

PLANTATION CROPS GENETIC RESOURCES RESEARCH IN INDIA

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INTRODUCTION

In India, crops like tea, coffee, and rubber which were grown as organized plantations under colonial rule, are traditionally referred to as plantation crops. However, crops like coconut, arecanut, cashew, spices etc., even though are essentially small holders crops, are also considered as plantation crops. In addition to these crops cacao and oil palm also fall under this category. The perennial nature, sustained income from plantation over a period of time, and tropical habitat of these crops lend support to this definition. Even though the cultivation of these crops is fairly ancient in India, they are primarily small holder crops occupying only about 2% of the total agricultural land. But in terms of national economy they contribute around 75 per cent of the export earning from agricultural commodities (Bavappa, 1977). Crops like arecanut, cashewnut, small cardamom, ginger, turmeric and tea rank first in world production while black pepper and coconut are in second and third position respectively in the total world production. In this context, it becomes very essential to give a high priority for genetic resources of these crops. Till recently, many of these crops did not receive much attention with the exception of tea and coffee which were bestowed with best attention. The plantations established in early years still exist in certain parts due to lack of

systematic replanting programmes. It is to be noted that most of these crops, except spices are introduced into India. But the situation of the plantations as indicated above led to the preservation of sizeable variability that was present in the original introductions, but with the growing awareness of the importance of these crops in the international trade, especially spices and cashew, and the advent of superior planting materials in these crops underline the urgent need to take stock of the situation and conserve available resources for posterity.

Status of germplasm holdings

The genetic resources programmes in plantation crops are being handled both in the ICAR Research Institutes (Central Plantation Crops Research Institute, National Research Centre for Spices, National Research Centre for Cashew) and Commodity Board's research institutes like Coffee Research Institute, Rubber Research Institute, Cardamom Research Institute and research units of private agencies like Toklai Research Institute and UPASI. In addition, under the three All India Coordinated Crop Improvement Projects on Palms, Spices and Cashew some of the University Centres also undertake collection and conservation programme in plantation crops. While in crops like tea, coffee, and rubber the research efforts are concentrated in a few centres, there is no duplication of effort between different research

units; but in case of crops like coconut and cashew, there is a scope to rationalize the efforts that are being made in collection and conservation to avoid duplication. For maintenance of collec-

tions, large areas are required and this land stands committed to those collections for a very long period as the life span in most of the cases range four to six decades. The centres which are main-

Table I. *Major plantation crops germplasm maintenance centres in India*

Crop	C.P.C.R.I		All India Co-ordinated Crop Improvement Project Centres and others
	Main Centre	Alternate Centre	
Coconut	Kasaragod	Andamans	Pilicode (Kerala); Veppankulam (Tamil Nadu); Coimbatore (Tamil Nadu); Arsikere (Karnataka); Ambajipet (Andhra Pradesh); Ratnagiri (Maharashtra); Mahuva (Gujarat); Kalyani (West Bengal) and Cuttack (Orissa).
Arecanut	Vittal	—	—
Cashew	Vittal	Shantigodu	Mannuthy (Kerala); Bapatla (Andhra Pradesh); Vridhachalam (Tamil Nadu); Vengurla (Maharashtra); Bhubaneswar (Orissa), Ullal (Karnataka).
Cacao	Vittal	Kidu	Mannuthy (Kerala).
Oil Palm	Palode	Andamans	—
Pepper	Calicut	Peechi	Panniyur (Kerala)
Ginger	Calicut	—	Solan (Himachal Pradesh); Pottangi (Orissa); NBPGR Centre, Peechi (Kerala).
Turmeric	Calicut	Palode	Solan (Himachal Pradesh); Pottangi (Orissa)
Nutmeg	Calicut	—	—
Clove	Calicut	Peechi	—
Cinnamon	Calicut	—	—
Cardamom	Appangala	—	Mudigere (Karnataka); Pampadumpara (Kerala); Cardamom Research Institute, Myladumpara.
Coffee	—	—	Central Coffee Research Institute, Balehonnur (Karnataka)
Tea	—	—	Toklai (Assam), UPASI (T. Nadu)
Rubber	—	—	Rubber Research Institute of India, Kottayam

taining the plantation crops (other than coffee, tea and rubber) germplasm in India are given in Table I.

While the collections in crops like coconut, arecanut, cardamom, pepper and cashew are largest in the world they cannot be considered as comprehensive and in quite a few instances the variability is minimum. In the absence of reliable information on the source population variability from which the collections are made, it becomes difficult to define these collections in strict terms as access-

ions. In general, in plantation crops the accessions constitute plant sample collected from a single location and are often identified by the place of origin/collection. However, the most systematic attempt in collecting germplasm in terms of species and definite characters were made in pepper (Rahiman *et al.*, 1979). This is one crop wherein clear differentiation of the germplasm into cultivated types and wild types has been made. In the case of all other spices (except ginger, turmeric and cardamom) the presence of wild types is not recorded. The germ-

Table II. *Germplasm holdings in Plantation Crops at CPCRI Centres*

Crop	Centre	No. of Accessions		
		Exotic	Indigenous	Wild
COCONUT (<i>Cocos nucifera</i> L.)	Kasaragod	62	35	—
ARECANUT (<i>Areca catechu</i> L.)	Andamans	24	—	—
CASHEW (<i>Anacardium occidentale</i> L.)	Vittal	29	43	—
CACAO (<i>Theobroma cacao</i> L.)	Vittal	5	243	—
OIL PALM (<i>Elaeis guineensis</i>)	Shantigodu	—	150	—
NUTMEG (<i>Myristica fragrans</i> , <i>M. beddomei</i> , and <i>M. malabaricum</i>)	Vittal	48	—	—
BLACK PEPPER (<i>Piper nigrum</i> L.)	Palode	6	1	—
GINGER (<i>Zingiber officinale</i>)	Calicut	—	301	—
TURMERIC (<i>Curcuma longa</i> , <i>C. aromatica</i>)	Calicut	—	184	76
CLOVE (<i>Eugenia caryophyllus</i>)	Calicut	—	124	3
CINNAMON (<i>Cinnamomum verum</i> , <i>C. malabaricum</i> <i>C. aromaticum</i>)	Calicut	6	166	8
CARDAMOM (<i>Elettaria cardamomum</i>)	Calicut	2	150	—
	Appangala	—	213	—

plasm holdings in different plantation crops at CPCRI are listed in Table II.

In the case of pepper and cardamom, systematic surveys were undertaken for documenting and collecting indigenous germplasm. Efforts are underway in coconut, cashew and tree spices like clove, nutmeg etc. The exotic germplasm was mainly obtained through exchange programmes. In these exchange programmes, material often was collected from a few individual plants, as is apparent from lack of easily identifiable and discernible variability and sent to India on request. In most of the cases the source, population description is not available, thereby limiting the utilisation potential of these collections. For example, the collection site description, altitude and latitude will be of a great help in choosing the accessions that can be evaluated at a given site. Even though the collections, as mentioned earlier, are the largest in the world, the impact can only be realized if proper collection record descriptors are maintained. The long life span of these crops which is normally considered as a disadvantage in the evaluation programmes, is in fact a blessing for retracing a collection sources (site) as well as source population even at a later date. Hence the attempts now should be made to collect such of those informations which are at present not readily available at the maintaining centres. The first systematic exotic collection programmes in these crops undertaken was in coconut in six Pacific Ocean Islands with the financial assistance from IBPGR (Bhaskara Rao and Koshy, 1982).

Collection priorities

In the future programmes, to overcome this lacuna, crop-based descriptors should be used in all the survey collection programmes. Some of the proforma which are developed on these crops by the Central Plantation Crops Research Institute are already in use.

In India the National Bureau for Plant Genetic Resources is the nodal ICAR Institute with the mandate to coordinate genetic resources programmes for all the crops. They are also vested with the responsibility of both introduction of the material from abroad and for organizing crop specific collection programme within the country as well as in exotic locations. The crop priorities for some of the plantation crops are listed in Table III.

The priority areas should be viewed primarily from three different angles namely conservation, collection of variability and locating resistance to a specific pest/disease. The top priority naturally in germplasm programme is conservation. The germplasm collections are often defined as the material preserved for posterity and it is not always possible to visualise the needs of the future. This necessitates even conservation of material from endangered areas. For example, the Western Ghat region which is very rich in indigenous spices genetic resources is an area which is perpetually threatened with the new settlements and denuding of the existing forests. Similarly the population pressure in smaller islands in Pacific and Indian Oceans resulting in migration to hitherto uninhabited islands, might endanger the available resources which are

Table III. *Priority areas for collections in some of the Plantation Crops*

Crop	Exotic	Indigenous
Arecanut	South Pacific, Nigeria	NE Region, Attapadi (Kerala)
Coconut	Indian Ocean Is South America, Melanesia and Micronesia	Gujarat; Andaman and Nicobar; Karnataka, West Bengal, Andhra Pradesh, Orissa
Cashew	Brazil, Mozambique Tanzania and Madagascar	Goa, Orissa, Tamil Nadu Andhra Pradesh, West Bengal, NE Region and Maharashtra.
Cacao	Amazon, Ghana, NC America	Karnataka, Kerala (Idukki, Kottayam and Wynad Dist)
Oil Palm	South and Central America, Malaysia, Nigeria	Kerala, Andhra Pradesh, Maharashtra (Sattar District)
Nutmeg	Moluccas Is. (Indonesia) Papua New Guinea	NE Region, Andaman and Kerala
Black Pepper	Malaysia, Indonesia, Brazil and Sri Lanka	Kerala, Karnataka, Tamil Nadu, Assam, Andamans
Ginger	Australia, Jamaica, China, Brazil	All over India
Turmeric	Malaysia, Indonesia, Guatemala, Sri Lanka, Pakistan	Assam, Meghalaya, Andamans
Clove	Moluccas Is. (Indonesia) Zanzibar, Indonesia, Solomon Is.	Courtallam, Nagercoil (Tamilnadu)
Cinnamon	Sri Lanka, Indonesia, China	NE region and Andamans
Cardamom	Guatemala, Sri Lanka	Kerala, Karnataka, Tamil Nadu, Assam
Great Cardamom	—	NE Region, Kerala
Vanilla	Seychelles, Solomon Is.	Western Ghats (Kerala)

present. Hence, the collection strategy of any given crop should also include the programmes for collection from such areas. In this context, the clearing of tropical forests which has been estimated to be about 47 hectares per minute

(Mayers, 1979) warrants programmes for collection of these crops in all the tropical forests especially in South America, and Brazil for crops like coconut, oil palm, cacao and cashew. Africa which is also rich in plantation crops like coconut, oil

palm, and coffee should be included in collection programmes. Even though the centre of origin need not necessarily be the centre of diversity, it is imperative to include the collections from these areas for both conservation as well as for enriching the variability. Priority areas for collections made from the regions where those for variability should be well defined. The regions to be included for collection for resistance of pest/disease is not an easy task. Prevalence of pests or disease in any given area gives an indication on the resistance reaction of given genotype of that area, the collections made from the regions where the pest or disease is absent needs to be studied again. In plantation crops in the absence of reliable screening techniques, field testing is the only alternative for locating the resistance/tolerance. This not only consumes considerable time but also resources. Therefore, a judicious approach is needed while making collections for pest and disease resistance. The possibility of locating the resistance/tolerance in the hotspots appears to be bright. This is also based on the postulation that any given genotype can evolve/mutant only under the selection pressure. However, the genotype which is not exposed to a specific pest/disease may be also included in screening programme.

From the above, it is apparent that the collection programme can be defined only in terms of the need or the objective. This is also true while collecting the proven cultivars. In other words, the priorities have to be defined in terms of gene introductions (for resistance) and plant introductions (for variability) (Frankel, 1985).

Sampling procedures

In plantation crops especially coconut,

oil palm, cashew etc., which occupies large area for maintenance, the representative sample to be maintained in the germplasm collection need to be realistic. In the case of coconut large size of seed imposes severe limitation on transportation as well. It has been recommended that a sample size of 100 nuts is sufficient for making a representative sample from any given site. For cross pollinated tree crops a minimum of 25 and a maximum of 50 are recommended for germplasm maintenance. The study carried out by Rajanaidu and Hassan (1985) is probably the most comprehensive one in plantation crops on defining sample size. Based on a study of 919 accessions of oil palm collected from different countries in Africa and South America, they have concluded that an extreme population has diversified from rest while within a given population the variability between palms is limited. Bhaskara Rao and Koshy (1982) during their coconut collection in Pacific Islands also recorded that between sites (different islands) there was much variability while the variation within a given population was low. Therefore, the sampling of individual plants at a given site can be kept low while number of sampling sites which are far apart have to be more in collection programmes where sampling genetic variability is the objective.

In the indigenous collections the priority at present is being given for collection of desired plant types for immediate exploitation in crops like coconut, cashew, pepper as well as in cardamom. In coconut, cultivars which are well adopted in drought prone regions and those with high yield potential have been collected from Tiptur

area in Karnataka. High yielding selections of Karimunda and Kottanadan cultivars of pepper in Kerala were collected during survey collection. Similarly, in cashew the immediate objective is to be collect the plant types with compact canopy, bold nuts and short flowering period. In an exotic germplasm collection in oil palm which is programmed for this year the priority will be to collect plant type with high yield which also showed desirable characters with high heritability. In these programmes, the sampling obviously is to be biased and collections made from individual trees.

While in the above defined programmes the collections itself is of no difficulty but possibility of realising the same genotype is doubtful mainly due to the cross-breeding nature of these crops. Therefore, collection of vegetative material has been thought of in case of pepper, cardamom and cashew where it is feasible. In the case of coconut and oil palm the necessity for secondary evaluation cannot be avoided. While looking for resistance in the hotspot areas the situation will be different. Large number of plants which does not show the symptoms need to be collected for retesting.

Quarantine precautions

It is necessary to define the minimum quarantine precautions that have to be observed before embarking on collections. Hewilt and Chiarappa (1978) defined the quarantine precautions for some of the plantation crops. The quarantine has to be viewed from two angles: (1) quarantine at the site of

collection; (2) the quarantine precautions at the port of entry. In this context, it may be emphasized that most often collections made will be added to the existing germplasm of that centre and the chances of being planted together are high. Hence, quarantine precautions need not necessarily be meant only for the exotic collections but also should be followed for indigenous collections as well. This is especially true in coconut where large number of diseases of uncertain aetiology are prevalent in different parts of the country. In pepper slow wilt, in ginger the rhizome rot, in cardamom Nilagiri necrosis and Katte diseases are a few examples of maladies which warrant strict quarantine precautions even during indigenous collections.

It is advisable that a collection team comprising a Plant Protection person and a Plant Breeder should visit the collection site. This is necessary not only to ensure that the collection worthiness of the material but also to document the pest and disease that are present in collection site. As mentioned earlier this will enable the identification of accessions which are to be given priority for screening for resistance to a given pest/disease. Crop specific quarantine schedules at the collection site as well as at port of entry need to be worked out. At present the procedure that should be adopted at collection site and also at the port of entry for quarantine inspection is available only for few crops (Bhaskara Rao and Koshy, 1984). This will facilitate fast clearance of the valuable material. Preparation of crop specific pest and disease list will help both collection teams as well as quarantine inspection officials.

While it is the first priority to see that there is no inadvertant introduction of pest/disease through new collection it is also essential to see that the collected material is safeguarded against indigenous pests and diseases that are prevalent at the maintenance site. Considering this, Central Plantation Crops Research Institute has established an offshore genebank in the Andaman Islands for maintaining world coconut germplasm. The collections from South Pacific, which often recorded as original home of coconut, has been made with the primary objective of locating resistance to root wilt disease. In an earlier attempt to locate resistance to lethal yellowing in Jamaica Whitehead (1966) made the collections from the same region and planted in natural epiphytotics. Most of the collections proved to be susceptible to lethal yellowing and these collections are now currently not available for any future programmes. A given genotype, susceptibility to a specific pest/disease does not rule out the possibility of the same genotype being resistance/tolerance to some other pest/disease. Therefore, while maintaining the collections in a protected offshore gene bank the utility of these collections can be enhanced. By producing sub samples, these collections, can be tested against a number of diseases. Therefore, it is not out of place to conceive an offshore quarantine statistics alon with a genebank separately for plantation crops. Considering the importance of these crops in the national economy establishment of such a station appears to be a priority.

Characterisation, evaluation and documentation

Genetic resources programme is one of

the first priorities which have been thought of in any crop improvement programmes. A number of collections were made in different crops especially in cereals, millets and legumes. More than 20,000 accessions of crop germplasm were collected by about 40 missions in the different countries of South East Asia during past decade; but less than 10 per cent of the accessions have been characterized (Chamchalow and Singh, 1985). While constraints like lack of manpower and other resources are understandable, considering the importance of characterization it has to be emphasised that preliminary characterization is a mandatory task. Unless the material collected is characterized the utility of the collection remains nil. Fulfilling this basic task also enables in avoiding redundancy in collection efforts. Very often a crop is collected from same site due to lack of information on the collections made earlier. This is more so in case of gene collections where sampling is done for specific characters. Yet another hazard in neglecting the characterization is, adding duplicate collections and making available resources more scarce for important functions like evaluation. In plantation crops where the collections are often maintained as active collection in field, there is a need to limit the collection size to optimise resource utilization. The preliminary characterization of data should be limited to collection record descriptors and data on characters which are easily distinguishable in different environments. Quantitative characters which are more often dependent on environmental factors could be misleading. As mentioned earlier the information on a given accession reaction to pest/disease at the source of collection

will be of immense value. Similarly reaction to drought, altitude at which collection is made will help in immediate utilization of the collections. The best example could be the San Ramon coffee which has become popular at low elevations.

The characterisation gives a preliminary insight into collection, but does not supplement evaluation. The performance at a given location needs to be tested separately. Even though characterization data are lacking in most of the plantation crops the evaluation data are fairly exhaustive. Almost in all the plantation crops, we have selections from germplasm which have certainly added to the high production and productivity of these crops in the country. However, it is to be mentioned that only a fraction of the material collected in different crops has been evaluated, especially for reaction to biotic and abiotic factors. The evaluations in different crops have been directed more towards higher yields, only with lone exceptions being coffee and to some extent pepper in which screening for disease resistance has received fairly good emphasis.

In plantation crops where data on an accession are collected over a period of few decades starting from source population characterization, nursery evaluation, juvenile stage evaluation, stabilized yield evaluation, the need for systematic information management cannot be over emphasized. Central Plantation Crops Research Institute has established a good documentation system with separate data registers for each of the crops. However, retrieval of information still is a tough task. With the advent of computerized

genetic resources management systems, this task has become relatively easier but is yet to be fully adopted in Plantation crops. Efforts in this direction are underway in coconut and cashew.

The immediate priority should be to consolidate the available information and bring out crop specific catalogue. This will not only enable effective use of collections already made but will also help in identifying gaps in collection, so that more systematic genotype resources programmes can be drawn up for this important group of crops.

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