the use of self sown or nursery raised seedlings. Further work consists only of weeding at intervals and the harvesting of the crop. These cardamom plots are always surrounded by tall untouched jungle and after a period of years, they are allowed to regenerate natural vegetation and new plots are opened.

At the opposite end of the scale, is the system of cardamom production in North Kanara. Here there has developed a type of spice garden which is quite characteristic. These gardens are situated almost invariably at the lower ends of hill valleys and consist of small areas of a few acres which are planted primarily with areca nuts and grow pepper and cardamoms as secondary crops. Scattered in and on the edges of gardens, a variety of plants are grown both for use and decoration—citrus fruits, Hibiscus shrubs, some handsome flowering Zingiberaceae, papayas and so on. These gardens receive considerable attention since the owners live beside them and the various needs of the crops involve

constant work within them. In this system, the cardamom is taken quite away from its natural environment, and grown as a garden crop.

Under the system here described as the southern system, cardamoms are planted in larger or smaller areas of jungle which have been cleared of all undergrowth and the overhead shade slightly thinned out. Planting is carried out either with seedlings obtained by jungle collection or by raising a nursery or with rhizomes from some earlier established area. The individual areas vary from a few acres to more than 1,000 acres. The standards of management vary greatly from that of a highly organized plantation with a permanent labour force, staff and buildings to small areas with a watchman and occasional visits from the owner and the hiring of temporary labour for weeding and harvesting. This system is that found in Travancore, the Madura, Tinnevely, Coimbatore and Malabar districts of Madras and in Cochin. It is also found to some extent in Mysore in the wetter areas of the Hassan district.

The Mysore system is really hardly to be separated from the southern system, but consists essentially of the utilization of moist ravines for cardamoms in estates whose main area is given over to coffee. In recent years, there has been a strong tendency to extend the cardamoms from the ravines up the slopes at the expense of the coffee and even to attempt complete replacement of coffee by cardamoms, thus changing over from coffee estates to cardamom estates of the same general type as those of the southern areas.

By far the greater part of the acreage under cardamoms can be classed under 'the Southern System' and the following descriptions of cultural methods will concern itself primarily with this type of cardamom production. Variations and special points which arise in the other systems will be noted as they arise.

#### *Preparation of the land.*

The first stage in opening land for cardamoms is the clearing of the undergrowth. This is done by cutting and heaping the debris in rows or piles to decay. Where slopes are at all steep it is advisable to utilize such debris in such a way as to assist in checking any soil movement, which the exposure of the soil surface may facilitate. At the same time, a certain amount of the tree growth may be thinned out to equalize light conditions, though this is often left for six months or a year after the land has been planted. There are obvious advantages in postponing the thinning of tree growth, so that the planter can become familiar with the light conditions of the area. It is unlikely that either the number or the size of the trees to be removed will result in any serious damage to the young plants in the first year. In the Cardamom Hills of Travancore, land leased for cardamoms has certain restrictions placed on tree removal, based partly on the species and partly on girth. This provision is of value in preventing the undue thinning of the jungle canopy and checking the degenerative changes in soil and vegetation which invariably follow the heavy thinning of evergreen jungle. It has one disadvantage, which will come out more clearly in the consideration of the problems of shade.

The aim of the tree thinning is to develop a complete overhead canopy of even density which experience suggests is most satisfactory for cardamoms growth and production. This normally involves the thinning out of practically



everything that does not contribute to the top storey of the forest, except in patches where the death of some forest tree has left a gap in the process of being filled by seedling trees.

In the 'male' system of Coorg, the small 16 to 25 cent plots are cleared completely of all growth. Great store is placed on the shaking of the soil by the fall of the big trees. 'If the soil shakes it will be good for cardamoms' is a belief that may perhaps rest on a rough indication of humus and organic matter accumulation. In this system, reliance is placed on suitable selection of the facing and shape of the plot to provide sufficient protection from excess of sunlight. With the tall evergreen jungle characteristic of the parts of Coorg where the 'male' system is followed, the plots are exposed to the direct sun for only very short periods of the day and for the remainder are in deep shadow as the jungle cuts out all lateral sunlight.

Where cardamoms are replacing coffee in Mysore the cardamom seedlings are planted under the coffee and the latter often gradually removed as the cardamoms develop. It is less usual for the coffee to be removed first, though in many cases the coffee stand, owing to neglect and borer attacks, is far from complete.

The planting of cardamoms in the gardens of North Kanara is associated with the bringing of fresh soil into the gardens from the neighbouring jungle, which is put into deep trenches and pits among the areca nut palms.

### *Pitting*

When the land has been cleared and the soil is soft enough the planting pits are prepared. There is considerable variation in planting distance in different areas. The larger varieties were seen at all distances from 8 ft.  $\times$  8 ft. to 12 ft.  $\times$  12 ft. while the distances for the smaller varieties varied between 5 ft.  $\times$  5 ft. and 8 ft.  $\times$  8 ft. As a rule, the smaller varieties are rarely planted wider than 6 ft.  $\times$  6 ft.

The most suitable planting distance is difficult to arrive at. Where it is intended to grow cardamoms on a limited cycle, with regular replanting, it is obviously desirable to plant as closely as possible without unduly restricting the plants, so that the early crops may be as large as possible. If a planting is only calculated to last for 10 years—a commonly suggested period—only seven crops are likely to be harvested and the first two at least will be dependent on the number of plants per acre. If, on the other hand, plantings are expected to last for long periods, then too close planting will lead to the early onset of overcrowding. This is of some importance as the cardamom clumps tend to spread outwards as they get older and there is less and less production of new shoots in the centre. Some areas of cardamoms which were some 30 odd years old strongly suggested that overcrowding had become an important factor.

On the whole, 10 ft.  $\times$  10 ft. seems the most suitable planting distance for the larger cardamom types in good situations, but good cardamoms were seen at 8 ft.  $\times$  8 ft. and this may prove quite wide enough if a regular replanting programme is envisaged. For the small cardamom types it seems undesirable to plant wider than 6 ft.  $\times$  6 ft.

In North Kanara, the cardamom pits are placed in the same rows as the areca palms and spaced about 5 ft. 6 ft. apart, although considerable irregularities occur. A fully stocked garden contains about 400 clumps.

Equal variability is to be noted in the size of the pits. In the southern areas, where cardamoms are opened up in evergreen jungle, the tendency is to increase the superficial area of the pits rather than the depth. A common size is 2 ft.  $\times$  2 ft.  $\times$  1½ ft. and it was rarely considered necessary to dig deeper than a foot. Experiments were being made in some estates with pits 3 ft. square, while one estate used pits 4 ft.  $\times$  4 ft.  $\times$  1 ft. In Mysore and North Kanara, pits are usually smaller in superficial area but greater in depth. In the latter area the common size is a 1½ ft. cube. The general principle in the southern areas appears to be that as cardamoms have a superficial root system and it is more important to produce 'seed bed' conditions over a fairly big area than it is to prepare the soil to any depth. In connection with this problem, it may be noted that on the whole the root systems seen in the southern districts were much more markedly superficial than those seen in Mysore and North Kanara.

The amount of care given to pitting is very variable. In many places no pitting of any kind is done, the plants being planted in a small hole scooped with a mamootie at planting time. In other areas considerable care is given and the pits are filled with surface soil, jungle soil or mixtures of soil and compost or well rotted cattle manure. In one estate, pits on steeper land are made superficially large, with their full depth on the lower side and only filled to the lower edge, in order to form small individual clump platforms.

### *Planting*

The planting material may be either seedlings or portions of rhizomes and the seedlings may be self sown or nursery raised. In general, though subject to a number of exceptions, the planting in the southern districts has been until recently carried out with rhizome material and the experience of raising nurseries is very small. In Mysore and Coorg, the raising of nursery plants is much more general and in North Kanara it is the only way in which plants are now raised though it was stated that rhizome planting was formerly common. In recent years a great deal of more attention has been devoted to the problems of raising nurseries in the districts where formerly planting was almost always by means of rhizomes. Considerable difficulties have been encountered and in several areas the problems of obtaining a good outturn of plants is still only partly solved. The question of the provision of planting material is so important that special attention was devoted to gathering information and the whole subject is dealt with in another section. In the present section, attention will be restricted to the field practices of planting out.

The larger plantations and many of the smaller more progressive holdings in the southern districts are planted with the larger varieties, mainly with the so-called erect Mysore type, though with considerable admixture of Hybrid types with flexuous panicles and to a much smaller extent with prostrate panicles. There is little question that where rainfall is reasonably well distributed these types are more suitable for extensive planting as they thrive over a rather wider range of conditions than the smaller types; which appear more exacting in their water requirements.

In Coorg, Mysore and North Kanara and on a number of small holdings in Travancore, the smaller or Malabar types are almost exclusively planted. They do not appear to do so well, planted extensively in Travancore as the erect types. In Mysore one or two small blocks of the erect type were seen but the local opinion does not favour them. The plants seen showed very excellent vegetative growth but cropping was stated to be poorer. At the Mysore Coffee Experiment Station, the erect variety has grown well under ravine conditions but has not yielded as well as the smaller types.

Planting time shows some variation, but in the vast majority of cases plants are put out in June-July. Variations from this period are largely conditioned by rainfall. In the districts experiencing very heavy south-west monsoons (Coorg, Mysore and North Kanara) planting is commenced in June and suspended during the very heavy rains of July and continued if necessary in mid-August and September.

In one district where the south-west rains are somewhat uncertain, experiments with planting just prior to the north-east monsoon rains which are reliable, gave poor results. The practice eventually found most suitable was to plant early in the year with the showers of April and May, fill vacancies, if any, in the south-west monsoon months. The general experience almost everywhere is that plantings made in late August and September lag much behind earlier planting in growth and development. One planter stated that late planting could be as much as year's growth behind earlier plantings by the next south-west monsoon.

In the actual planting, whether of seedlings or rhizomes, great emphasis is placed almost everywhere on the necessity of avoiding deep planting. The normal practice is to scoop a small depression in the filled pit, lay the plant down at an acute angle to the ground and just cover the rhizome with a thin layer of soil and a covering of mulch.

It is a fairly general practice, when seedlings are planted, to put two plants per pit, one of which can be later used for supplying a vacancy, if both establish themselves.

#### *After-care of new plantings*

Once the plants have been planted out, after care for the first year consists of weeding and mulching. Frequent weedings in the first year or so are essential to keep down the regenerating undergrowth and to prevent the young plants being choked. As a rule, this weeding is done over the whole area, but in some estates, ring weeding alone is resorted to. The weeds are used for mulching the young plants, or the mulch is moved from the centres of the rows around the young plants and the weeds piled in its place.

On steep land in one or two estates, small revetments, first of wood and later, if stone is handy and when labour is available, of stone. These wooden revetments, consisting of two or three vertical stakes in a row to hold 3 or 4 straight poles laid horizontally above one another and fastened with lashings of creeper, are easily made from the debris resulting from clearing and they help to hold up soil and mulch around the plants.

In the southern areas, this comprises all the attention given on the most intensively managed estates. In North Kanara, the mulching of young plants

is done exclusively with the leaves of the Nelli (*Phyllanthus emblica* L.). In Mysore, there is a tendency to follow the practices of coffee estates and cardamoms planted in old coffee land receive some form of digging or forking.

The time at which planting come into bearing depends largely on type of planting material used. Rhizome planted plants may be expected to give a small crop in the second year, a fair crop in the third and a full crop from about the fourth. Two year old nursery plants may give a small crop in the second year from planting and a full crop from the fourth. Younger nursery plants are not expected to yield anything until the third year, and begin to give full crops from about the fifth year.

#### *Care of adult cardamoms*

##### (a) *Soil*

In the vast majority of cardamom areas the soil receives the minimum of disturbance. Weeding is carried out periodically, usually just before the beginning of the crop harvest and at the beginning of the dry season with perhaps an additional one early in the south-west monsoon. In the large areas where labour is only available seasonally for crop harvest, the weeding is determined by the harvest. In estates or gardens with a permanent labour force, it is possible to adjust weeding times more accurately to the periods of heavy weed growth. Again, in Mysore, the practice approximates to that common on coffee estates. In the more northern areas, the necessity of repressing as much additional growth in the dry season is greater since this is much more severe and the problem of conserving soil moisture is more pressing.

In the more intensively managed areas, great importance is attached to the preservation and augmentation of the mulch cover. In a few places, mulching has been carried out with transported green material from neighbouring jungle areas, but the costs of this prohibit it from being applicable to more than small areas where the natural mulch development is poor and the distance from a source of material is small.

There is some variation with respect to the mulching or earthing up of clumps. While experienced planters place great importance on the careful mulching of clumps, in many places the general tendency is to clear the mulch away from the clumps. Of course, a great deal depends on the type of cardamom grown. Where the cardamom cultivated has prostrate fruiting shoots, it is more convenient for the development and the harvesting of the fruit, if the mulch is cleared away from the clumps. On this account, many planters in the southern districts do not favour these types, since the fruiting shoots get covered by the mulch. From the point of view of the health of the plant, attention to mulching the clumps seems highly desirable. The extensive root exposure, which clearing clumps involves cannot but be injurious to a plant whose root system is largely superficial. In parts of Mysore where mulch accumulation is less abundant than in the southern districts, similar considerations support the practice of earthing up clumps from time to time.

In areas developed in cardamoms direct from evergreen jungle, soil cultivation has only been attempted experimentally on one or two estates and these were usually on the deeper and heavier soils. Good results were claimed on one estate from a forking in a two year old planting, but there was no intention to make this a routine operation. Another estate found no response to an

envelope forking in February-March. In one or two places a certain amount of renovation pitting was noticed, i.e. the digging of small pits 2 ft. x 2 ft. or 3 ft. x 1 ft. and 1—1½ ft. deep in alternate spaces between four plants. These pits are allowed to fill up with mulch and weeds and then covered over. Fresh series of pits are opened at intervals.

Soil cultivation of one sort or another is much commoner in Mysore in areas which have been developed in cardamoms from old coffee land. Soil treatments in such areas approximate to those used in coffee, such as periodical forking and renovation pitting. The practice on one fairly typical area visited was to fork in September and October about once every three years. This forking is carried out up to within a foot of the clump and in order to avoid damage to the prostrate fruiting shoots, these are lifted up. Forking is sometimes replaced by renovation pitting on a similar cycle.

On the whole, there seems little to recommend any form of soil disturbance in cardamom cultivation, especially in the light of recent research on the effects of soil cultivation and on soil moisture movements. In the more southern areas planted in evergreen forest land the practice of leaving the soil alone is, generally speaking, justified by results. The position is altered in those areas which are planted with cardamoms after a period under coffee. In general, soils in such areas are heavier and often tend to crack in the dry weather, mulch accumulation is less and one would expect a lower organic matter content in the soil. The tendency to treat soils which harden in the dry season by forking or other cultivation measure is a natural one. At the same time, it would seem that an equal effort devoted to improving the organic matter position and encouraging mulch accumulation would probably be sounder.

In relation to the problem of cultivation, it is of some interest to note that root development is less superficial in the cardamom areas of Mysore than it is in the southern districts. Although the suggestion has been made that this might be a varietal characteristic based on a comparison of the roots of the vigorous erect cardamom which is largely grown in the south with those of the smaller prostrate cardamom cultivated in Mysore, my observations indicate that it is more likely to be environmental since the latter type of cardamom is equally surface rooting in the southern districts where it has been planted in evergreen jungle land. An explanation may probably be found in the longer dry seasons, less marked accumulation of mulch and lower humus content of the surface soil and the common practice of regularly earthing up the clumps. It seems to me rather doubtful whether the greater depth of rooting is accompanied by any great advantage to the plant. The depth of penetration is not very great and the cultivation practices must cause mutilation. It must be remembered that the cardamom is a plant adapted to a very specialized environment and field observation suggests very strongly that a high content of rotting vegetable matter in the root zone is an essential for satisfactory development. This is borne out by the very marked responses which have been noted in several places to applications of compost, cattle manure and other vegetable waste. One report stated that the application of a mixture of coffee husk and soil to planting pits, some time before planting gives outstanding results in development and plants so manured give a good flowering a year earlier than untreated plants. In North Kanara, the only treatment given to established

cardamom clumps is the occasional application of leaf mould. An interesting comparison of evergreen jungle soil and that of an area which had been under cardamoms for 25—30 years nearby showed practically no differences in the Potash and Phosphate content, but a marked difference in the Organic Matter and Nitrogen, both of which were  $\frac{1}{3}$  less in the planted land.

Experiments with fertilizers have been conducted on several estates in Madras and Travancore, usually through the cooperation of fertilizer firms but the results have been indefinite. As is so often the case, the experiments were quite unsuitable to detect any effects unless they were extremely large. It is unfortunate that so much effort and materials should be expended on fertilizer trials which experience has shown so abundantly in other crops are quite inadequate to give any useful information.

The general impression created by the observations made is that the care of the soil for cardamoms rests as much as anything on the care of the shade. If the shade canopy is good and capable of producing an abundant and regular leaf fall, so that the mulch is maintained, the soil can be kept in good condition for cardamoms. In areas where, owing to previous cultivation, mulch maintenance is difficult and soil organic matter reduced, cardamom improvement requires primarily attention to these problems.

#### (b) *Plants*

The plants themselves receive comparatively little attention after they are planted. Such attention as they receive consists in the periodical removal of old leafy shoots which have completed their cropping life and are showing signs of drying off. These are either pulled off or cut off a foot or so above the ground. In some cases, a more thorough cleaning up is given in which old leaves are removed from younger shoots and old fruiting shoots cut off. As a rule, however, old fruiting shoots are left to rot naturally. Some care has to be exercised in pruning off old leafy shoots as if they still bear cropping shoots these soon die. In one or two areas where, after the drought, cleaning up of clumps had been carried out rather vigorously, there were signs of considerable death of fruiting shoots.

The practice of mulching or earthing up clumps has already been dealt with in connection with soil treatment.

In some old cardamom fields where the clumps had spread considerably and begun to break up, some consideration was being given to the possible value of thinning out and clearing away the remains of rhizomes which were no longer producing leafy shoots.

The main problem in the care of the plants is that of deciding on the length of time they should be left, before replacement. Considerable areas were seen which were planted with cardamoms between 30 and 40 years ago and which had never been replanted other than to supply vacancies. All these cardamoms were of the vigorous erect variety. In one case, the yield records suggested that no serious falling off of crop had occurred over a period of about 20 years. Taking the first five years' yields as 100, the subsequent five year periods were 115, 88 and 85. It should be pointed out that the cardamoms were between 5 and 10 years of age at the beginning of the first year period. In a fifth five year period the yield level fell to 33 but this was associated with the appearance of thrips and a sequence of dry years. In another estate over

three periods of five years, the first of which commenced when the cardamoms were some 15 years old, the yield level appeared to be falling, the yield index being 100, 86 and 45. In this case, thrips attack was experienced for the first time in the last year but the very small crop of that year was considered as primarily resulting from drought. Further in the last period of five years very unfavourable weather conditions were experienced in at least one other year.

It is difficult to draw any very satisfactory conclusion from these data since weather and pest factors complicate matters. However, when allowance is made for these and the appearance of the old fields is taken into consideration, I am inclined to think that 20 years probably represents the maximum period of cropping efficiency for this variety of cardamom in areas where growth conditions are good and the situation is not complicated by mosaic. A period of 20 years is longer than was suggested by several planters as a suitable cycle of replanting. Estimates varied between 10 and 15 years in various areas but I was unable to find any figures on which to base an accurate estimate. It is certain that many areas deteriorate rapidly in comparatively short periods but the standards of work are often low, and the shade ill cared for.

One planter, who has embarked on a replanting programme considered that 10-12 years was the economic life of plantings of the vigorous cardamom types. In this estate, mosaic was very severe in the 9-10 old year areas and this in itself rendered replanting essential.

With regard to the smaller cardamom, the economic life seems shorter. The planter mentioned above, who estimated 10-12 years as the life of the vigorous types, gave 8 years for the smaller cardamom. In Mysore 7-10 years used to be regarded as the life of a planting but the recent inroads of mosaic look as if they will force planters to an even earlier replacement. In North Kanara, the mosaic situation is so severe that two or three crops are all that can be expected and it is clear that cardamoms as a main crop would be impossible in that district.

In Coorg, the 'male' plantings may last for from 15 to 20 years but it is probable that the yield level is low, especially in the later years. On the question of a replanting cycle, it is obvious that no hard and fast rules can be laid down. The main point to emphasize, in my opinion, is that some regular replanting cycle is essential. With a plant like the cardamom which has a continually extending underground stem system, the time must come when the ground becomes over-occupied with these rhizomes and the products of their decay. It is very noticeable in old cardamoms how the centres of clumps die out. These centres, on examination are found to consist almost entirely of the remains of rhizomes, the outer layers of which are very resistant to decomposition, and nothing grows within them. The persistence of the outer skin of the rhizomes after the flesh has rotted away produces a system of open tubes which may perhaps facilitate the drying out of the soil in the immediate neighbourhood of the living rhizomes.

The advantages of replanting were seen in several areas. On one estate, the yield between 1936-37 and 1939-40 on a field replanted in 1930 was approximately double that of an old field of approximately the same size. On the same estate a recent replanting gave a yield of 64 lb. per acre in its third year, whereas the best yield in the same year from old cardamoms was about 16 lb.

It may be remarked that the year in question was one of relatively unfavourable climatic condition for cardamom crops. It may be noted that on this estate, the 1930 replanted field showed rather severe infection with mosaic and its condition was falling off, suggesting that 10-12 years might be the life of a planting in this area.

With such short cycles, the problem of economics requires careful consideration since out of every ten years or so, three years may be reckoned as unproductive, and the periodic costs of clearing out the old clumps and replacing them with new plants will add considerably to expenditure. More detailed studies of this question are desirable but are extremely difficult as only on relatively few estates are accounts maintained in such a way as to facilitate the working out of detailed production costs.

(c) *Shade*

The care of the shade is restricted to the encouragement of secondary tree growth in open patches, when old trees die and to the planting of permanent shade trees in such sites. In Travancore and Madras, the Wattakany, *Macaranga peltata* is the most commonly encouraged temporary shade and it appears to come up spontaneously in open patches. In the Cardamom Hills, *Clerodendron infortunatum* was also seen performing a similar function. On one estate in the Madura district, *Vernonia travancorica*, *Solanum giganteum* and *Trema orientalis* were allowed to fill vacant spaces pending the establishment of more permanent shade trees.

Although the planting of some *Albizzia moluccana* seedlings from nurseries was seen on several estates, the usual practice when any shade planting is done, is to transfer collected jungle trees seedlings to sites where they are required. In some cases, almost any jungle tree seedling is employed but special preferences were shown in one or two estates for *Acrocarpus fraxinifolius*, *Cedrela toona* and species of cinnamon.

In the southern areas, certain trees were regarded as bad for cardamoms. These appear to fall into two main groups. One estate mentioned *Nephelium longana* and *Mesua ferrea* as bad trees, yet good cardamoms were seen around these trees, both of which are common in most of the jungles in which cardamoms have been grown. The objections to these trees seem to me to depend on extremely local conditions and cannot be considered at all as applicable generally. Other trees which were reported as bad for cardamoms included *Terminalia tomentosa* and other trees which are not evergreen jungle trees at all and may be regarded as indicators of unsuitable sites for cardamoms.

In the evergreen jungle itself, one or two trees seemed always to be unfavourable for cardamoms. It was not possible to identify them at the time owing to the absence of flower or fruit. On the whole their unfavourable character seemed to be due mainly to an unduly low and dense canopy.

In the most ravines where cardamoms are grown in Mysore, *Elaeocarpus tuberculatus* is regarded as a good tree but it is probable that it is as much an indicator of a generally favourable plant association for the insertion of cardamoms, as a specially favourable shade in itself. In the cardamom areas in Mysore opened up in coffee land, the shade is that of the coffee which preceded the cardamom. The canopy is therefore made up largely of *Grevillea robusta*, *Ficus* spp. *Albizzia lebbek*, *Artocarpus integrifolia* *Bischofia javanica*,



*Terminalia belerica*, *Acrocarpus fraxinifolius*, etc., while *Erythrina lithosperma* provides temporary shade where it is needed.

In addition, it must be remembered that where the cardamoms have been interplanted in the coffee, the coffee itself shades the ground and root system of the cardamoms.

On the whole, the shade in these areas contains a much higher proportion of deciduous trees and the canopy is frequently lighter and less even than is to be found in the younger areas planted in evergreen jungle, I consider this to be a marked disadvantage to cardamoms wherever they are planted away from ravines and similar moist situations. It may perhaps not be unimportant to remark that damage by 'Mysore Katte' is not considered serious in any other district, where, when such symptoms appear, they can almost always be referred to shade deficiencies.

The problems raised by shade are of the very first importance to successful cardamom cultivation and there is much to be learnt from an examination of the older cardamom areas, where errors in the management of shade seem to account for much deterioration.

The use of shade in cardamom cultivation is to provide a suitable environment for a crop plant whose natural habitat is the moist evergreen jungle. The effects of shade on the environment are very numerous and complex but as far as cardamoms are concerned I think the main emphasis may be laid on the influence of the shade canopy on humidities and evaporation rates. The special importance of humidity and evaporation factors seems to me to be indicated by the light shade canopies which cardamoms, especially the smaller varieties, can bear, if soil moisture supplies are adequate. On the other hand, it could be seen very frequently that in areas where soil moisture conditions were not very favourable, shade deficiencies were clearly indicated in poor growth and development and the appearance of pathological symptoms.

In considering shade management, the cultivation of cardamom in the evergreen forest areas presents rather a different series of problems from those presented in the old coffee areas now being planted with cardamoms.

When evergreen forest is opened up for cardamoms, with care and foresight in preparing the land, the shade problem presents comparatively few difficulties. The natural canopy is likely to be reasonably complete, and this could be seen in many of the areas newly opened. The evergreen forest is, however, not a static plant association and under natural conditions, there is a continuous cycle of old trees dying and new trees taking their place. When land is cleared for cardamoms, however, large numbers of young trees are removed in the course of undergrowthing and consequently the balance of the jungle is considerably upset. This disturbance may not show itself as a problem to the cardamom grower for a number of years as the cyclic changes are comparatively slow, but one by one old trees die and gaps are left for which there are no replacement trees available. Under natural conditions, there would be some younger seedlings established and ready to fill the spaces, so that the gap in the canopy could be filled.

The absence of young trees is especially marked in some parts of the Cardamom Hills where the rules permit trees removal only on a basis of girth.

It seems that care of shade in these areas should include the protection of a certain proportion of saplings of larger species of trees especially in the neighbourhood of trees which by their age, condition of their canopy or load of parasites may become casualties in a comparatively short time. Some lopping of older trees may sometimes be desirable in the interests of younger trees in the neighbourhood. It is also probably desirable in weeding to avoid the removal of seedlings of useful shade trees when these can be identified readily by weeding coolies. If they are too numerous or obviously unnecessary, they can be removed after a year or two, but such provisions will provide material for the more rapid replacement of shade if older trees are lost.

It is true that such seedling trees may take a long time to reach the upper canopy, but at least they will have a better start and will be useful sooner than if the regeneration of shade is left to transferring seedlings after the gap has been created.

The problem is naturally an extremely difficult one and makes great demands on supervision, but an examination of many older cardamom areas leads to the conclusion that deterioration in the overhead canopy and excessive reliance on temporary shade such as *Macaranga* is an important factor in the deterioration of the cardamoms.

There was ample evidence that jungle tree seedlings do occur commonly enough to permit efforts to be made along the lines indicated. If this is combined with a careful watch on the elements making up the canopy, it should be possible to reduce the period of exposure brought about by casualties and to ensure a succession of suitable trees.

The need for temporary shade still exists and for this purpose the *Macaranga* species appears entirely suitable as long as its function as a purely temporary shade is not forgotten. Although it springs up spontaneously, it seems worth experimenting with cuttings, for insertion in gaps to give a quicker cover.

In Mysore, the shade contains a higher proportion of deciduous trees and it seems likely that efforts to replace at least those which go out of leaf in the hot months is desirable. If one of the major effects of shade is the preservation of humidities in the cardamom 'zone', then it is required most of all in the dry months of the year when temperatures are high, radiation almost continuous through the day and open air humidities at their lowest.

On the whole, *Erythrina lithosperma* does not appear to be a very satisfactory temporary shade for cardamoms. It would seem that trials with *Macaranga peltata* might be well worth-while. The tree grows quite commonly in the Mysore Malnaad but as far as I could see was not made use of anywhere in the area. In some areas, *Salix tetrasperma* is planted for shade in Mysore but its use is likely to be restricted to areas where moisture supply is good.

In Mysore, where the range of trees used for shade is largely restricted to those planted for coffee shade, the prospects of natural regeneration are less promising and the necessity of raising shade nurseries seems imperative. As in the case of coffee a wide variety of trees is to be preferred to any attempt to establish one species, however good it is.

In general, the question of shade management seems to be the most important single factor in the successful maintenance of extensive areas of

land under cardamoms. It is less important perhaps where cardamoms are planted in moist ravines, especially when these are sheltered from the western sun. It naturally presents no problem when small patches are cultivated in small plots in the jungle as is done under the Coorg 'male' system. In North Kanara, the shade is provided by areca palms which constitute the main crop. From the appearance of clumps this type of shade seems quite satisfactory under the other environmental conditions and in any case is hardly open to modification for the benefit of a secondary crop.

### *Conclusion*

The account given of cultural methods indicates in my opinion that the main factor in soil preservation and in the care of the plants lies in the shade conditions. This implies that the opening of land in cardamoms demands a very careful appraisal of the existing vegetation. If a satisfactory canopy is not present in the beginning, it will be a difficult and expensive business to produce it, if it can be produced at all. It would be safer to regard all areas without a good initial canopy as unsuitable for cardamoms, unless soil moisture conditions and aspect and lateral shade protection are otherwise especially favourable.

It must be admitted that good cardamoms were seen in several places on old coffee land, though the best of them were on land which had been allowed to lapse back to jungle conditions for a number of years. Much of the development of cardamoms in coffee estates in Mysore seems likely to have a short life, as the planted area extends from the moist ravines and sheltered sites and as the coffee under which the cardamoms were initially planted dies out or is removed. At the same time, in a number of areas in Mysore, the development of cardamoms interplanted with coffee was notable. The growth and colour were very markedly superior in areas interplanted with the coffee than they were in neighbouring areas in the absence of the coffee. The combination of coffee and cardamoms seems a very suitable one for the small holder, provided it is recognized that the coffee is an essential element in the combination, and that the disappearance of the coffee is likely to be associated with the deterioration of the cardamom.

In Coorg, the general opinion appeared to be that even where laid was held on terms which permitted the opening of cardamoms on plantation methods, better results were obtained from the plot system in which the individual planted areas never exceeded 25 cents. and were surrounded by solid belts of thick evergreen jungle. It seems probable that moisture and light relations are more satisfactory under this system in these areas where the draught length is usually greater than in the southern areas.

In considering the cultivation of cardamom it must always be remembered that in the wild state, the plant is an element in the ground flora of moist evergreen forests and in all probability only a transient element in sites where owing to the death of large trees or other factors, the overhead canopy is lightened. It is unreasonable to assume that cultivation measures designed for other crops of different habit and type will be suited to cardamoms. On

the whole, beyond the shade adjustments already noted and the maintenance of the structure of the forest soil the chief requirement appears to be the maintenance and renewal of a stock of healthy clumps in the planted area. The importance of selection of good types under such circumstances is too obvious to need extensive comment.

### *Cropping and harvesting*

Cardamom fruits ripen successively over an extended period and this period varies considerably in different districts. The figures given in Table III show the distribution of crop in various selected areas.

TABLE III  
*Crop distribution in different districts (per cent.)*

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
<i>Malabar type</i>										
Mysore Estate 1 .	2	13	28	27	21	8	1	..	..	..
Mysore Estate 2 .	..	7	24	31	21	13	4	..	..	..
Coorg (rough estimate)	5	25	30	25	15	..	..	..	..	..
<i>' Mysore ' types</i>										
Mysore Estate 1 .	..	..	4	17	33	36	10	..	..	..
Nelliampathies .	..	4	9	16	17	18	15	11	6	4
Anamallais .	..	..	12	19	21	16	14	16	2	..
Cardamom Hills .	..	1	5	18	25	21	12	7	4	..

Two interesting features appear from this table. In the first place the smaller cardamom cultivated mainly in Mysore, Coorg and North Kanara crops earlier than the larger type even in the same district. In general, in Coorg, Mysore and North Kanara the crop is over before the end of the calendar year. In fact at the time of my visit to North Kanara at the end of November, the crop harvest was practically complete. Secondly, even in the same type, fruit continue to ripen up to May and June in the more southerly districts while there is nothing left worth harvesting in Mysore after February. This is probably associated with lesser north-east rains and the earlier onset of drought conditions.

Harvesting is usually done on a 30-40 day round and considerable care is devoted to picking fruit which are just attaining ripeness. In the smaller cardamom this is fairly easily detected by the paling of the unripe green colour. In the larger cardamom this stage is more difficult to detect and considerable experience is required for efficient harvesting. Fully ripe fruit tend to split on

drying, do not develop a good colour when dry and give a poor out-turn. In some small holdings, harvesting is still done by cutting off the fruiting shoots and stripping them. Naturally the quality of the produce is very adversely affected by this method.

The harvested fruit are dried either in a drying house, on a sheltered drying platform or on the ground in the sun. On larger estates, drying houses are substantial buildings fitted with racks of wire mesh or jute hessian and heated by a system of pipes connected with an outside furnace. In some smaller holdings in Coorg cardamoms are dried on platforms heated from beneath and sheltered by a thatched roof, but open at the sides. Sun drying is carried out on barbecues of beaten earth.

Kiln-dried cardamoms of the larger varieties are green in colour, but the smaller type cardamom capsules dry a more yellowish green. Sun dried cardamoms are always light in colour. The out-turn from fresh fruit to dried capsules varies between 20 and 28 per cent.

Cardamoms are usually sold in bulk, grading and sorting being done by the buyers. One planter stated that he had found great difficulty in getting hold of sieves of the type used by merchants for this purpose, in order to do his own grading. The demand for bleached cardamoms seems to be much smaller than it once was and no bleaching is now done on estates. The dried remains of the floral parts are usually removed by rubbing and winnowing.

#### YIELD

As with many crops it is almost impossible to give an average figure for yield per acre which has any really useful meaning. The problem is further complicated in the case of cardamoms by the fact that in Mysore, Coorg and North Kanara, the actual acreages under cardamoms on individual holdings are very uncertain. In Mysore, large areas are mixtures of coffee and cardamoms, patches of pure cardamoms merging gradually into pure coffee. In Coorg, while the total area of a cardamom 'male' may be known, it is very difficult, if not impossible, to get any idea of the acreage actually under cardamoms. Finally, in North Kanara, cardamoms are a secondary crop with areca nut and few gardens are fully stocked with plants at any one time. Acreage yields in these areas are at the best very rough estimates, and it must be admitted that many small holders are very reluctant to reveal their yields and almost always give unduly low figures.

Accurate figures are available from a number of plantation managed estates in southern districts and may be taken to indicate approximately the yields which may be expected under the best cultural conditions. Two estates in different districts both gave similar figures for average yields over extended periods. These were both slightly over 100 lb. of dry capsules per acre for extensive areas of the larger cardamom types. In one case the yields covered 21 years starting some eight or ten years after the commencement of planting and in the other the period was 14 years, commencing some 12 or 15 years after the opening up period. It is very doubtful whether these figures would be exceeded in any area, though small patches under highly favourable conditions might do better.

The average yield per acre for the larger type of cardamom under reasonably favourable conditions and management may probably be taken as lying between 50 and 100 lb. of dry cardamoms per acre. It is impossible to give a more precise figure than this.

No satisfactory figures for the smaller cardamom could be obtained owing to the fact that there are very few areas where any accurate acreages were available. It seems probable that an average of two to three maunds (56—84 lb. per acre) is a reasonable figure under good conditions. A small garden in Coorg gave an average of about 35 lb. per acre for the past three years, but weather conditions were most unfavourable in two years. At one place in Mysore, it was stated that up until a few years ago, about  $2\frac{1}{2}$  maunds was the average yield per acre but in recent years it had fallen off considerably and was not more than about  $\frac{1}{2}$  maund per acre for the past three years.

The yields fluctuate widely from year to year. In the case of the two estates from which accurate figures were obtained the maximum yields were 176 lb. and 224 lb. per acre respectively, while the minimum yields were 37 lb. and 36 lb. during the periods covered by the data. The reasons for these fluctuations depend primarily on climatic variations. One planter stated that he considered that adequate March rains were essential for good cropping. An examination of the yields of both the estates mentioned in relation to rainfall tends to support this view and it is hoped to publish a more detailed analysis of the figures later.

In the last few years, yields have shown a very sharp fall almost everywhere where cardamoms have been under cultivation for some time, and have been largely below expectations in most of the newer areas. The reasons for this are complex. In the first place weather conditions have been relatively unfavourable over a large part of the cardamom districts for several years. Secondly, in at least two areas, marked falls in yield coincided with the appearance of thrips. Thirdly, it seems likely that ageing factors may play a part in some of the older plantings. It is very difficult to separate the effects of these various factors and it seems very likely that the poor rainfall conditions and thrips may be to some extent connected.

Thus, in the Anamallais, where thrips have been present since the 1934-35 crop, the March rainfall on one estate has been below 20 cents. in three years and below an inch in another, while the north-east rains have been below average in at least two years of the seven. In the Cardamom Hills, yields showed a sharp drop in 1938-39 and low yields continued in 1939-40 and 1940-41. In the first of these years, an experienced planter, after a survey of a number of estates concluded that the major factor involved in the poor crops was unfavourable weather. In the two succeeding years, the weather condition on this planter's estate were almost equally unfavourable, the rainfall of January, February and March amounting to 1.70 inches and 0.28 inches against an average of 3.55 inches for the preceding 15 years. At the same time, thrips attacks were severe in both years.

In Mysore and Coorg, where thrips are less severe than in the Anamallais and the Cardamom Hills, very small crops have been characteristic of the last

two or three years. Thus, one estate under the 'male' system in Coorg, after a good crop of  $19\frac{1}{2}$  candies of 560 lb. each in 1938, gave only 7 candies in 1939 and an estimate of 5 candies in 1940. On this estate thrips damage was very slight indeed. Over Coorg areas as a whole, it was estimated that there has not been a good crop since 1937.

In North Kanara, cardamom growth is less dependent on weather than in most areas, since the moisture supply is determined by permanent streams or seepage from tanks. In this district, the yield is estimated at 28 to 56 lb. per acre in a fully stocked garden, but after two years' crops the yields fall off very rapidly on account of the 'Katte' disease.

I think it must be concluded that a considerable proportion of the yield reduction in recent years must be attributed to weather conditions, but that in the southern districts, the situation has been considerably aggravated by thrips attacks. As will appear in the consideration of this pest, the unfavourable weather for the cardamoms has tended to favour the multiplication of the thrips.

It must be borne in mind that the effects of a very dry hot weather are likely to extend beyond the actual year in which it is experienced. The dry weather in that part of the year will probably react unfavourably on flowering shoot growth and fruit setting, thus adversely affecting the crop of that year. At the same time, vegetative growth is also checked and this will result in a reduced development of flowering shoots in the next year, so that, even if weather conditions in the second year favour fruit setting, crops may still be small owing to the reduction in the number of flowering shoots. If two unfavourable years follow one another, their effects are likely to affect crops adversely for several years. During the survey, the effects of the extreme drought of 1939-40 were visible in the drying off of flowering racemes and in the extremely stunted growth of those which still lived. This seemed much more marked in the erect flowering shoot types than in the prostrate types.

The importance of ageing as a factor in determining the fall of yields is difficult to determine. Some consideration has been given to this question in connection with replanting.

There can be no question that these small yields have had a very important effect on the industry. While they have tended to maintain the price of the commodity during a period when most primary products have been fetching low prices, they have reacted very unfavourably on the plantations. There were ample signs of increasing neglect of older plantings, while the price level has encouraged extensions in newer areas. At the same time, there has been a considerable rousing of interest in the possibilities of making improvements through investigation into the causes of the decline in production.

### III. PROPAGATION

Cardamoms can be propagated either vegetatively by means of portions of rhizomes or by seedlings. At present, propagation by seedlings is almost universal in North Kanara, Mysore and Coorg and the larger holdings in Madras,

Cochin and Travancore. Most of the small holdings in Travancore appear to use the vegetative method. However, up until comparatively recently practically all the propagation in the southern areas was by rhizomes and experience of nursery management except on one or two exceptional estates is still very limited in those districts. Rhizome propagation does occur in the northern areas, especially for supplying vacancies, but the raising of nurseries is usual when any extensive area is planted. Although in former times, rhizome propagation was general in North Kanara, the method has been abandoned almost completely, largely on account of mosaic disease.

### *Vegetative propagation*

The system of propagation by rhizomes consists of the splitting up of established clumps into sections consisting normally of at least one old and one young shoot. The section of rhizome is placed in a small depression in the prepared, filled pit and covered over with soil and mulch, while the leafy shoots are placed almost parallel to the soil surface. New shoots arise from the rhizome and reconstitute a clump. The method is simple and reliable and permits the multiplication of any selected clump or type. Such plants normally come into bearing earlier than seedling plants by a year. The disadvantages of this method lie in the fact that the number of plants obtainable from any one clump is limited—rarely more than twenty or so—so that it is unsuitable for opening up clearings of any extent or for starting a plantation in areas where substantial quantities of plants are not available. Secondly, it is not suitable in areas where mosaic occurs commonly as some affected rhizomes are liable to be used and even where great care is taken, the number of affected clumps in the early stages is higher than in seedling plantations. The sale and transport of rhizomes for this form of planting is to be strongly deprecated as there are considerable risks of spreading diseases such as mosaic and pests such as thrips from affected to unaffected areas. This, of course applies most strongly to those areas which are at present free.

There is one further point, which, while perhaps of small practical importance at present, might become so if more attention is directed to selection. Cardamoms depend on cross pollination for fruit setting and if an attempt were made to build up large blocks with clonal progeny, i.e. plants all derived from one superior individual there would be a serious risk of poor fruit setting from the absence of pollination. While this danger is easily avoided by suitable mixing of clones, it deserves mention as such an error has been made before with another crop in which self sterility occurs.

The question is frequently asked whether continued vegetative propagation will not lead to degeneration. The balance of evidence from other vegetatively propagated crops is that this mode of multiplication does not of itself lead to degeneration, provided there are no specific diseases which are likely to be more readily spread by this means. The risks of increased presence of mosaic in rhizome plantings has already been mentioned, but if further investigation indicates that this can be guarded against, there seems no valid objection to this mode of multiplication.



The ability to multiply selected types vegetatively with ease is of the utmost value in work on selection and breeding and will simplify investigations considerably. For this work, however, it will be necessary to devote some attention to the possibility of reducing the size of the rhizome pieces so that the numbers of plants raised from any desired selection may be as large as possible. This is not likely to present any serious difficulties.

### *Seedling propagation*

In most areas at some stage in development propagation by seedlings has been necessary, but this has not necessarily involved any elaborate methods of nursery management. Under the most primitive conditions, the cardamoms which come up spontaneously on thinning the overhead canopy, provide the seedlings which can be redistributed to form a more even stand. In one area, it was stated that when cardamom planting was first commenced, the first step taken was to cut the paths through the area to be planted and the cardamoms which sprang up in the cleared strips provided the planting material for the rest of the area. Methods of this type are still employed in a number of places, either by the use of wild seedlings which appear on thinning the jungle canopy or of volunteer seedlings occurring in older cardamom plantings. Such seedlings are either collected and planted in prepared nursery beds until they are required or transferred direct to their permanent positions.

The next stage of development is the sowing of cardamom seeds in areas where they may be expected to germinate but without any more preparation than is involved in thinning the overhead canopy sufficiently to ensure favourable conditions for germination. This method was seen in use on several estates during the survey. The most striking example was on an estate in Coorg in which cardamoms are cultivated on the 'male' system. A plot of jungle is cleared in the same way as is done for ordinary planting on this system and seed is sown broadcast about February or March. The seeds germinate in the hot weather months and the seedlings are left to develop until the following year, when they are transplanted to permanent positions. A similar system was seen on an estate in the Anamallais, with the difference that the seeds were sown under light shade along the edges of planted areas and the seedlings were left for two years before planting in their permanent positions. This longer seedling period has the advantage that it shortens the time between setting plants in the field and their first crop. This is a matter of some importance if a comparatively short replanting cycle is to be followed.

The most developed system of nursery management involves the germination of seed in prepared beds, from which they are transplanted into nursery beds and finally into the field. This is obviously the only sound way if high out-turns of seedlings from given quantities of seed are to be expected and it is only with the development of these methods that advantage can be taken of selected seed and breeding work can be developed on a satisfactory basis.

At present, results from germinating beds and nurseries are very variable and even in the most successful cases the out-turn of plants can hardly be considered satisfactory.

In a general way, it seems that trouble in getting satisfactory germination is greater in the southern districts, since complaints on this score were fewer in Mysore, Coorg and North Kanara. It must be pointed out, however, that in the latter districts, most holdings are small and annual planting programmes limited, so that there is less concern over high efficiency in the nursery than there is likely to be on holdings under plantation management with large planting programmes. Nevertheless, I think it is true to say that germination gives much less trouble in the northern districts.

In Mysore, most complaints arise from extensive failure after germination, which in many cases appears to be associated with a nursery leaf disease which is described in the section dealing with cardamom diseases.

### *Nursery management*

#### (a) *Seed rate*

It was found very difficult to get any very satisfactory figures on the numbers of seeds per pound of seed and on the out-turn of plants. In some cases figures given were obviously pure guess work. The most reliable figures varied between 15,000 and 25,000 seeds per pound. Data kindly supplied to me by Mr R. L. Narasimha Swamy, Geneticist at the Mysore Coffee Experiment Station gave the fresh weight of seed taken straight from ripe capsules as 25,000 seeds per lb. in the case of the Malabar type and 18,000 in the case of the larger cardamom (Mysore or Ceylon). These figures can be applied directly to estimate seed rate where seeds are planted immediately on harvesting and will be low for those cases where seeds are dried somewhat before planting. The figure of 20 to 25,000 given on two different estates where the Mysore cardamom is planted is probably accurate enough for practical purposes.

The number of plants obtained for planting from a pound of seed was stated to be rarely more than 10,000 under the best conditions and was frequently very much less than this. Losses occur from the failure of many seeds to germinate and from extensive losses from 'damping off' and nursery leaf rot.

#### (b) *Seed selection*

Apart from taking seed from well grown plants of the type considered most satisfactory for the estate, very little attention has been given to selection. On one estate, however, considerable attention was being devoted to this question. On this estate about two dozen clumps had been selected on the basis of the number of flowering branches formed on the panicles by September and on the number of seeds per capsule. All these were selected within the variety with rather flat flexuous panicles, known as 'Mixed Malabar' which belongs to the group commonly known as 'Hybrids'. On this estate there is an area of 10 acres planted from seed from one single clump which may be of great value to any work which may be developed on selection. There is obviously ample scope for selection work as can be seen from the variety of types occurring in cardamom plantings and there is little doubt that it is along such lines that improvement of the position of the industry can be best developed.

### (c) *Preparation of seed*

Seed for planting is collected from fully ripe capsules and is then either washed in water and planted immediately or mixed with ash and dried for from two to nine days in the shade. The first method appears to give the best results and is almost universal in Coorg where great importance is attached to quick sowing after collecting the seed. In North Kanara, although seeds are mixed with ash, they are not dried but sown immediately in beds.

Immediate sowing of fresh seeds is obviously only possible when seed collection is done on the estate where it is required. If seeds have to be transported any distance, some drying is essential to prevent mould development.

In one or two places, seed was stored for some months before planting and in one place appeared to give satisfactory results. In this case, seed was collected in September, washed, dried in ash in the shade for four or five days and kept in sealed tins or in well made tightly closed wooden boxes until February, when it was sown broadcast in a prepared jungle clearing. The general opinion was, however, that keeping seed resulted in a very considerable loss of viability and great delay in germination.

The fact that in many areas, on thinning out jungle shade, cardamom seedlings spring up spontaneously very quickly suggests that under natural conditions cardamom seeds can lie dormant for considerable periods in the soil. As will appear later, the storing of seed for some time would probably be of great assistance in certain districts and it seems that investigations on seed preservation might be of very considerable value.

### (d) *Sowing time*

In the northern areas, Coorg, Mysore and North Kanara, seeds are usually sown in September and germinate in about a month. As has already been pointed out, complaints of poor germination were much less frequent in these districts. In the southern areas, however, an examination of the crop distribution table (Table III) shows that there is rarely any likelihood of getting good seed early enough for sowings at this time. In fact seed is rarely put down before November and germination is more irregular and takes considerably longer. A clue to this may perhaps be found in the lower temperatures in the latter part of the year. Records in the nursery at the Coffee Experiment Station at Balehonnur show that both air and soil temperatures show a marked drop in November and December and low temperatures at this time may account for some of the difficulties experienced with seed sown late in southern districts.

On one or two estates in the south, seed is collected in February and sown in February or March with fairly satisfactory results. Seed can normally be obtained at that time in most southern districts and it might prove more satisfactory in such places to put down seed in February and March when temperatures tend to increase, than to sow late in the year, when temperatures are low.

(e) *Seed-bed*

The preparation of seed-beds varies in detail in different places but follows the usual general lines for seed-bed preparation. In most areas they are made on the ground, but raised above the general ground level. The size is determined by convenience but is usually not more than four feet wide and some thirty or forty feet long. Beds of such a size are sufficient for about 8 oz. of seeds. The top soil layer of the bed may be well pulverized ordinary soil from which all stones have been removed or may consist of jungle soil or mixtures of jungle soil and sand, soil and compost or matured cattle manure or mulch debris. On the whole it seemed to me that germination beds should not be too rich and the utilization of a substantial proportion of sand in soil mixtures for germinating beds was a feature of more than one successful nursery system.

On some estates where considerable difficulties had been experienced with germination, beds had been raised off the ground and the soil mixtures used treated with heat or chemicals to effect partial sterilization. It seemed doubtful whether these refinements were necessary, although raised beds of this kind do provide some protection against ants which are sometimes troublesome. It seemed to me that the poor results in these cases were more likely to be improved by improvements in selection of planting time and ensuring that seeds were in a high state of viability.

Increased rate of germination was reported on one estate from soaking seeds in cattle manure slurry and also from watering beds with the proprietary growth promoting substance Hortomone. Both these experiences offer suggestion for further study.

In Mysore, seed-beds and nursery beds are almost always situated in wet lands, and the beds are separated by deep channels into which water is run. This ensures moisture supply but as the soils are frequently heavy, there is some risk of excessive moisture in the soil.

It is a general practice to mulch the seed beds with grass or straw, while in North Kanara, the mulching material is practically always the fine leaves, of the Nelli (*Phyllanthus emblica*, L.) which are reputed to be of especial virtue for this purpose. The beds are not, as a rule, shaded from the sun until after the seedlings begin to appear. Watering is carried out to keep the soils moist but care must be taken to avoid undue wetness. One successful planter recommended fairly heavy waterings applied at intervals of several days rather than lighter daily waterings. On several estates, the early waterings were always done with warm water.

The emphasis placed on leaving beds exposed to the sun in the early stages and the use of warm water for watering suggest that temperature is probably a vital factor in satisfactory seed germination, supporting the conclusion suggested by the effect of planting season. Experiments with this factor in view may be of some assistance on estates where difficulties have been experienced.

(f) *Shading*

Once the seedlings have appeared, which under the most favourable circumstances is after about a month, but which may extend to three months, the

beds must be shaded from the sun. The usual practice is to raise pandals some four to five feet above the beds and to thatch them with jungle tree branches whose leaves are known not to fall on drying. These pandals are essentially similar to those used by tea and coffee planters for their nurseries, though they tend to be slightly heavier. It is important to avoid drip from the pandal in wet weather as the young plants are tender and easily damaged.

Two variations in pandalling were seen. In one the beds were shaded by a low pandal not more than three feet above the bed, which was covered with a thin grass thatch to give an almost complete cover. In the dry weather this was kept moist by watering to maintain the humidity. In the other, shading was done by suspending dry leafy branches from a frame work some five or six feet above the bed, instead of laying them on the top of the frame work. It was claimed that this reduced drip injury and gave adequate shade.

On the whole, however, there were no special points about shading nurseries, beyond the universal emphasis on its necessity if plants are not to be damaged by sun scorch.

#### (g) *Transplanting*

In the vast majority of holdings, seedlings are transplanted from the germinating bed into fresh beds. Some exceptions in this were encountered in one or two holdings in Mysore and Coorg but it was impossible to say how general this was. It may not be without importance that in each case in Mysore where seedlings were not transplanted into fresh beds, there was considerable complaint of nursery losses from disease. This obviously suggests that overcrowding is an important factor in damage by the nursery leaf rot.

Beds for transplanting are prepared in the same way as for seed beds, although there is frequently the addition of more compost or pulverized cattle manure. The seedlings are usually planted about six inches apart but may be spaced wider. In North Kanara nine inches is a common spacing while occasionally they are placed as far as two feet apart. On one holding in Coorg, where seedlings were left for two years in the nursery, the spacing was one foot.

The time at which transplanting takes place depends of course, very largely on the time at which seed is put down. A comparison of the time of transplanting in different districts offers some interesting evidence on the advantage of early planting.

In Coorg where seed is put down about September, transplanting takes place in December or January, while on an estate in the Nelliampathies where seed is put down about November or December, transplanting is not begun until June and has usually to be suspended during the heavy rains of July and early August. In the estates where seed is put down in March, transplanting is carried out about November of the same year. It is not certain that the size of plants at transplanting is the same in all these areas but the early sowing after the south-west monsoon certainly permits a very much earlier transplanting than later sowing. In North Kanara, where seed is sown about the same time as in Coorg, transplanting is usually done about February or March.

In view of the trouble from nursery leaf rot in the monsoon in Mysore nurseries, where transplanting is not done it would seem to be advantageous to have seedlings transplanted and well established before the onset of the heavy rains. In areas where south-west monsoon is very wet, plants from seed sown in March are unlikely to be large enough for transplanting before the rains. This places a very serious limitation on such a sowing time in these areas, owing to the dangers of nursery disease such as damping off and nursery leaf rot. The estates where March sowing was practised lie in districts where the south-west rains are not very heavy.

The seedlings are usually transplanted when they have grown a couple of leaves and are large enough to handle. After transplanting regular watering is required in dry weather and the shade protection must be maintained. Bordeaux mixtures spraying has given satisfactory results in reducing the damage by nursery leaf rot in several places where this disease sometimes causes trouble. Other reports indicate less favourable results in the control of this disease by spraying, but it seems likely that a little experimentation on timing the applications might alter the response.

The length of time seedlings are kept in the nursery varies considerably. In Coorg, Mysore and North Kanara plants are sometimes planted out within 12 months of sowing the seed. That is to say, either in June or late August to September of the year after sowing the seed. It is more usual, however, to keep them a further year in the nursery. Where seed is put down later and transplanting is not done until June, planting is carried out in the following June. The total time in the nursery is thus only rarely less than a year and frequently extends to two years.

The cost of upkeep of nurseries for these periods led to an interesting modification on one estate in order to reduce the costs. On this estate, the seed is sown in germinating beds in the usual way about November or December as ripe fruit became available. In June, when the seedlings are ready for transplanting they are taken out of the germinating bed and transferred to an area in the estate, which is well shaded, and in particular, sheltered from the afternoon sun and planted in pits, two feet apart. For this purpose small planting pits are prepared and in each pit, two seedlings are inserted, nine inches apart. This jungle nursery received no watering but is weeded regularly. A further modification of this consists of using the spaces between plants in newly planted blocks for transplanting nursery seedlings and thus avoiding the necessity of special weeding costs. It was admitted that losses were higher with the use of this method, but there was a considerable saving of expense. The losses were stated to be smaller if the soils of blocks used for nurseries of this kind were light. It must be borne in mind that this estate lies in a district where the rainfall is well distributed.

#### *General remarks*

It must be understood that nowhere were nursery out-turns high and if any work is to be done on seed selection and cardamom breeding, it will be necessary to find means of improving nursery technique. For estates where

experience with nurseries has been exceptionally bitter, the observations made during the survey suggest that special attention devoted to ensuring warm germinating beds may be of assistance. The number of points in nursery management which might be improved by simple experiment are considerable. The possibilities of storing seed, the pretreatment of seed with hot water, cattle manure slurry, or growth promoting substances, the composition of seed bed soils and the adjustments of transplanting times are all susceptible to simple experimentation.

#### IV. INSECT PESTS OF CARDAMOMS

Until 1935, it could hardly be said that cardamom suffered from any serious insect pest. There was a number of insects which occasionally did more or less serious damage but with one exception they could scarcely be considered as cardamom pests.

In 1915, Bainbrigg Fletcher gave a list of five insects associated with cardamoms, one of which had only been reported in Ceylon. Up to 1935, the only additions to this list were the reports of damage done by hairy caterpillars of species of *Eupterote*, and the rhizome borer, *Prodiocetes haematicus*, recorded in Ceylon.

In 1935, a species of thrips, described by Ramakrishna Ayyar as *Taeniothrips cardamomi* assumed the position of a serious menace to cardamom production in South India and caused alarm among growers in nearly every cardamom district in South India. During the survey, especial attention was devoted to the position of this pest and notes were made on such other pests as were encountered.

#### THRIPS

The cardamom thrips is a small insect which spends its life behind leaf sheaths and bracts, extracting its food supply by injuring the epidermal tissues and sucking the sap. Although the damage done to leafy shoots is not conspicuous, it is quite otherwise with respect to that done to the flower buds. In extreme cases, the flowers fail to set and there is abundant evidence that this causes very severe loss of crop. When the injury is less extreme, the flower may set but the injuries caused by the thrips result in the development of rough corky scabs, varying from slight injuries along the angles to extensive scabbed areas which result in checks to fruit development leading to malformations. These reduce the weight and spoil the appearance of capsules and seriously affect their market value. In years of bad attack, it may be almost impossible to find an unscabbed capsule.

#### *History and distribution*

This pest was first reported in the crop season of 1934-35 in the Anamallai Hills, as being responsible for the extensive scabbing of the capsules. T. V. Ramakrishna Ayyar and Kylasan described the insect and the type of damage in two papers, and an account of its life history has recently been published by V. K. Subramanyam.

The pest soon made its appearance in other districts. I received evidence that there was a severe outbreak in a small area of cardamoms in the Gandamanyyakanur Zamindari in 1935 and its presence in Mysore dates from about the same time. The newer areas in the former district have shown signs of thrips attack ever since they came to cropping age. In Mysore the severity of the attack has varied considerably but it was very severe about 1937. In the jungle areas of Coorg, thrips and some thrips injury could be found but it did not appear ever to have been serious enough to cause much comment. The garden areas in North Coorg showed more damage, resembling conditions in the neighbouring areas of Mysore.

The first reports of thrips injury in the Cardamom Hills date from 1937 in the north and by the 1937-38 crop it had spread south to Kallar. In the following year the pest was present throughout the Cardamom Hills though the attack was only noted towards the end of that crop in the extreme south. Finally, the sole estate south of the Periyar lake was infested in the 1939-40 crop.

The Nelliampathy Hills, which is the closest cardamom area to the Anamallai Hills was free of the pest as far as could be seen on a short visit in February 1938, but its presence was reported in the crop of 1938-39.

Two small areas, one in the extreme south and the other in the extreme north, appear to be free of this pest. These are the Singampatti area in the Tinnevely District and the spice gardens of North Kanara. The evidence for this statement is that in the examination of large numbers of fruit no signs of thrips injury could be seen and no thrips were found in a considerable number of leaf sheaths which were examined. One small interesting qualification must be made to this statement. In the Singampatti area, one fruit was found on a wild cardamom which showed a very slight injury resembling a slight thrips scab along one of the capsule sutures, but a search on the plant did not reveal any thrips. In the same area, the examination of a quantity of cardamoms collected from wild plants showed one or two which had slight injuries of the same type. It must be admitted that these marks could not be definitely stated to be thrips injuries, but the possibility exists that freedom from the insect as a pest in this area may not be due to the complete absence of the insect. In the North Kanara district, there were no signs of the pest whatever and its effects on the fruit were quite unknown to the cultivators.

The question arises as to whether this is a new invader of the cardamom or whether it is only a normal associate of the plant, which has suddenly increased in numbers as a result of the withdrawal of some natural check or the occurrence of an exceptionally lengthy period of favourable climatic conditions. This is a question which obviously can hardly be decided with certainty, but it is desirable to consider the evidence with some care as it is a matter of some importance to any discussion of the future of the industry.

The main evidence available is that of cardamom planters themselves, but it was found very difficult to get any very definite expression of opinion as to whether the characteristic thrips injury was entirely new or whether it **did occur** prior to 1934 to any slight extent. Positive statements that such



injuries to the capsule had been seen before were obtained from two sources and one of these definitely stated that it was a fairly regular form of injury to the extent of one per cent or so, but that it had never been recognised as due to insect injury. The absence of more general statements to this effect is not a matter of great surprise when it is borne in mind that the industry has not been one of intensive management and for a number of years past has been prosperous without any great attention to detail. Large areas receive only the scantiest of supervision and little is done beyond weeding once or twice a year and harvesting the crop.

A consideration of the distribution of the cardamom districts and of the times when thrips injury reached noticeable proportions does not suggest the spread of a new pest from one centre. The nearest cardamom area to the Anamallais, where the pest first appeared, is the Nelliampathies which was one of the last to show infestation. The appearance of the pest in the Gandamanayakkanur area as early as 1935, although this area contained at that time, very few cardamoms and there was little or no likelihood of exchange of material with the Anamallais, does not offer much support for a theory of new pest extending its range. Between the Anamallais and Gandamanayakkanur lie the Cardamom Hills and the Palni Hills, both of which have grown cardamoms for a long period and which did not show signs of thrips infestation until two years later.

The spread of the pest in the Cardamom Hills themselves, however, does suggest a movement of the insect southwards from some point of origin or introduction in the north, although there is a possibility of an explanation on climatic differences.

It was suggested in Mysore that the insect might have been introduced with rhizome material from the Anamallais, but no satisfactory evidence that rhizome material was introduced into the main cardamom areas in South Mysore at the critical period could be obtained.

On the whole, I am inclined to accept the positive evidence obtained from planters as indicating that thrips attacks are the result of the removal of some natural check on an insect previously present but never in such numbers as to constitute a menacing pest. What the natural check may be it is difficult to decide. It cannot be overlooked that 1934 was the driest year but one in the Anamallais since 1903, and that from 1934 to 1939, the rainfall in most westerly hill districts of South India was deficient, especially in the hot weather and north-east monsoon months.

Recent work on a species of thrips on coffee in East Africa suggested in that case, a strong connection between high temperatures and attacks of the pest. Observations by Subramanyam indicate that the numbers of thrips fall off and rates of reproduction decrease during wet and humid weather. It seems likely therefore that seasonal conditions may have some bearing on the outbreaks of cardamom thrips during the past six years, or at least with their persistence and severity.

It must be admitted that it is easy to raise many objections to this view. The dry conditions in the hot weather of 1934 were very general in the western

districts of South India. In one estate in the Cardamom Hills, records which were available showed ten inches less rain in 1934 than in any year for ten years. One might have expected a more general appearance of the pest in the following crop, if the insect was at all generally distributed in small numbers. An explanation might perhaps be sought in terms of the distribution of some other host plant, but there is insufficient information on this question to warrant any conclusion. Ramakrishna Ayyar gives *Panicum longipes* as another host. The distribution of this plant under the name *Cyrtococcum longipes*, A. Camus, is given in Gamble's 'Flora of the Madras Presidency' as Mysore State, west coast and Ghats—2,000 to 5,000 ft. This is not sufficiently detailed to be of much assistance in the consideration of the problem.

During the course of the survey, thrips were found in the leaf sheaths of a number of species of Zingiberaceae growing in jungles in the neighbourhood of cardamom estates. As far as could be seen with a pocket lens they were similar to the cardamom thrips. No search was possible at any great distance from cultivated cardamoms, so it is impossible to say whether these thrips are normally associates of these plants, or have spread to them from the cardamom. There seems a strong possibility that the host range may be fairly wide.

#### *Extent of damage*

There is no question that the pest can cause a heavy reduction in yield, but it is difficult to arrive at any figure for this. Consideration of the problem was greatly complicated during the course of the survey by the very great reduction of crop in many areas which could without doubt be attributed to the long drought of 1939-40.

The figures in the following table are not without interest in relation to this problem. The yields of two estates are compared in the following way: The yield for the years 1926—29 are taken as 100 for each estate and the yields of the periods 1930—33 and 1934—37 are expressed as a percentage of this. Both estates are of approximately the same age (35 years) and have both been under plantation management, but they are in different districts; estate A recorded thrips for the first time in the 1934-35 crop, while estate B had its first outbreak in 1938-39. On the whole, the general yield level in the two estates in the first period was fairly similar.

TABLE IV

#### *Crop yields and thrips attacks*

Crop	Estate A	Estate B
1926-29	100	100
1930-33	76	67
1934-37	51	28
		(Thrips appeared 1934-35)
1938-39	17	30
	(Thrips appeared 1939)	

It is clear that the crop in estate A, taken in four year periods has fallen off in the 12 years between 1926 and 1937. There is no question that part of this is attributable to weather conditions, more particularly in the third period, when the hot weather rain in three years out of four were well below average. A similar falling off is shown by estate B, but this is much more marked in the third period, when the situation was worsened by thrips.

One experienced planter put the crop loss from thrips at 10 to 25 per cent. It may be noted that an increase of 20 per cent. in the average for estate B in the third period would have given a yield showing the same reduction below the second period as the second showed below the first, as actually occurred in estate A. It is unwise to push such fragmentary figures too far, but they were the only figures available from which any examination of the position was possible.

It may be added that the figures for the last two crops on estate B show no further fall, whereas those for estate A, for these years, coinciding with the thrips attack, show a big reduction, the index figure being only 17. It must be added however, that weather conditions in 1938 and 1939 were considered by planters in this locality to account for a considerable part of the reduction in yield during these years.

It is still more difficult to decide how serious the insect is as a cause of falling off in vegetative vigour. Several planters stated their belief that thrips had brought about substantial reductions in vigour and development. While one would expect heavy infestations of sucking insects to reduce vigour it is difficult to collect evidence. Very fine cardamoms were seen of 3 or 4 years of age which have been liable to thrips attack since they were planted and these were as fine as the best cardamoms of the same age and type in thrips free areas. On the other hand, the chief reports of a falling off in vigour came from areas of old cardamoms, where other causes may play a big part in the loss of vigour. In all areas the effects of recent droughts introduce a further complication.

#### *Varieties and thrips attack*

All varieties of cardamom appear to harbour thrips, but the extent to which fruit injury occurs varies very considerably. All growers agreed that types with prostrate panicles suffered less than the types with erect panicles, and this was confirmed by direct observation in every district visited where thrips injury occurred. In addition it was also noticed that among the so called Hybrid cardamoms with flexuous panicles, individuals occurred which seemed to be especially tolerant of thrips attack, since although thrips could be found readily in the leaf sheaths, the fruit were almost entirely free of the thrips injury, when neighbouring plants showed extensive damage. Some observations suggested that factors such as variations in the adherence and persistence of bracts around the flowers and young fruit and variations in the length of the flower pedicel play a considerable part in determining the amount of thrips injury. It is fairly obvious from what is already known of the habits of the cardamom thrips that any anatomical feature which led to the early exposure of the ovary would be helpful in reducing the damage done.

The comparative freedom from thrips injury on prostrate panicle types was abundantly indicated by the differences in crop when such plants were planted along with erect types. The differences in extent of injury are not exaggerated in an example of two panicles taken from neighbouring plants one with a prostrate panicle and the other with an erect panicle, which happened to have equal numbers of fruits. Out of 23 fruits more or less fully developed on each raceme only 4 showed thrips injury on the prostrate panicle type, against 19 on the erect panicle type.

The reason for the difference in susceptibility to attack warrants investigation. It may be said that it appears to be common to all prostrate panicle types, irrespective of other characters. Perhaps, the micro-climatic differences which exist between the soil or mulch surface and points one or two feet above the soil level may play an important part in determining the distribution of the insect. It must be remembered that thrips can usually be found with ease in the leaf sheaths of plants whose fruit show very slight signs of injury.

#### *Growth and cultural conditions and thrips*

There seems little doubt that on the whole, the severity of thrips in recent years has been closely related to weather conditions, as has already been suggested during the consideration of the spread of the attack. Little is known about the influence of growth and cultural conditions on the attacks except what can be inferred from the status of the pest in different districts. On the whole, the severity of thrips attack has been quite low in Coorg, and apart from one or two years and certain individual areas, does not appear to be so serious in Mysore as it is in the Anamallais and Travancore. The fact that the predominant variety in Mysore and Coorg is one with prostrate panicles may have a great deal to do with this. One additional factor which may also be of some importance is the fact that in Mysore and Coorg, flowering panicles are annual and that there is usually a period of a month or so when the plants are without flowering shoots. In the other areas, to the south, panicles continue flowering for as long as two years and plants are never without living flowering shoots. In the areas which experience strong north-east rains, there is frequently a new flush of flowering shoots formed in the latter part of the year. There are thus flower-buds available for thrips all through the year and migration from bud to bud is simplified.

There is ample room for experimental work on the effect of the removal of all racemes at the end of the crop season on the incidence of thrips attack.

Examination of the leaf sheaths show that as a rule, thrips are only to be found in the older sheaths which have begun to separate from the stem. In one or two areas only, were thrips found in the unrolling leaf buds. The possibility that careful cleaning up of clumps of all old leaf with care to avoid leaving suitable breeding places might assist in mitigating thrips damage merits closer investigation.

#### *Direct control measures*

Experiments on control of thrips with insecticides have attracted a great deal of attention in all affected districts and Government assistance has been

given in the laying out of experiments in Travancore and Madras. In Mysore experiments have been made at the Coffee Experiment Station. So far no results have been published as to the effects of the treatments. As is so often the case, most trials have been made without any effective check on the results and casual inspection is quite insufficient to give an adequate picture of the position. With one exception, I saw no trial which was suitable for statistical examination. There are some general indications that some reduction of thrips injury has followed the use of nicotine sulphate and of tobacco decoction, but the frequency of application used in the trials was quite outside of practical possibilities. From another source it has been reported that an application of sulphur dust resulted in a reduction of thrips injury and the Mysore Department of Agriculture reports some success with Pyrethrum dust. It is clear that the thrips is readily killed by a number of contact insecticides, but the problem of bringing an insecticide into effective contact with the insect presents very great difficulties, on account of its habit of living entirely under the cover of leaf sheaths and bracts. The insecticides which have shown some promise are those which exert an influence by vaporization, suggesting that their effects depend more on their action as fumigants penetrating the enclosed spaces inhabited by the insects than on actual contact.

The difficulty in all trials so far carried out is the absence, until recently, of any details of the life history and also of a complete lack of knowledge of the fluctuations of the insect throughout the year. Some information on these questions is essential for planning any spraying programme, which has in view the provision of a practical weapon of control. At the same time, I must admit that I do not consider that spraying or dusting against thrips can be seriously considered as likely to provide a practical solution to the thrips problem, except perhaps on relatively small areas of cardamoms managed on a plantation system, with ample readily available supplies of additional temporary labour. For the large areas of small holdings, with only seasonal labour supplies, it would require an entire change of organization to make spraying possible.

I do not suggest that trials of insecticidal control methods should be completely abandoned, but that such trials should not represent the main approach to the problem. The survey has shown clearly that there are quite definite possibilities in selection for thrips tolerance and such a solution is one which could be made available eventually to all types of cardamom cultivators.

#### *Future prospects of the pest*

There is no question that this insect has given cause for considerable alarm during recent years and has led to many pessimistic statements with regard to the future of the industry. While in no way denying the very serious damage done by the pest, I consider that the position is not quite so serious as it appears. I am much struck with the parallelism between this invasion of cardamoms and the invasion of coffee in Mysore and Coorg by green bug (*Coccus viridis*) in 1912-13. In that case dire consequences were predicted and for several years considerable damage was done, but with the passage of time, the menace dwindled and although few estates are free of this insect it is only occasionally

and locally that attacks become severe. It was a case of a pest suddenly extending its range and with a sequence of several years of favourable weather, causing extensive damage. With a return of less favourable weather the attacks became less serious and now, only a few estates find it a serious practical problem.

When it is remembered that we have only five or six years experience of cardamom thrips and that during those years weather conditions such as would almost certainly favour the insect have been exceptionally frequent, it is too early for extreme pessimism.

The crops this season in nearly all areas were reported to be less affected than last season and it was some encouragement to see younger fruit in many estates much less affected than the older ones. It is true that crops this year are small in almost all areas, but although thrips are partly responsible for this, I think there can be little doubt that weather conditions have played a major part. The 1939 hot weather rains were short in most areas, limiting shoot growth and consequently reducing prospects of panicle production in early 1940. Although the 1939 north-east rains were good thus improving the position slightly, the unprecedented drought of December to April 1939-40, which affected all districts to a greater or less degree, was obviously the major factor, as was shown by the poor and stunted growth of such panicles as were formed.

In the areas where the most pessimistic views were expressed it seemed to me that there were many other factors involved in the poor condition of the cardamoms and that it was doubtful whether the thrips were in any way a primary factor, in plant deterioration. While the problem undoubtedly demands more detailed investigation, it seems probable that a solution is more likely by a flank attack than by direct assault. At the same time, I think that there is a reasonable hope that wetter seasons may assist in reducing the severity of the attacks.

#### HAIRY CATERPILLAR

Some trouble has been experienced from time to time in cardamom areas from the appearance of enormous swarms of hairy caterpillars which destroy the foliage and in extreme cases kill out the plants.

A severe outbreak occurred in 1937 and 1938 in North Coorg and the adjoining area of South Mysore and at the same time in a considerable part of the Cardamom Hills. In the latter area it was estimated that 5,000 acres were severely damaged and another 5,000 suffered some injury. In the former districts it was difficult to estimate the affected area, but it was not very extensive. The damage done was however locally very severe and some few small gardens were completely abandoned on account of it.

The caterpillars appeared about September and October and descended in enormous numbers from the shade trees on to the cardamoms. Working by night, they stripped the leaf blades to the midribs and during the day they collected in clusters under leaves and in dark places on tree trunks. Pupation occurred about March in the top inch or so of soil in places where mulch accumulated. Collected pupae emerged about July in the laboratory. The moths belonged to the Eupterotidae and it appeared as if more than one species was involved.

Since the attack in 1938-39 no further outbreak has occurred in any district.

A previous outbreak was reported in Mysore by Kunhi Kannan, about 1924-25, after which there were no further records until 1937.

A pest of this type is very difficult to deal with. As a rule it is not reported to any agricultural officer or entomologist until it is too late to take any effective measures. If it is tackled in time, the caterpillars can be destroyed in large numbers and if the affected area is not too large, a stomach poison spray can be expected to give some protection. After pupation has occurred, the risks of a second year's attack can be considerably reduced by the collection of pupæ, which can be easily discovered in large numbers in the top soil under mulch accumulations.

The evidence suggests that it is only after a series of dry years that outbreaks are likely to occur, and that good north-east monsoon rains result in a very heavy mortality from a fungus disease.

The hairy caterpillar is not strictly a cardamom pest, but a forest pest which attacks cardamoms incidentally. In Mysore and Coorg it first defoliated a great number of the shade trees before it attacked the crop. The maintenance of vigilance, especially if there have been several dry years, and the prompt recognition of the commencement of an outbreak should make it possible to minimize the worst effects of such invasions.

During the survey, a small amount of damage by a Lasiocampid caterpillar was noted on a small area near Vandiperiyar, at one or two points in the Cardamom Hills and on a few plants in North Kanara. In no case was it at all serious and could be dealt with by the destruction of the caterpillars in the course of weeding operations.

#### SHOOT AND CAPSULE BORERS

Shoot borer, *Dichocrocis punctiferalis* was met with in every cardamom area, attacking shoots and, occasionally, panicles. This insect is probably the best known cardamom insect although it is rarely more than a minor pest and can usually be dealt with by the removal of affected shoots in the course of weeding or cleaning up. The symptoms of attack on shoots are the drying up of the shoot tip and the appearance of bore holes about an eighth of an inch diameter on the stems through which the grub pushes out its frass. As castor (*Ricinus communis*) is an alternate host plant of the insect, this crop should be avoided in the neighbourhood of cardamoms.

A certain amount of fruit injury appears to occur from this insect but although bored fruit were commonly met with in most districts, I found few containing grubs. Some of these borings were probably due to the capsule borer *Lampides elpis* but this could not be established. Except in Coorg, where the position is peculiar, damage from capsule borers was nowhere serious.

A shoot bud borer was noted on one estate in the Cardamom Hills. The tissues of the bud were rotted and contained a number of small grubs, which were probably Dipterous larvæ. This pest may be much more widespread than this single observation suggests as the symptoms visible to a casual glance do not differ greatly from those of *Dichocrocis*, except for the absence of holes in

the stem and expelled frass. Similar damage in young plants recently planted out in the field was reported to me a year or two ago from a newly opened area in Coorg where it was estimated that 50 per cent of the plants had been destroyed. Specimens have also been received from nurseries in the Nelliampathies and Mysore. The larvæ appear to be those of a Syrphid but adults have not yet been bred out, and the life history is unknown.

At various times reports of severe damage by a Scolytid borer in the capsules have been published. Bainbrigge Fletcher records such an attack in Coorg some years prior to 1915 and it has attracted attention in the same district in recent years, when it was identified as *Thamnurgides cardamomi*. I was unable to find any signs of this pest during the survey. A few injured capsules were noted in Coorg, but no specimens of the beetle were seen. Some Scolytid beetles from cardamom capsules were referred to me a year or two ago from an estate in Mysore, but apparently the damage done was not very serious.

#### RHIZOME BORER

In two districts, the Gandamanayakkanur Zemindari and the Cardamom Hills, borings were found in the rhizomes and bulb bases and in one, a larval stage of a beetle was found. I am indebted to Mr. Jones, the Travancore Assistant Entomologist, working on cardamoms, for the information that these borings were due to the weevil, *Prodiectes haematicus*, which has recently been reported as doing serious damage to cardamoms in Ceylon. Its exact status and distribution in South India is uncertain, but it will be referred to again in connection with another problem.

#### ROOT BORER

In all the cardamom areas in Madras and Travancore, very numerous cases of a root borer were observed, but it was not found in any plants examined in Coorg, Mysore or North Kanara. Bainbrigge Fletcher noted a root borer, the caterpillar of *Hilarographa caminodes*, in 1915 in a list of cardamom pests, but stated that although known in Ceylon it had not been recorded in South India. As far as I know, no report of its presence in South India has since been published. Mr. M. C. Cherian, who kindly examined specimens of grubs more closely than I was able to do, informs me that they were beetle larvæ, so this must be regarded as a new cardamom insect. It may be that there are several borers boring in cardamom roots, but this question can only be cleared up by more extensive collections than were possible during this survey.

The grub bores in the cortex of roots, making tunnels filled with frass which may reach up to the rhizome, but do not appear to penetrate it. It always appears to work towards the rhizome and not away from it. The grub itself, a small yellowish larvæ, when present, lies in healthy tissues, but invariably the root behind the borer is rotted. It is commonest in superficial roots but can also be found in roots well into the soil. As a rule it attacks the thick, main roots, at varying distances from the rhizome. In some cases, roots are put out from above the point of injury leading to a characteristic brush of new roots, but it often happens that rots follow the boring too rapidly and the roots decay up to the rhizome.



Its status as a pest requires investigation and I am inclined to regard it as of some importance. In many areas where the poor condition of the cardamoms was a matter of concern, this borer was found injuring a very substantial proportion of the roots. It seemed surprising that it had not received any comment previously, in connection with reports of the deterioration of cardamom plants. I am inclined to think that in some cases of reports of fungus rots of the rhizome, the primary damage may be attributable to the borer, which affords an entrance to soil fungi of comparatively weak parasitism.

#### MINOR PESTS

Two or three species of scale insects were noted on racemes during the survey. Only on one small estate did they appear to be anything more than a very minor pest and could doubtless be dealt with there without great difficulty with one of the usual contact sprays.

Mites are frequently found within the leaf sheaths almost everywhere, but apparently do no damage. One species was noted as being predatory on thrips but the numbers were too small to exert any effective control.

*Stephanitis typicus*, reported as a very minor pest of cardamoms by Bainbrigg Fletcher, was not seen, but does occur occasionally, though, without ever attaining any practical significance.

In Coorg the general complaint in the 'male' areas was of capsule damage by insects, rats, snakes and frogs. Inspection suggested that damage by crickets and grasshoppers and by rats did occur to some extent. The general level of attack was not very high and must be considered as practically inseparable from the method of cultivation, in which small plots, rarely of more than 100 to 150 plants, are surrounded by jungle. It is extremely doubtful whether any practicable control measure could be devised to suit such primitive agricultural conditions.

In concluding the section, the insect pest position can be summarized as follows: Thrips is the only major pest which appears likely to be a permanent feature of cardamom cultivation in most areas, and it seems worth some effort, in the two areas at present free of this pest, to prevent the risk of its introduction. Two borers, the rhizome and the root borer, have a somewhat uncertain status, but I think both require watching and deserve further study. The hairy caterpillar and a scolytid capsule borer appear to be occasionally serious. Both are apparently forest pests and reach epizootic proportions only at long intervals. The remainder are minor pests which can be dealt with by recognized pest control measures where necessary, but which are rarely worth any considerable expenditure of money.

#### V. DISEASES OF CARDAMOMS

The diseases of cardamom appear to have received even less attention than the pests and the position has become extremely confused owing to similar names having been given to different diseases in different districts. In at least two cases, the common names widely used are distinctly misleading and there

is ample scope for further study. At the same time, with one or two exceptions most of the recorded diseases do not appear to present very serious practical problems.

*Marble disease, mosaic, katte (North Kanara)*

This disease is characterized by a pale mottling and curling of the leaves, most easily visible in the youngest leaves, and by a rapid dwindling in the size of newly formed shoots, followed by the death of the whole clump. It is generally regarded as a virus disease, and while this seems very likely, it has never been actually proved by transmission studies. Sahasrabuddhe and Bapat, working in Bombay, published a study of the soils in the cardamom gardens of North Kanara and concluded that the disease was the result of a form of soil sickness, especially associated with the prevalence of certain types of soil protozoa. While these results are of considerable interest, it seems doubtful whether they can be considered as affording a satisfactory proof of the cause of the disease. However, no parasitic agency has been found in affected plants and the symptoms strongly suggest a disease of virus origin.

The disease is known as 'Marble Disease' in the Anamallais, 'Mosaic' in the Cardamom Hills and 'Katte' in North Kanara. The last name is also used for this disease in Mysore but it is also employed for two other quite distinct affections.

*Distribution and history*

The disease occurs in the Travancore Cardamom Hills and in areas of cardamoms near Pallivasal, in the Anamallais, Mysore and North Kanara. It was not seen in the cardamom areas inspected in the Gandamanayakkanur Zemindari in the Madura District, Singampatti in the Tinnevely District, the Nelliampathy Hills in Cochin and Malabar or in Coorg. I was given to understand that it has not been noted in the small areas of cardamoms in the Wynaad and Nilgiri-Wynaad areas.

It was difficult to get any definite information as to when it first appeared. It has been known for a very considerable time in North Kanara where it is very severe and is, in fact, the only disease of any importance. It is probably the disease referred to by Mollison in 1900. In Mysore, where it has been almost unrecognized or at least confused with another trouble, it is vaguely reported as having appeared in the last eight or ten years. It was noted by officers of the Mysore Agricultural Department at least 10 years ago and may have occurred for some time before that. In the Anamallais and Travancore, its appearance is usually put at some 15 years ago.

Its distribution within the districts affected show distinct peculiarities. In North Kanara it is so severe in the spice gardens south of Sirsi that the disease renders replantings useless after about three crops, yet in a garden visited some six or seven miles north of Sirsi, the disease was absent although cardamoms had been cultivated in that garden for many years. In Mysore several individual estates showed no signs of the disease at all, while others were very heavily infected. In the Anamallais, no area was free of the disease, but the extent

of the attack varied considerably. Similar remarks could be applied to estates in Travancore cardamom areas. Two small areas south of the Cardamom Hills near Vandiperiyar showed no signs of the disease though affected areas occurred only a few miles away.

On the whole, it appears that the disease is most common in areas where cardamoms have been under cultivation for a considerable time, though several exceptions were noted.

#### *Extent of damage*

The extent of damage varied considerably. Some areas in the Cardamom Hills, mostly under small holding management showed at least 50 per cent of the clumps affected. One well managed estate in the same area had thrown 14 per cent of its acreage out of production on account of this disease, as the greater proportion of the plants were affected. On the other hand, another large, well managed estate showed very few cases and the disease was not considered a serious menace. Some areas in the Anamallais have been practically abandoned. The reasons given were poor crops, Marble Disease and thrips and there could be no question that in these areas the percentage of affected plants was extremely high. On other estates in the same district, the proportion was much lower and it seemed possible to keep the disease within bounds. On one such estate, the roguing rate for this disease was given at less than ten clumps per acre, which is less than 2 per cent.

In Mysore, one area was seen where the disease was sweeping through fields so that hardly a clump had escaped infection. Other areas showed no more than 10-15 per cent diseased clumps.

The situation in North Kanara has already been commented upon. It can be said that by the fifth or sixth year, not less than 80 per cent of the plants are affected in the majority of gardens and the planting becomes commercially valueless. It is clear that in this district, the disease has rendered cardamom growing very nearly impossible and the industry would have disappeared long ago if it had been a primary crop. It may not be without importance that it is in this area that cardamoms have been cultivated continuously for the longest period of time, the present system with but small differences having been described by Buchanan in 1807.

#### *Observations*

I could obtain no indications from observations during the survey that the incidence of the disease could be associated with any special soils, situations or cultural measures. The same disease could be seen with almost equal severity under such widely divergent climatic conditions and cultural methods as those found in South Mysore, North Kanara and the Cardamom Hills.

In large estates, where the severity was not too great it appeared to develop in patches, but in one case of severe attack it seemed to be spreading regularly through a large field from one end to the other. It was suggested that it was a disease following unfavourable environmental conditions, but although it seemed associated in most areas with older plantings or with land that had long been

under cardamom cultivation, I could not see any clear indications that the more affected areas were regularly poorer in respect to shade or soil conditions than other less affected areas in the same neighbourhood.

In North Kanara, the incidence of the disease increases with age; thus, in one garden, in a portion planted about six years ago, 40 clumps were examined in a row taken at random, out of which 34 showed definite symptoms of attack and only two plants could be considered really healthy and vigorous. Near by, an area had been planted this year (1940), partly with rhizomes and partly with seedlings. In the rhizome plantings, about 40 per cent of the plants were affected, while amongst the seedlings, the percentage of affected plants was only 1-2 per cent. In another garden, the planted area giving its first crop showed only a very small incidence of the disease, whereas in a second area, giving its second crop, nearly 80 per cent of the plants showed the disease. In the garden where the disease did not occur, the condition of the cardamoms was certainly not good and the standards of cultural treatment were no better than in affected gardens.

In other districts, the disease was rarely seen in new seedling plantings. In one area, where there was considerable disease in the older cardamoms, seedling replantings have been made in the last four years and no disease was seen in the 1938 and 1939 plantings, though one or two plants showed infection in the 1937 plantings. However, in Travancore, the disease was seen in some quantity in a four year old planting with jungle collected seedlings in new land never previously under cultivation.

Areas planted with rhizomes in affected areas showed more disease in the early stages. In many cases this is undoubtedly the result of lack of care in selecting planting material. Many new plantings or replantings in the Cardamom Hills were seen in which recently planted rhizomes already showed symptoms of the disease, i.e. within three or four months of planting. It seemed almost certain that these rhizomes were taken from already affected clumps. Even where the most careful selection is exercised, there is likely to be a higher proportion of affected plants in rhizome plantings than in seedling plantings. In one estate, where both types of planting material were used in approximately equal halves of a replanting, the percentage infection after one year was reported as about 3 per cent in the seedlings against 10 per cent in the vegetatively propagated plants in spite of the most careful selection.

In North Kanara, it is usual to leave an area fallow for one to three years before replanting, but one area was seen which had not been under cardamoms for ten years. In this area, there were no signs of the disease at the second crop, although practically everywhere else in the district showed a substantial proportion of affected plants by that time.

The absence of the disease in Coorg is of some interest since cardamoms have been cultivated in this province for a long time. The greater part of the production is, however, under a specialized system in which individual areas under the crop are very small and these are allowed to revert back to jungle after a limited period. These may be important factors in explaining the freedom of these plantings. With the exception of the Nelliampathies, the other areas so far free of the disease are all of recent development. Even the

Nelliampathies is a comparatively new district although one small field going back 25 years was seen.

As far as could be seen all the main types of cardamoms are susceptible to the disease, but no opportunities presented themselves for a satisfactory comparison of the relative susceptibility of different types. In one badly infested area of the smaller cardamom, occasional plants appeared to have escaped attack, but it could not be decided whether this escape was on account of any inherent resistance. Although a look out was kept for signs of similar symptoms on various wild species of Zingiberaceae in various districts, none were seen.

#### *Control measures*

In the absence of any accurate diagnosis of the disease, the only control measure possible in the past has been the rooting out and destruction of affected plants. On several estates this treatment has been reasonably successful and it was reported that the disease could be kept within bounds in this way. The evidence suggests however that if the method is to be effective, the destruction must be done on the spot or with as little transport as possible and that the rounds for spotting the disease must be frequent. It was pointed out on one estate where it had been the practice to bring diseased clumps to central points for destruction, that the incidence of the disease showed a considerable increase along the sides of the paths used. My own observations on this estate supported this as far as could be seen in the course of a short visit.

In other areas this method has been less successful, but it may be that the spotting of diseased clumps was inefficient or the number of inspections annually too few. In one area where the method has been a success, a permanent pest gang is maintained which makes a round of the estate every 30—40 days especially to deal with diseased clumps and every coolie is expected to mark any such clumps by breaking back the stems to facilitate recognition by the pest gang.

Various control measures have been tried on the assumption that the disease is a root disease—isolation trenches, soil treatment with lime or iron sulphate—but results have been negative. Sahasrabuddhe and Bapat concluded that partial soil sterilization by heat reduced the disease, but the evidence they gave only indicated that in the case of the soils they worked with, growth and development were greatly assisted by this treatment during the first two years after planting. This period, however, is one in which symptoms of the disease are comparatively rarely encountered.

#### *General conclusions*

It is obviously extremely difficult to estimate the position and prospects of a disease, the cause of which is uncertain and concerning which there are no detailed records of incidence and spread.

Experience in North Kanara especially indicates that it is a disease of enormous potentialities for damage and the extent of its presence in many small holdings in Travancore and Mysore is such as to render it a severe threat to their

productive capacity. Even under plantation management, it can rapidly assume serious proportions although there was evidence that with vigilance it need not present a very serious menace to production.

Once the disease has a hold on an estate it seems that nothing less than a complete replanting can give any prospect of success and the new planting requires very careful and frequent roguing. Even then, the experience in North Kanara is anything but encouraging.

While it has been generally concluded that the disease is a virus, the evidence is purely negative—the symptoms closely resemble those of other virus diseases and no parasitic agencies have been found in diseased plants. It is true that Sahasrabuddhe and Bapat referred the disease to a form of soil sickness, but it does not seem that this view will fit all the facts. The undoubted success that thorough roguing has given on at least one estate does not fit in with this theory, nor the tendency the disease shows to spread. It seems desirable at present to treat the disease as an infectious virus pending further experimental work. The evidence favours this hypothesis rather than one based on unfavourable environmental conditions.

If this hypothesis is true, suitable control measures can only fall into one of three groups—control of the transmitting agency, thorough roguing of diseased plants as they occur or the cultivation of an immune or tolerant variety.

With regard to the first possibility, we do not know how the disease is transmitted and it is of little use speculating in the absence of more knowledge. However, the observation mentioned earlier that the disease seemed to increase more rapidly beside paths along which diseased plants had been transported for destruction at central points, suggests the possibility of transmission, through injuries caused by diseased plants being forcibly pushed past the roadside plants. The development of the disease in patches might be explicable on the basis of pickers handling and picking diseased plants and then handling neighbouring healthy ones. These are only speculations but they are suggested because any risks can be avoided by the comparatively simple means of destroying all affected plants *in situ* and by insisting that the harvesting of diseased plants should be done by separate coolies.

It has been suggested that thrips may be the transmitting agents of the disease. While the matter requires examination the distribution of thrips and that of mosaic does not suggest that this theory is very likely. Mosaic was known long before thrips acquired the status of a serious pest and has shown no abnormal increase since. Thrips are common in several districts where mosaic is unknown and are absent in North Kanara, where this disease is probably most severe. Naturally in any detailed study of the disease, a close examination of the insect associates of the cardamom plant as possible vectors will form an important part of the work.

A really satisfactory solution of the problem as of so many others in connection with cardamoms, would be the discovery and propagation of resistant or tolerant types. The cardamom areas of Southern India provide ample opportunities for a search for such types. There are many neglected areas with a heavy incidence of the disease and if disease free plants can be found in such areas,

they may well provide starting points for the development of more suitable strains.

An important feature of this disease is the fact that there are several well defined areas which are at present free of this disease and that at least in Mysore and North Kanara there are estates or gardens where the disease is absent. Whether it is possible to maintain this freedom cannot be stated with certainty, but the position in North Kanara, where long established gardens are free, although separated from affected areas by less than a dozen miles, is encouraging.

One district, the Nelliampathies, has already taken action and the Governments concerned have utilized their Pest Acts to prevent the importation of rhizome material into the district. It would seem advisable to extend these provisions to the hills of Tinnevely, the hill range lying between the Cumbum valley and the Srivilliputtur-Tenkasi road and to Coorg. The two former areas are well defined and have few approaches and the prohibition of import of rhizome material from other areas involves no hardship since plants can be raised from seed and there is at present plenty of good planting material available locally.

Coorg presents rather more difficulty as the cardamom areas of South Mysore and North Coorg are practically continuous and although no mosaic was seen in the gardens visited in the latter district, it is not unlikely that it may occur in some gardens as is the case in South Mysore. The prohibition of import of cardamom rhizomes would be of little avail, if nothing was done to prevent rhizomes being moved from one garden to another within the province. If a closer inspection of the northern cardamom gardens in Coorg shows that the disease is in fact absent, then prohibitory legislation would seem worth introduction.

In districts where affected and unaffected estates or gardens occur, it is highly desirable that agricultural officers should impress upon growers the risks involved in purchasing rhizomes or seedlings from other estates, especially if their plantings are at present free of the disease. It seems to me unlikely that legislative action prohibiting the movement of rhizomes or seedlings within such districts would be of any additional value.

#### *Rhizome and root diseases*

In the Cardamom Hills, cardamom clumps suffer from a disease known there as 'Damping off'. The name is unfortunate since this term is usually employed by pathologists to describe the destruction of nursery seedlings by soil fungi such as *Pythium* and *Rhizoctonia* spp. This disease, however, consists of the decline and death of adult clumps in the field. Diseases of a similar general type were met with in practically all districts although they were less frequently brought to my notice in Coorg and appeared to be absent in North Kanara.

The symptoms of this group of diseases are not easy to define as they are rather generalized—paling and yellowing of the foliage, premature death of older leaves, weak new shoots and greater or lesser decay of the rhizomes and stem bases. Perhaps the most characteristic phenomenon is the brittleness

of the shoot bases. In many cases, the diseased clumps are made conspicuous by fallen leafy shoots, so that in one area, the trouble was described as 'Falling Disease'. Even in cases where there were few collapsed shoots, a slight pull was sufficient to cause standing shoots to break off at the bulbous base. In some cases, shoot collapse was the most marked visible symptom, while in others, foliage yellowing was the only indication of a diseased condition.

The examination of the roots and rhizomes of affected plants gave varying results. In at least two areas, the shoot bases, rhizomes and roots were found to be rotted and the outer tissues to contain black lines of fungus mycelium. In another area, rhizome and shoot base rotting was soft and brown but without the black lines. In all areas, however, plants could be found with the external symptoms described, but without any obvious signs of rhizome or stem base rotting. On one estate in the Cardamom Hills, I was informed that up to 30 per cent of affected plants contained the rhizome borer, while on two other estates in different districts, borings were noted in the rhizomes of sickly plants. In practically every case, diseased clumps showed extensive decay of the roots and in the southern areas this was very frequently associated with root borers. In Mysore and Coorg, the root borer was not found although cases of roots rotting and of rhizome decay were found and have been reported by other workers. In one case showing yellowing and death of leafy shoots the roots showed extensive rotting, although the rhizomes did not appear to be affected until after the death of the shoots.

Two diseases of the underground organs of cardamom have been described, one involving *Rhizoctonia* (Small in Ceylon) and the other associated with a species of *Cephalosporium* (Thomas, in Madras and Narasimhan, in Mysore). The former is described as a dry rot of the roots followed by a rot of the rhizome and the latter as a soft rot of the rhizome. Thomas obtained proof of the pathogenicity of the *Cephalosporium* by inoculation on young rhizomes.

While symptoms resembling those of these two described diseases were met with, it is clear that similar above ground symptoms are frequently associated with attacks of rhizome and root borers. In some cases it looked as if the fungal decays followed the attacks of these borers.

This group of clump decays showed no special relation to environmental conditions as a rule. In one or two cases symptoms were seen in areas where the obvious trouble was inefficient drainage but such cases, although showing similar external signs, can be separated from the many cases where no such simple explanation is possible. In the estates where one type of these decays is recognized as 'damping off' or 'falling disease', affected clumps appear to occur in patches on 10-15 plants. On two estates, it was reported that this disease was worse on land which formerly bore 'eeta' (*Ochlandra travancorica* Gamb.) thickets. In another district where this disease was practically the only trouble, there was a considerable development of this bamboo in the neighbouring jungles.

No evidence was forthcoming that plants failed to come on in areas from which diseased clumps were removed. In one area, it was stated that a certain



proportion of attacked plants recover by throwing new shoots from healthy portions of the rhizome, but elsewhere, recovery was considered unusual or unlikely.

### *Control*

As a general rule, the only method of control in use is the destruction of infected clumps, sometimes with the addition of lime to the pits. It is occasionally the practice to leave pits open and fallow a year before supplying with new plants.

In one area, experiments had been made with applications of sulphate of potash and lime to affected clumps and good results were claimed. The examination of a number of treated clumps, however, suggested that any improvement was only temporary and that the disease was still present and the clumps deteriorating.

### *Importance and status*

On the whole, in no area could it be said that this group of diseases was seriously menacing where normal agricultural care was practised, but here and there they could be considered troublesome.

It is obvious that there are several distinct diseases which produce similar symptoms and further information of the causative organisms and their inter-relations and their relation to environmental factors might assist in bringing them under more effective control. The possible importance of root and rhizome borers in relation to these decays indicates one line of study which might be fruitful. At the same time, these problems are not of such pressing importance as those presented by thrips and mosaic.

### *Leaf diseases*

Several leaf diseases are known but only two appear to be of any importance.

(a) In the Cardamom Hills, a leaf disease was noted which causes the death of a greater or lesser area of the leaf blade. Affected tissues become dry and brown and shredded into thin strips. As a rule one side of a leaf is affected more than the other. During the period covered by the survey it was clear that the disease was not active. Affected leaves were usually of some age and had been succeeded by one or two new leaves which were quite healthy and normal. Only one or two freshly infected leaves were seen, and these appeared to have been attacked in the unrolling bud stage. The more severe infection of one-half of the leaf seemed to be due to the unrolling of the leaf, the first half to unroll being less affected than the second half. Judging by the type of injury and the position of the leaves attacked, the disease is one of young leaves in sheltered situations during periods of rain and high humidity. In some respects, it seemed to resemble the disease known as 'nursery katte' in Mysore, but whether the fungus involved is the same remains to be examined. In the area where the disease is most prominent, it is known as 'Pythium', though I was unable to discover how this name became attached to it, since it seems improbable that the disease is actually caused by a species of *Pythium*. Old material I examined certainly showed no signs of a *Pythium* though fungal hyphæ were abundant in the tissues.

The disease appears to occur fairly generally in the cardamom areas but nowhere, except on one or two places in the Cardamom Hills, did it give rise to any comment.

(b) 'Katte' (Mysore).—The term 'katte' which is employed loosely in Mysore for almost any disease affecting the leaves or shoots, is used here to describe a peculiar disease of the leaves characterized by longitudinal necrotic streaks. These streaks are limited by the leaf veins and are at first separate lesions some half to one inch in length and one-eighth to one-quarter of an inch wide. They increase in size and fuse and eventually whole areas of the leaf blade dry up. The young leaf normally shows no abnormal symptoms, thus distinguishing the disease from mosaic (the 'katte' of North Kanara). As the leaf ages, the first visible sign of abnormality is the appearance of small water soaked spots, visible most clearly from the lower surface. These grow larger, turn brown and then pallid and give rise to a series of necrotic streaks. Eventually the leaf dries off.

Symptoms of this type were noted in every district visited but did not give rise to any concern except in Mysore, where they are regarded as a symptom of the decline of the clumps. This decline is apparently less rapid than that of mosaic affected plants. Affected plants usually occur in patches.

In nearly every place where the symptoms were noted, there appeared to be a close association with excessive exposure to the sun. In the southern districts, on the larger cardamom types, there was no doubt that this was the cause of the injuries. In Mysore, on the smaller cardamom, a clear relation to exposure was less obvious.

I am inclined to regard the symptoms as the result of some physiological disturbance, perhaps resulting from unfavourable light and water relations, but the matter requires further study in Mysore. It may not be without significance that in Mysore, there are larger areas planted in land previously under cultivation, usually coffee, than in any other district. This probably implies a lower organic matter content of the soil. The shade frequently contains a much higher proportion of deciduous trees and of exotics, such as *Erythrina lithosperma* and *Grevillea*. Further, the rainfall distribution is less well distributed over the year than in the southern districts. All these factors would tend to make light and moisture relations more variable, both at different points in estates and at different times of year. As has been pointed out, cardamoms seem extremely sensitive to slight changes in environment which affect soil moisture, soil organic matter and light intensity.

It may seem curious, at first sight, that if these symptoms are the result of intense sun, the 'male' areas in Coorg, where small plots are completely cleared, do not appear to suffer from them to any serious extent. It must be borne in mind, however, that the plots are very small, with the narrow dimension usually north and south, very great care is exercised in avoiding a western facing and the boundaries of the plots are always composed of tall and thick evergreen jungle. They are therefore exposed to the full sunlight, for only short periods and never in the afternoon when transpiration rates are at their highest.

In North Kanara, where the rainfall distribution is even less favourable than in Mysore, most of the areca gardens receive moisture supplies all the year through from permanent streams by seepage from tanks and the areca palms afford efficient protection from the sun.

It should be pointed out that as far as could be seen in a preliminary examination of this disease, no signs of any parasitic agency could be made out. Without further investigation it is impossible to say very much more about this disease, beyond recording its occurrence and indicating the factors which suggested themselves in the course of the survey.

(c) *Other leaf diseases.*

No other leaf diseases were noted during the survey. Two leaf spots have been received for report on previous occasions, in one of which a species of *Mycosphaerella* was found. No organism could be found in the other and it seemed likely that it was a form of sun scorch. Neither disease could be considered serious.

*Nursery diseases*

As has been pointed out in a previous section, considerable losses frequently occur in nurseries. These losses are especially serious in Mysore but they are liable to occur wherever nurseries are made. Some of these losses are probably due to ordinary damping off fungi which commonly attack delicate seedlings which are overcrowded or over watered. In Mysore, very heavy losses are commonly caused in nurseries by a disease known as 'Nursery Katte' which is perhaps better described as nursery leaf rot. It has also been recorded from other districts. It occurs in the wet season and is often severe enough to wipe out whole nursery beds of seedlings. A fungus is involved which has been identified by the Mysore State Mycologist as a species of *Coniothyrium*.

Examination of diseased leaves shows in the early stages water soaked spots which extend into large areas in which the chlorophyll is completely destroyed. The tissues become flaccid, and though wet, shrink up to the midrib. The diseased areas bear numerous dark coloured pycnidia which contain numerous single celled spores. In material examined by me these spores were colourless, placing the fungus in the form genus *Phyllosticta*, but there is no doubt that it is the same fungus as that described by the Mysore Mycologist as a *Coniothyrium*, since the spore colour may well vary with conditions.

Reports are conflicting as to the successful control of this disease by Bordeaux spraying, but successes have occurred in estates in both Mysore and Coorg. The failures may have been due to errors in time of application of the spray.

It seems that the disease is largely a matter of the coincidence of unfavourable conditions of soil moisture and humidity with a susceptible stage in the plant development. There is considerable room for comparatively simple experiments on modifications in the composition of nursery beds and in adjustments of transplanting times. It is perhaps not without significance, that in Mysore, where most reports of this disease originate, seedlings are often not transplanted and nursery beds are frequently laid out in wet lands, where soils

are often heavy and moisture excesses liable to occur. In North Kanara, this disease appears to cause little trouble and the soils of nursery beds are usually lighter. On one estate in the Cardamom Hills, the comment was made that 'field nurseries' are more successful in light soils than in heavy ones.

The successful control of this disease and other forms of nursery loss is bound up with the whole question of nursery management, on which, as has already been pointed out, a great deal remains to be done.

### *Conclusion*

On the whole, the diseases of cardamom, with the exception of mosaic and to a lesser extent, nursery leaf rot, do not appear to present very serious difficulties. The nursery losses can probably be reduced considerably by a little simple investigation, while the other diseases demand little more than a policy of 'cut and burn'. As in the case of insect pests, the usual mode of cultivation of cardamoms does not permit the utilization of control measures requiring much expenditure of money or accuracy of timing. Only with considerable increases of yield per acre would it become profitable to explore more intensive methods of disease and pest control. In the case of mosaic, it seems that the most hopeful lines of work lie in the direction of careful roguing and of selection for tolerance or resistance.

## VI. RESEARCH WORK ON CARDAMOMS

Research on a crop like cardamoms presents exceptional difficulties. The special requirements of soil, climate and elevation for the crop mean that the cultivated areas are in more or less inaccessible localities far from the larger centres of population. Usually the only other crops grown nearby are equally specialized types and there are no other staple products which might justify experimental farms in the neighbourhood, which could devote some attention to cardamoms. Further, cardamoms cannot be grown anywhere in South India at or near existing research institutions or experimental farms, if one excepts the Mysore Government Coffee Experiment Station at Balehonnur. These circumstances have rendered any sustained research on cardamoms practically impossible in the past and prohibit any real development in tackling the problems of the industry at present.

The result is that our knowledge of the problems of the crop has been derived entirely from occasional visits by research officers and from specimens submitted from time to time for report.

In North Kanara, where cardamoms are fairly accessible and form an element in a well developed garden industry, some investigational work on cardamoms was carried out by Sahasrabudde and Bapat in 1929, but this does not seem to have been continued. In the programme of the Bombay virus research scheme, work on cardamom mosaic is included. The existence of a pathological laboratory at Sirsi for areca nut work should simplify the control of work on this disease of cardamoms in this area. However, the small acreage of cardamoms does not favour this area as a centre for general cardamom research, but any information obtained on the biology of mosaic disease would be of considerable benefit to the industry as a whole.

In Mysore, the cultivation of cardamoms under one type of conditions common in the State has been possible in ravines at the Coffee Experiment Station. A small collection of types of cardamom has been made there and comparative data on their performance are being collected and some hybridization work has been carried out. Some experiments on the control of thrips by insecticides have been conducted, and V. K. Subramanyam, the Assistant Coffee Scientific Officer of the United Planters' Association of Southern India carried out some life history studies on this pest in 1938. Unfortunately the area available for development is very restricted and the amount of attention that can be given to cardamoms is strictly limited by the demands of the major crop. Finally,, although the conditions are fairly suitable, they are by no means typical and the Station is some distance from the main cardamom areas of the State.

In Coorg, the vast majority of the cardamom plantings are extremely inaccessible and the lack of any agricultural organization has precluded any investigational work. The cardamom 'males' come under the jurisdiction of the Forest Department and this Department under the guidance of the Forest Research Institute has carried out some studies on the effects of certain clearing practices in and around cardamom plots on the extent of capsule damage by insect agency. The results so far do not appear to provide any guidance for control. The 'male' plot system presents considerable difficulties for experimental work, since each individual plot is so small, rarely containing more than 100 clumps, and conditions from plot to plot vary considerably.

In Madras, some work on thrips in the Anamallais was carried out by Ramakrishna Ayyar and Kylasan in 1934-35 when this pest first appeared. At present a series of experiments on the control of thrips by insecticides are in progress on an estate in the Anamallais. Here, again the difficulty is that without special staff, supervision of even such simple experiments involves considerable journeys and much time. Any close study of the crop is impossible, since at none of the experiment farms in the presidency are conditions suitable for normal growth of cardamoms on a scale suitable for experimental work.

The difficulty of inaccessibility is equally present in Travancore, where the main cultivated areas lie in a tract of country entirely without motorable roads. The very serious position facing the industry in the last few years, as a result of poor crops which were certainly in part due to thrips, led to the appointment of an Assistant Entomologist to the Cardamom Hills and a small field laboratory was fitted up on one of the principal estates, to study thrips and hairy caterpillar damage. Here, the main attention has also been devoted to field experiments on the control of thrips by insecticides, though work on the life history and seasonal sequence of attacks is being taken up. A short report of a preliminary nature has been published. It must be admitted, I think, that the control measures at present being experimented with bear very little relation to the problem of practical control. The most urgent need is obviously some more detailed information on the fluctuations of the thrips population in relation to climate, so that there may be some hope of defining a period when insecticidal control can be undertaken with a strictly limited

number of applications exerting their maximum effect. If this is not possible, then any hope of successful control of thrips by spraying or dusting under the present cultural conditions must be abandoned and it would be more profitable to direct research in other directions.

## VII. RECOMMENDATIONS

From the survey, it is clear that the cardamom industry is in urgent need of technical assistance. After a long period of freedom from serious problems over the greater part of the producing area, the situation has deteriorated rapidly in the past six years. The sudden appearance of thrips and its rapid spread over the whole cardamom producing area, combined with a series of climatically unfavourable years, has brought about an enormous reduction in yield and threatened many plantations with extinction. At the same time the extension of mosaic cannot be regarded without some concern in view of the damage it has shown itself capable of doing in North Kanara. From the point of view of the grower, the attacks of thrips have loomed most seriously and the demand has been for research on control methods for this pest. Attempts have been made by three administrations to meet these demands, though I think it will be admitted by all concerned with these trials, that they can be considered of very small value without a greatly increased knowledge of the pest and that even if successful results are obtained, their usefulness will be limited to a very small proportion of cardamom producers and most of these will be those who combine cardamom production with other crops.

In planning any programme of technical assistance to the cardamom industry, it is essential to keep in mind the mode of cardamom production. It must be remembered that the vast majority of cardamom producers are small holders and that a large proportion of them are not resident on their holdings. Further, the cultural works and the harvesting of the crop are carried out by temporary labour forces which are only available at certain seasons. Even where the grower lives on his holding, cardamoms frequently do not represent his sole crop and work on cardamoms has to be fitted in with the requirements of other crops such as rice, areca nuts or coffee. Even the larger plantation holdings maintain only very small permanent labour forces.

These considerations lead me to the conclusion that investigations based on the possibility of direct control measures for thrips, or in fact any other pest or disease, which will involve accurate timing of sprays or dustings or considerable increases in the labour forces at specific times other than the existing working seasons, can only be of very limited usefulness.

If we examine the thrips problem with this point of view in mind, we are faced with two other possible lines of investigation—the search for some means of biological control, or the search for resistant or tolerant strains of cardamoms. While the first line of approach is attractive and one which catches the imagination of the layman, its practical possibilities do not appear promising. Even if suitable parasites or predators were found, they would demand a considerable organization to distribute them and to maintain supplies until they became thoroughly established. Further, biological control measures are

only likely to be effective under certain very specialized circumstances and it is doubtful whether these circumstances occur in the present instance. Finally, if successful results did accrue, they would be only related to one problem of the industry and leave others untouched.

There remains the possibility of selection for resistance or tolerance to thrips attack. Enough evidence was forthcoming during the survey to suggest that work along such lines is the most promising method of tackling the problem. There were undoubtedly wide differences in susceptibility to thrips injury among different types of cardamoms and there is every reason to believe that closer investigation would permit the development of types suitable in other respects to replace existing highly susceptible varieties.

In addition, a carefully planned programme of selection work involving the study of other characters besides thrips resistance would be bound to assist the industry by the provision of better yielding types of more even quality. Such assistance would have the important advantage that it could be effective without requiring any revolutionary changes in labour supply or distribution. Higher yields and less liability to pest or disease attack would increase the ability of the industry to introduce more intensive methods of management, where present methods are primitive. At the same time, it seems more than probable that the only practical approach to the problem of mosaic disease lies along the path of selection for tolerance or resistance to the causative agent.

I consider, therefore, that any research scheme to assist the industry would be far better based primarily on a selection programme than on one designed to tackle disease and pest problems directly.

A further consideration supports this view. Unlike many research schemes which can be carried through at existing experimental farms or research institutions, any research scheme for cardamoms necessarily involves the establishment of a research station or stations in a cardamom growing area. As has been pointed out in discussing past and present work on cardamoms, it has been impossible to carry out any sustained work departmentally, except to a small extent in Mysore, owing to the absence of any experimental farm or research station in the cardamom growing centres. From the point of view of organizing work and of affording a nucleus for expansion, a selection programme makes a much more satisfactory basis for a research station than a programme based on the study of any specific disease or pest. This would not weigh so heavily, if circumstances suggested the desirability of direct investigations, but as I am convinced they do not, it simplifies the planning of work and the efficient use of the time of the staff.

I do not under-estimate the desirability of further investigations on the life history and seasonal fluctuations of thrips and even on chemical control measures, but I think the evidence of the survey indicates that much more is to be expected from selection work and this should be given first place.

A consideration of the distribution of cardamom cultivation and the various forms it takes in different districts leads to the inevitable conclusion that a single station is inadequate to meet the needs of the industry. One need only refer to the wide difference in climatic and cultural conditions and in the

type of cardamoms cultivated between Mysore and Travancore to emphasize this point. It seems essential that there should be at least three working centres though two of them would need to be only on a very modest scale.

To carry out the work of a cardamom research scheme to the best advantage, it must be designed to cover the whole cardamom industry, irrespective of the individual administrations in which the cultivated areas lie. For this purpose it seems to me that while any scheme should work in cooperation with various individual Agricultural or Research Departments, it should be controlled jointly by some small representative committee rather than by any one administration and should be in charge of an officer of sufficient experience and status to take complete charge of the activities of the scheme subject to review by the committee.

#### *Situation of research station and sub-stations*

Considering a research scheme on the basis of three working centres, it is necessary to decide on their situation. One of these centres will be the main station and the headquarters of the scheme, while the others, sub-stations for the duplication of variety trials and the multiplication of promising selections.

As a station primarily concerned with the collection and testing of cardamom varieties will require to introduce into one locality, collections both of seed and rhizomes from all cardamom districts, it is obvious that it can only be situated in an area where there is no risk of introducing pests or diseases not already known in the area. This provision appears necessary in this case mainly on account of the difficulty of ensuring freedom from mosaic in rhizomes. This limits the selection of sites to the Anamallai Hills in Madras, the Cardamom Hills in Travancore and the Munzerabad Taluk in Mysore. These three areas can be considered as suitable from this point of view for the establishment of stations.

Of considerable importance for the establishment of such stations is the availability of suitable land and of buildings which might be rented for laboratory and living accommodation. Although no specific enquiries were made on this question, in all three areas it seemed probable that these facilities could be made available by planters with a direct interest in cardamom research. The presence of such facilities would be an important factor in avoiding the necessity of any considerable capital outlay.

The question of which district is the most suitable for the main station remains to be decided. In my opinion there is little doubt that the Anamallai Hills is the most suitable. It is more central than either of the other two districts, the cardamom areas are readily accessible by road and it is only 65 miles from Coimbatore. Although the area of cardamoms in that locality is not very large, the estates growing cardamoms are individually of a fair size and reasonably typical of cultural conditions in the southern areas and the owners or managers have all expressed great interest in cardamom research and can be relied on to cooperate in assisting any sound research scheme. The proximity to Coimbatore with the resources of the Agricultural Research Institute would be of immense benefit to the workers on cardamom who will inevitably have to rely on a larger institution for reference purposes.



The Cardamom Hills, although the largest cardamom growing area present difficulties of accessibility and the maintenance of contact with the other growing districts would be more difficult. This area should undoubtedly form the site of a sub-station in view of its importance as a growing area, but is obviously less suited for the main station.

The problem of accessibility is less acute in Mysore, but this area is a long way from the southern districts and the type of cardamom grown and conditions of cultivation differ markedly from these districts. It is well suited for a sub-station which will have as its special concern the requirements of Mysore and Coorg.

I would recommend therefore the establishment of a main experiment station for cardamoms in the Anamallais with two sub-stations one in the Cardamom Hills of Travancore and the other in the Munzerabad taluk in Mysore State.

#### *Main lines of work*

In the first place, I would recommend the laying down of an adequately replicated test area of the four or five main types now found in cultivation, at each station. Speaking on the basis of observations made in the course of the survey, I should say the types might be (1) the erect 'Mysore' or 'Ceylon', (2) the flexuous paniced Hybrid, (3) the prostrate paniced Hybrid, (4) the typical round fruited Malabar and (5) the prostrate paniced type commonly grown in North Kanara. Such an area planted up with rhizomes taken from a number of typical clumps of each type would form a test of the comparative performance of these main types in each locality. It would ensure that whatever results were obtained from the scheme one result could be ensured from the beginning—at the end of five to seven years, it would be possible to present detailed evidence of the performance of each type with respect to yield, disease and pest resistance and tolerance of climatic conditions. There is no reason why such trials could not be duplicated on private estates in other areas by co-operation between the staff of the scheme and planters. At present, there is no satisfactory evidence on the comparative behaviour of the different types in different districts although many opinions were expressed, some of them contradictory.

At the same time, a collection of as many selections as possible should be made so that the whole range of types available in South India may be brought under observation under uniform conditions, plants being raised from selected clumps both by seed and by rhizomes. This would involve a more detailed study of the material available with a view to the discovery and distribution of better strains within the main varieties. This work could be extended to include hybridization, with the aim of producing a plant with desirable capsule characters, high yields and tolerance or resistance to the main diseases and pests.

This work necessarily involves the development of a satisfactory nursery technique which can be relied upon and of rapid and efficient methods of vegetative propagation. As has been pointed out, the present position with respect to seedling propagation is unsatisfactory. This means that the study

of propagation methods must take a prominent place in the scheme. Such work, besides being essential for the selection and breeding work, might be expected to produce useful practical results in the early stages of the scheme.

It is unnecessary at this stage to go into any greater detail. It is obvious that a great deal of work on flowering and fruit set, distribution of growth and the relation between vegetative growth and flowering shoot formation will be involved in the studies on cardamom types. Besides being necessary for the comprehensive comparison of types, such work will form a basis upon which studies on cultural treatments could be taken up at a later date.

Subsidiary to this main programme, I think some entomological work is desirable. Apart from the possibility that chemical control of thrips might prove useful to a certain number of growers if it could be based on a knowledge of when severe outbreaks are likely to occur, I think the very prevalent root borer in the southern districts deserves attention. I was struck with the possibility that it might be connected with some of the forms of clump decay observed and it seemed certain that it must accentuate considerably the injury done by drought. This, I regard however, as secondary, to the main scheme.

The objection may be raised that it will be some time before practical results accrue and still longer before better strains can be multiplied rapidly enough to supply any extended area. These objections are of course common to most technical investigations but are, I think, less serious than at first appears. The trials of the main types should begin to give results in three years with respect to thrips tolerance and suggestions of a general nature on the most suitable variety among the main types could be made. The nursery investigations could be expected to be of use to the industry at a very early stage and studies of rapid methods of vegetative propagation should assist in making promising types quickly available. With three working centres, the increase of promising types could be made quite rapidly.

#### SUMMARY OF RECOMMENDATIONS

The main recommendations can be summarized as follows:—

1. The establishment of an experiment station for cardamoms in the Anamallai Hills, with two sub-stations, one in the Cardamom Hills of Travancore and the other in the Munzerabad taluk of Mysore State.
2. The programme of research to be based on selection and breeding work, with special reference to the multiplication of types resistant to thrips attack.
3. The scheme to be under the control of a small representative committee, rather than under any one administration, perhaps on the lines of the Tea, Rubber and Coconut research schemes in Ceylon.

## APPENDIX

## A DRAFT RESEARCH SCHEME TO IMPLEMENT THE RECOMMENDATIONS OF THE REPORT

The following suggested scheme is based on the one proposed by the Madras Department of Agriculture, modified in accordance with the recommendations made in the report

*Staff*

No.	Post and scale	1st year Rs.	2nd year Rs.	3rd year Rs.	4th year Rs.	5th year Rs.	Total Rs.
1	Assistant Botanist, 190—25/2—240—30/2—480, starting at 215	2,580	2,580	2,880	2,880	3,240	14,160
	Unhealthy allowance at 67/8	810	810	810	810	810	4,050
4	Assistants, 75—7½/2—105, starting at 90	4,320	4,320	4,680	4,680	5,040	23,040
	Unhealthy allowance at 45	2,160	2,160	2,160	2,160	2,160	10,800
1	Laboratory man at 50—5/2—75	600	600	660	660	720	3,240
4	Fieldmen at 30—3/2—48	1,440	1,440	1,584	1,584	1,728	7,776
	Unhealthy allowance, Lab. man at 22-8-0	270	270	270	270	270	1,350
	Unhealthy allowance, Fieldmen at 13-8-0	648	648	648	648	648	3,240
3	Peons at 12	432	432	432	432	432	2,160
	Travelling allowance.	3,000	1,500	1,500	1,500	1,500	9,000
							78,816

*Remarks*

For the present, I have left the rate of pay for the Assistant Botanist at the same figure as that given for the Entomologist in the Madras Scheme. I think it will probably be desirable to have an officer of a higher grade if the scheme is to be worked under a committee as suggested in the report.

The four assistants include an officer for each sub-station who should have a botanical or agricultural training and an officer of similar training and an entomologist for the main station.

I consider that the post of laboratory man might include such clerical work as might be required at the main station.

The fieldmen would be distributed to provide one field man at each sub-station and two at the main station.

I consider that peons could be recruited locally as is done at the Mysore Coffee Experiment Station.

I have left the unhealthy allowances as given in the Madras scheme, except those for the peons.

The Travelling Allowance allotment has been substantially increased as obviously in the early stages a considerable amount of touring for the collection of material will be essential. Provision must also be made for the regular visiting of the sub-stations.

*Laboratory and field expenditure*

	1st year Rs.	2nd year Rs.	3rd year Rs.	4th year Rs.	5th year Rs.	Total Rs.
<i>1. Laboratory, etc.—</i>						
Rental of buildings . . . . .	2,000	2,000	2,000	2,000	2,000	10,000
Apparatus and materials . . . . .	4,000	500	500	500	500	6,000
Furniture . . . . .	1,500	..	..	..	..	1,500
Contingencies . . . . .	1,000	1,000	1,000	1,000	1,000	5,000
<i>2. Field—</i>						
Lease of lands, 50+20+20 acres at Rs. 10	900	900	900	900	900	4,500
Working expenses . . . . .	3,000	2,500	2,500	2,500	2,500	13,000
						40,000
Total staff . . . . .	..	..	..	..	..	78,816
						1,18,816

It is impossible to give a definite figure for rentals without further enquiries of suitable estates. There might be some difficulty in obtaining accommodation for a staff of six suggested for the main station and providing a building for a laboratory. However this staff is smaller in number than that suggested for the station in the Ananallais in the Madras Scheme.

The other items under laboratory expenditure call for little comment. An item for furniture is included because in my experience the fitting up of the most modest field laboratory on an estate always involves expenditure under this head.

I have omitted the leasing of planted cardamoms and put in 50 acres of land for the main station and 20 acres at each sub-station. As these stations

will be situated on cardamom estates there will be ample areas of adult cardamoms for observational work and for any experiments on thrips control, without the necessity of the areas being worked by the station. The main requirement is land which can be planted (or replanted) with cardamoms collected as the basic material for selection. If any of this land carried yielding cardamoms, the produce could remain the property of the owner, subject to the adjustment of harvesting charges.

The working costs have been calculated on the basis of about 1/3 coolies per acre working for 10 months in the year. This is higher than normal cardamom estate practice, as will be necessary on an experiment station. The details of carrying out field works would have to be considered in some detail once suitable sites were decided upon.

