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Genetic Resources of Cashew

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1. INTRODUCTION

Cashew (*Anacardium occidentale* L.) is commercially grown for its kernels, although cashew nut shell liquid (CNSL) and apples are also valuable byproducts. It is considered to be the most important edible nut in the world trade (Ascenso, 1986a). Cashew crop which has been considered only useful for soil conservation, afforestation and for development of waste lands, has today assumed a status of an important dollar earning horticultural crop in India (Chadha, 1991). The objective of any germplasm collection programme is to increase the range of genetic variation available for use by the breeders. The value of the germplasm resources will increase as they become more adequately described, evaluated and catalogued (Sprague, 1980). Cashew is a cross-fertilized species and therefore highly heterozygous exhibiting a wide variation for a number of characters such as growth, yield and quality (Ascenso, 1986b). In this chapter an attempt has been made to report the work being carried out on cashew Genetic Resources in our country.

2. ORIGIN AND DISTRIBUTION

Cashew (*Anacardium occidentale* L.) believed to be the native of Brazil, was introduced into India in the Malabar Coast in the Sixteenth century by the Portuguese. From this focal point, it is presumed to have dispersed to other parts of the country and also to South East Asia (de Costa, 1578). It is also presumed that about the same time it was also introduced in the East African countries. However the cultivation of cashew only in India was taken up on large scale compared to other countries and India ranks number one for both area (5.40 lakh hectares in 1992-93) as well as production (3.4 lakh tonnes).

Even though Bailey (1958) described the *Anacardium* as a small genus with only eight species, over 20 species of *Anacardium* are known to exist in Central and South America (Source: Index Kewensis). Till recently only *A. occidentale* was available in India but in the newly established National Research Centre for Cashew (NRC-Cashew), three other species of *Anacardium* viz., *A. microcarpum*, *A. pumilum* and *A. orthonianum* are also available. However, only *A. occidentale* is commercially cultivated in all the countries for the kernels. Reliable records of the early introduction are not

available but it is most likely that the original introductions were from very few trees which is responsible for the narrow genetic base of the population available in this crop in the country. As the crop is cross-pollinated high heterogeneity is noticed in the population. The variability recorded for various characters is mainly due to the cross pollinated nature of the crop and the seed propagation which was practiced hitherto, which resulted in natural segregations.

3. GERMPLASM COLLECTION

3.1 History

The early attempts for germplasm collections were made during the early fifties with the sanctioning of ad-hoc schemes in the States of the then composite Madras, Travancore, Cochin and Bombay. The research stations started in the above schemes in Kerala (Kottarakkara), Karnataka (Ullal), Tamil Nadu (Vridhachalam), Andhra Pradesh (Bapatla) and Maharashtra (Vengurla) took up the programme of collection of locally available elite plants for evaluation and further selection. These were the first attempts in collection of cashew germplasm in the country. In these attempts the emphasis was on high yielding types and the collections were made on individual tree basis and not as population samples. Therefore, in all the research centres individual trees are considered as an accession and even when more than one tree is available in the progeny of a single source tree they are given individual tree numbers. Further in these collections only open pollinated seeds are collected which led to considerable variability within the individual accessions at all the centres.

Many of the other research centres which were established subsequently have collected the seeds of germplasm from the centres viz., Bapatla, Kottarakkara, Ullal, Vridhachalam and Vengurla. Due to inherent heterozygous nature, the sub-samples from original collections do not very often exhibit the characters of original collections. While making the initial collection of germplasm these centres have confined their survey mainly to the respective states and hence they represent the local germplasm available in that state. Since the inception of All India Coordinated Spices and Cashew Improvement Project in 1971, Central Plantation Crops Research Institute (CPCRI) also took up the programme of cashew germplasm collection under the coordinated project programme and established a germplasm collection of 292 accessions at CPCRI, Regional Station, Vittal/Shantigodu in Karnataka. This consists of mainly the seedling progenies of collections which are available at Bapatla, Vengurla, Anakkayam and Vridhachalam and a few collections made locally from Karnataka.

Subsequent to the establishment of NRC-Cashew, Puttur, the germplasm collection through seeds has been discontinued and only the vegetatively propagated material is being collected with an objective of establishing a National Cashew Gene Bank. A coordinated approach was brought in the cashew germplasm collection by organising joint survey teams consisting scientists of NRC-Cashew and the All India Coordinated Cashew Improvement Project (AICCIP) centres of the respective States. In the crop

season, the source population is surveyed and trees for collection are identified. Later from the same identified trees the scion sticks are collected for making the soft wood grafts in the respective coordinating centres as well as at NRC-Cashew. This procedure currently adopted ensures collection of representative sample of the source trees identified and also ensures that duplicate sample is maintained at respective coordinating centre in the State, which aids in proper conservation of collections. Efforts are underway to identify the important and diverse genotypes in the collections already available based on available evaluation data and multiply them clonally and plant them in conservation blocks at a closer spacing.

3.2 Size and Source of Collections

The current holding of cashew germplasm in different Research Centres in the country is presented in Table 1. More than one thousand accessions of seedling origin and more than 500 clonal accessions are being maintained in different Cashew Research Stations in the country. Among the seedling accessions, 23 are exotic collections, of which nine were collected from Brazil, Nairobi, Mtwara, Lindi, Nacala, Mozambique, Ex. Tanganyka, Singapore and Australia (Rai and Vidyachandra, 1981) and 14 were collected from Republic of Panama (Rao, 1991). These exotic collections are being maintained at Ullal and Madakkathara. Rai and Vidyachandra (1981) reported that none of the exotic collections were comparable to the indigenous selections in their yield performance.

Table 1 : Cashew germplasm holding in India.

State	Research Station	No. of accessions	
		Seedling	Clonal
Andhra Pradesh	Cashew Research Station, Bapatla	87	26
Karnataka	Central Plantation Crops Research Institute, Regional Station, Vittal/Shantigodu	292	—
	National Research Centre for Cashew, Puttur	—	300
	Agricultural Research Station, Ullal	111	—
	Agricultural Research Station, Chintamani	75	—
Kerala	Cashew Research Station, Anakkayam	84	—
	Cashew Research Station, Madakkathara	93	68
Maharashtra	Regional Fruit Research Station, Vengurla	80	77
Orissa	Cashew Research Station, Bhubaneswar	67	—
Tamil Nadu	Agricultural Research Station, Vridhachalam	219	68
West Bengal	Regional Research Station, Jhargram	81	8
	Total	1189	547

3.3 Quarantine

As cashew is relatively free of disease problems not much attention has been paid to develop any quarantine schedule for the germplasm collections. Further, as there

were not much exotic introduction, the need for quarantine procedure was not felt. It is also not known whether the earlier introductions were made following quarantine procedures. However, the plant protection committee for South East Asia and Pacific Region in their Information Letter No. 127 (Anon. 1980) suggested that the introduced cashew seednuts should be given seed treatment (dust) with Capton or Thiram. Fumigation of vegetative material @ 32 g/m^3 (2 lb/1000 cft) for 2 hr at 21°C was reported to be the safe treatment. However, the fumigation dose and time are to be reduced if done at higher temperatures. From now onwards since only scion sticks will have to be collected for multiplying a particular germplasm collection, fumigation of scion sticks of exotic germplasm collections will have to be standardized.

3.4 Future Priorities

The most immediate priority will be to enhance the genetic variability in the germplasm in the country. As mentioned earlier, as all the existing trees were raised from limited introductions made in the sixteenth century, the genetic base is very narrow. In order to develop varieties for resistance to major pests of different regions, exotic introductions are very essential. It is suggested that these introductions may be made from the Central America and Brazil which are the original home of cashew. Introduction of *A. gigantium* from Surinam which was reported to have the biggest apple (200 g) (Tirimanna, 1984) will be advantageous, especially in States like Goa, where the apple utilization contributes substantially to the economy of the state. Introduction of dwarf clones reported from Brazil (Ascenso, 1986b) will be useful in developing high density plantings which will enhance productivity considerably.

One of the main problems in cashew is that all the existing germplasm is susceptible to stem and root borer which kills tree. There is a need to screen the allied species (for their suitability as root stocks) which have relatively hardwood and also possess smooth bark. It is suggested that introduction of other species like *A. rhinocarpus* and *A. spruceanum* which are reported to possess hardwood will be useful for testing suitability as root stocks.

4. CHARACTERIZATION AND DOCUMENTATION

The International Board for Plant Genetic Resources has suggested discriptor lists for collection, characterization and evaluation of cashew germplasm (IBPGR, 1986). While the lists suggested are very exhaustive, some of the characters may not be effectively used for characterization of source population. The following characters which are considered useful may be used for characterization of the germplasm material:

i) Age of the tree

ii) Plant habit (erect/bushy/spreading)

iii) Branching (intensive/extensive)

iv) Trunk girth (15 cm from ground level)

v) Canopy shape (compact/medium/sparse)

vi) Leaf length

vii) Leaf breadth

viii) Number of laterals/leader

ix) Flowering duration

x) Panicle shape (conical/pyramidal/irregular)

xi) Panicle length

xii) Panicle breadth

xiii) Number of fruits/panicle

xiv) Coherance of nut with apple (tight/loose)

xv) Apple colour (yellow/red/pink)

xvi) Apple shape (round/pear/long)

xvii) Apple weight

xviii)Average nut weight

xix) Shelling percentage

xx) Nut yield/tree/year

The most immediate priority is to catalogue the available germplasm and identify the duplicates in the collections available in the country. As mentioned earlier, from the initial collections made by the five research centres, all the other centres had drawn sub-samples in addition to making some regional collections from respective States. Therefore the same accession exists in more than two or three research centres at present, which can be avoided if characterization and cataloguing has taken up on priority. This is being carried out under AICCIP and with the computerised data base established at NRC-Cashew it should be possible to identify the duplicates and define the core collections to be maintained at different cashew research stations in the country in the near future.

5. EVALUATION

Evaluation of cashew germplasm is being done at NRC-Cashew, AICCIP centres and other research stations in the country.

5.1 Nursery Stage

Evaluation of cashew germplasm at nursery stage is not being done unlike in other crops. However, the correlation studies conducted at CPCRI Cashew Seed Farm, Shantigodu have indicated that the evaluation of germplasm could be done at nursery stage (Kumarån, 1986). Correlation coefficients of 33 characters namely, seed, seedling, juvenile plant and mature plant characters, have been worked out by studying 38 accessions. The correlation and path analysis have revealed that some of the seed characters such as seed length, seed weight, seedling characters, such as length from cotyledon to first leaf and mature plant character like mean spread of canopy, contribute substantially to nut yield in cashew. This gives scope for selection of seedlings and mother tree for improvement of cashew. There was significant negative correlation between nut yield and days taken for germination. This association suggests that seedlings that are late in germination should be discarded.

5.2 Evaluation for Agronomic Characters

Evaluation of cashew germplasm for agronomic characters is being done at NRC-Cashew and other research stations.

5.2.1 *Cashew Research Station, Anakkayam/Madakkathara (KAU), Kerala*

At Cashew Research Station, Anakkayam, 84 accessions (few seedling progenies and other airlayers of germplasm from Kottarakkara) and at Madakkathara, 93 seedling accessions and 68 clonal accessions are being maintained (Anon. 1989). In addition, seeds of 18 accessions from the Republic of Panama were introduced and sown during July 1988 and seedlings of 14 accessions were planted during September 1988 for evaluation (Anon.1989). From the germplasm screening four selections were made and they have been released by the Kerala Agricultural University as Anakkayam-1 (BLA-139-1), BLA-39-4, K-22-1 and NDR-2-1 (Rao, 1989). The salient features of these varieties are presented in Table 2. Ramadas and Thatham (1981) have studied 38 accessions for different characters and they observed variability for yield (0.525-23.025 kg/tree), 100 nut weight (252-567 g), shell weight (64.0-75.4 per cent), testa weight (1.5-7.6 per cent), whole kernel recovery (1.0-28.8 per cent), broken kernel recovery (0.0-28.8 per cent), shelling percentage (21.2-31.6 per cent) and 100 Kernel weight (68-200 g).

5.2.2 *Agricultural Research Station, Ullal/Chintamani (UAS), Karnataka*

Agricultural Research Station, Ullal, Karnataka, has one of the oldest cashew germplasm collections. During the period 1954-57 about 111 collections were made from the cashew growing states and were planted for evaluation. After evaluating their performance for 18-20 years, 15 selections were made. In the year 1984, two types namely, 8/46 Taliparamba (Kerala) and 3/67 Guntur (Andhra Pradesh) were released by the State Varietal Evaluation Committee as Ullal-1 and Ulla'-2 respectively for

cultivation in Karnataka (Krishna Murthy *et al.* 1985; Khan and Kumar, 1988; Rao, 1989). The salient features of these varieties are presented in Table 2. Rao and Hassan (1956) have reported the variations in seed characters of 100 seed samples of cashew germplasm collected from within and outside the country. They observed variability for nut size (4.4-12.7 cm^2), number of nuts/kg (106-166), volume of 10 nuts (25-115 cc) and shelling percentage of unroasted nuts (25.0-50.0 per cent).

At the Agricultural Research Station, Chintamani, (Karnataka), 75 accessions are being maintained (Anon. 1989). These are mostly accessions collected from Ullal research station and a few from other coordinating centres. Currently this centre is taking up survey in maidan parts of Karnataka for germplasm collection.

5.2.3 *Agricultural Research Station, Vridhachalam (TNAU), Tamil Nadu*

At Agricultural Research Station, Vridhachalam (Tamil Nadu), 219 accessions were maintained and evaluated, of which 20 were clonally multiplied and planted in the germplasm conservation block. Another 48 clonal accessions were collected through survey and planted during 1989 (Anon. 1989). Two selections made from the germplasm screening, namely M 10/4 (Vazhisodhanipalayam) and M 44/3 (Kathupalli) were released by the Tamil Nadu Agricultural University as VRI-1 and VRI-2, respectively (Rao, 1989). The salient features of these varieties are presented in Table 2. The seedling progenies of VRI-2 performed uniformly well at six coordinating centres of AICCIP. It is probable that this selection has prepotency and the same has been recommended for cultivation in all States. However the nut size of this selection is relatively small (about 5 g) and needs to be improved.

In the characterization of germplasm, 34 types with early flowering, 80 types with mid-season flowering and 20 types with late flowering habit were identified. Large apple (more than 50 g weight) was recorded in 23 accessions. In M 11/2, M 16/3, M 21/4 and M 26/1, 10-15 nuts/panicle (cluster bearing) was observed. Nut weight in most of the types was less than 5 g except in 37 types in which over 6 g nut weight was recorded.

5.2.4 *Regional Fruit Research Station, Vengurla (KKV), Maharashtra*

At Regional Fruit Research Station, Vengurla (Maharashtra), 157 accessions (80 old collections and 77 new collections) are being maintained. Some of the old collections were utilized as parents in the hybridization programme (Anon. 1989). Based on the germplasm evaluation, the Konkan Krishi Vidyapeeth, Dapoli, has recommended two high yielding varieties, namely, Vengurla-1 (Ansur-1) and Vegurla-2 (Vengurla 37/3) for cultivation in Maharashtra (Sawke *et al.* 1985; Rao, 1989). The salient features of these two varieties are presented in Table 2.

A total of 57 bold nut types (more than 10 g nut weight) have been collected and the largest nut size (18 g) was recorded in the collection made from Kankadi area of Maharashtra.

Table 2 : Released cashew varieties selected from germplasm evaluation/screening.

Research Station	Variety	Parentage	Age of tree (years)	Yield/ tree (kg)	Average nut wt. (g)	Shelling per cent	Remarks
1. Vengurla	Vengurla-1	Ansur collection	28	23.0	6.0	31.0	Early
(Maharashtra)	Vengurla-2	WBDC-VI (vengurla 37/3)	20	24.0	4.0	32.0	Short flowering and fruiting phase (45 days)
2. Vridhachalam (Tamil Nadu)	VRI-1	Vazhisodhanipa-layam collection	17	7.4	5.0	20.0	Early
	VRI-2	Kathupalli collection	17	6.0	5.0	28.0	Early
3. Ullal	Ullal-1	8/46 Taliparamba	25	19.0	7.0	31.0	Early, Long duration
(Karnataka)	Ullal-2	3/67 Guntur	25	18.0	6.0	30.0	Late
4. Bapatla (Andhra	BPP-3	3/3 Simhachalam	25	16.0	6.0	28.0	
Pradesh)	BPP-4	9/8 Epurupalem	17	12.5	6.0	23.0	
	BPP-5	T.No. 1	50	42.0	5.2	24.0	
	BPP-6	T.No. 56	50	42.0	5.2	24.0	
5. Anakkayam/	Anakkayam-1	T.No. 139 of Bapatla	20	35.0	6.0	28.0	Short flowering duration
Madakkathara	BLA-39-4	T.No. 39 of Bapatla	15	20.0	6.2	26.8	(25-30 days)
(Kerala)	K-22-1	T.No. K 22 of Kottarakkara	15	13.2	6.2	22.7	
	NDR-2-1	Naduvellur	15	17.1	7.2	26.2	Kernel count 210/lb.
6. Puttur (Karnataka)	Selection-1	VTH 107/3(3/8 Simhachalam)	16	10.0	7.6	28.8	Kernel count 210/lb.
	Selection-2	VTH40/1 (2/9 Dicherla)	16	8.8	9.2	28.6	Kernel count 210/lb.
7. Bhubaneswar (Orissa)	Bhubaneswar-1	WBDC-V (36/3 Vengurla)		9.8	4.6	32.4	Cluster bearing
8. Jhargram (West Bengal)	Jhargram-1	T.No. 16 of Bapatla	17	8.5	5.0	30.6	Kernel count 280/lb

5.2.5 *Cashew Research Station, Bapatla (APAU), Andhra Pradesh*

As a result of extensive survey carried out in cashew growing districts of Andhra Pradesh, a collection of 400 types of cashew has been built up in the fifties and vigorous screening of the available material has resulted in the selection of nine high yielding types, namely, T.No. 1, T.No. 56, T.No. 39, T.No. 273, T.No. 40, T.No. 135, 3/3 Simhachalam, 9/8 Epurupalem, and 9/3 Ambugam. Out of these, four have been released as BPP-3 (3/3 Simhachalam), BPP-4 (9/8 Epurupalem), BPP-5 (T.No. 1) and BPP-6 (T.No. 56) by the Andhra Pradesh Agricultural University for cultivation in Andhra Pradesh (Nagabhushanam *et al.* 1977; Rao, 1989). The salient features of these varieties are presented in Table 2. At Cashew Research Station, Bapatla, at present 113 accessions (87 old and 26 clonal accessions) are being maintained (Anon. 1989).

5.2.6 *Cashew Research Station, Bhubaneswar (OUAT), Orissa*

Characterization of 67 available germplasm accessions enabled identification of 10 medium nut types (T.No. 109, T.No. 275, BLA-39-4, Assam No. 3, Madras Arcot mixed sample, M 16/4, M 17/4, M 26/2, M 28/4, T.No. 121), three cluster bearing types (Mysore Kotekar, Bapatla ST 56, BLA-39-4), six compact canopy types (Mysore Kotekar 53, Madras Arcot mixed sample, Bapatla ST 75, M 35/4, K-25-2, Kerala layer), 11 large apple types (M 16/3, M 18/3, T.No. 125, Sch. 3/3, K 25-2, T.No. 20, Assam No. 3, T.No. 275, BLA-39-4, Selection 9/8, T.No. 59) and two early flowering types (Bapatla ST 56, Mysore Kotekar). Based on the germplasm evaluation, WBDC-V (Vengurla 36/3) was found to be superior and the same was released as Bhubaneswar-1 for cultivation in Orissa (Table 2).

5.2.7 *Regional Research Station, Jhargram (BCKV), West Bengal*

In the available germplasm collection promising types for different characters such as high yield (Ansur No. 1, Sawantwadi, Vetore-56), cluster bearing habit (Bapatla ST 75, Vetore-56, 8/7 Sompeta, M 6/1), bold sized nuts (Sawantwadi, M 16/3, BLA 273/1, NDR 2-1, 2/9 sicherla) and big sized apples (2/4 Baruva) were identified. In the screening of germplasm, T.No. 16 introduced from Bapatla centre was found to be superior and the same was released as Jhargram-1 for cultivation in West Bengal (Table 2). In addition, the BLA-39-4 a tertiary introduction from Anakkayam centre (original parentage T.No. 39 of Bapatla) was also found to be superior in evaluation trials and same was also recommended for cultivation in West Bengal.

5.2.8 *ICAR Research Complex for Goa*

Mathew and Nagabhushanam (1988) have surveyed the cashew growing regions of Goa keeping in view the importance of both the nut size and the apple size. While making selection of individual trees in a plantation, the tree yield coupled with bold nut size and largeness of apple were considered as most important attributes of tree. Nine trees were identified (Table 3) and clonally multiplied for further evaluation.

Table 3 : Germplasm collections made by at ICAR Research Complex for Goa.

Accession No.	Location	No. of nuts/ panicle	Age of tree (years)	Yield/tree (kg)	Av. nut weight (g)	No. of nuts/kg
1.	Balli	8-9	25	42	8.6	117
2.	Balli	4-5	25	45	8.7	115
3.	Balli	8-12	30	35	9.3	107
4.	Betul	5-6	20	35	10.6	95
5.	Chicherewal	2-3	35	25	12.2	82
6.	Farmagudi	3-4	20	25	13.2	76
7.	Khedderm	3-4	30	35	13.0	77
8.	Mardol	1-2	30	25	12.7	79
9.	Shirlim	1-2	30	30	12.0	84

5.2.9 *National Research Centre for Cashew, Puttur, Karnataka*

As mentioned earlier a total of 292 accessions were collected and planted both at Vittal and Shantigodu (CPCRI) for evaluation purpose. Most of these are secondary collections obtained from different Cashew Research Stations in the country (Table 4). Initially seednuts were collected and planted @ 8 plants per accession adopting a spacing of 8 m × 8 m. An attempt was made for classification of 161 accessions available at CPCRI, Regional Station, Vittal (which were planted in RBD with two replications and

Table 4 : Cashew germplasm accessions collected during 1972-74 by CPCRI Regional Station, Vittal/ Shantigodu.

Sl. No.	Source	No. of accessions
1.	Cashew Research Station, Vengurla	26
2.	Cashew Research Station, Anakkayam	19
3.	Cashew Research Station, Vridhachalam	34
4.	Cashew Research Station, Bapatla	136
5.	Primary collections	77
	Total	292

four plants per plot) by Mohan *et al.* (1987). They suggested the index score of 1, 2 and 3 for low, middle and early or low, medium and high respectively, for nine characters. The characters considered were the earliness of flowering, duration of flowering, leaf size, panicle size, number of flowers per panicle, percentage of bisexual flowers, fruits per panicle, yield and nut weight. Based on the cumulative index score which ranged from 10 to 23 in different accessions, the accessions were grouped in 12 clusters. However, the range fixed for low, middle and early or low, medium and high for these characters was felt inadequate and subsequently the ranges were modified and individual tree data were collected in all the 292 accessions (1418 trees). The data were computerised

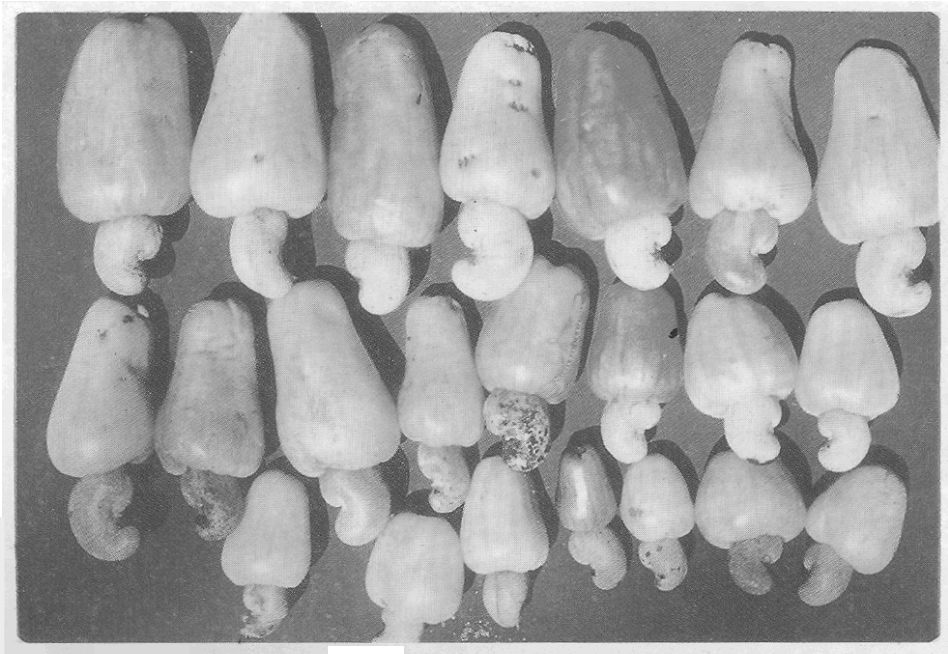

Fig. 1 : Variability for apple shape and **size.**

Fig. 2 : Variability for nut **size.**

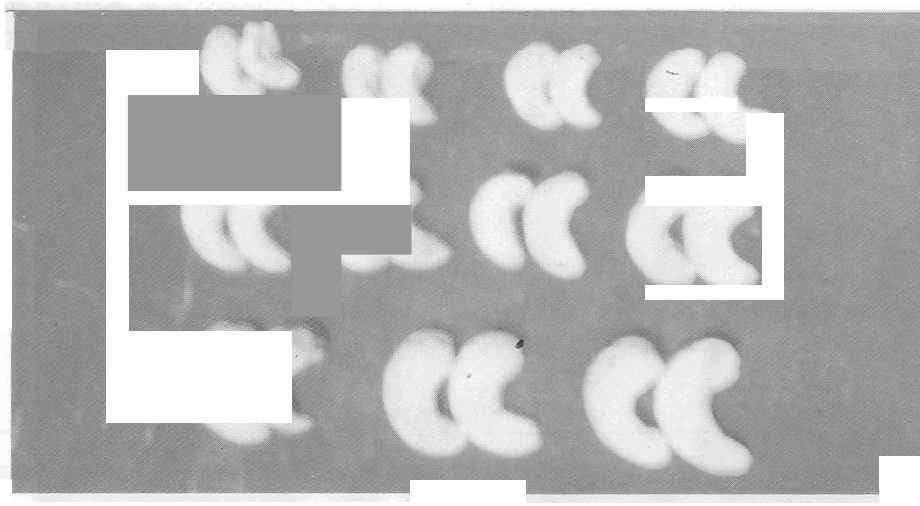

Fig. 3 : Variability for apple kernel size

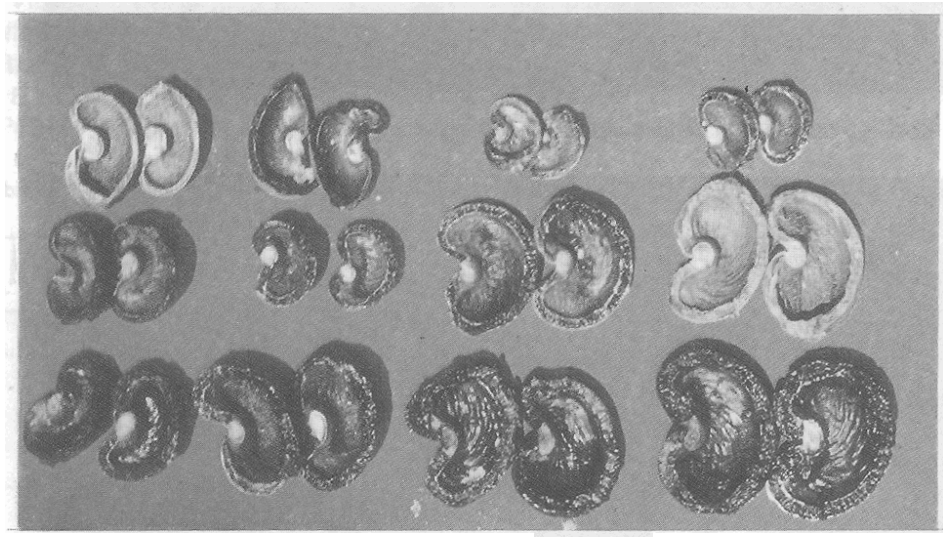

Fig. 4 : Variability for apple shell thickness

for characterization. The accession/trees were grouped for some of the important characters (Swamy and Thimmappaiah, 1988b) and grouping of these trees is presented in Table 5. Swamy and Thimmappaiah (1988a) reported that there is considerable variation present among the accessions for some of the economic characters such as flowering season, flowering duration, harvesting duration, number of nuts/panicle, apple weight, nut weight, apple to nut ratio, shelling percentage, kernel weight, kernel count/ lb, shell thickness and mean yield/plant (Table 6).

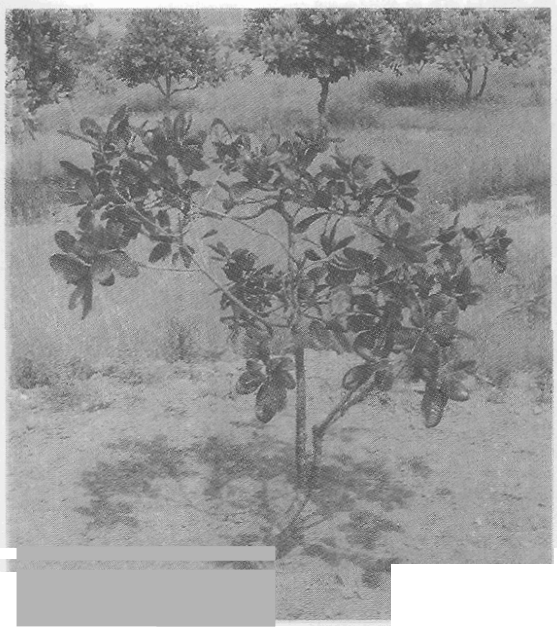

Fig. 5 : Purple plant genotype (Mutant)

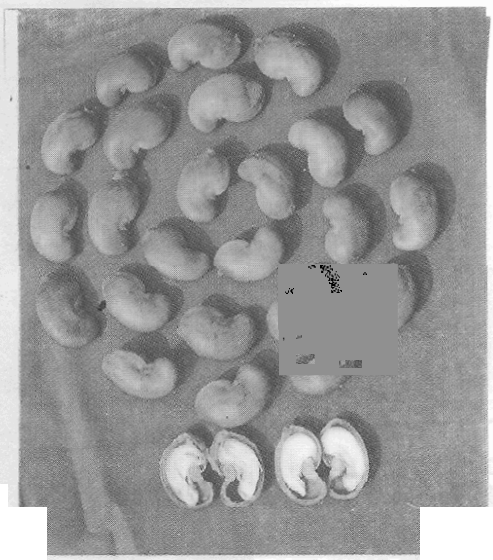

Fig. 6 : Cashewnutshell liquid (CNSL) free genotype (Mutant)

Fig. 7 : *Anacardium pumilum.*

Fig. 8 : *Anacardium orthonianum*

Fig. 9 : *Anacardium microcarpum.*

Table 5 : Grouping of germplasm accessions (seedling progenies) for some of the characters

Character	Category	No. of trees
Flowering duration	Short (< 60 days)	148
	Medium (61-80 days)	381
	Long (> 80 days)	889
No. of fruits/panicle	Low (1-2)	695
	Medium (3-5)	665
	High (> 5)	58
Apple size	Small (< 40 g)	355
	Medium (40-70 g)	876
	Big (> 70 g)	187
Nut sire	Small (2-5 g)	785
	Medium (6-9 g)	614
	Big (> 10 g)	3
Shelling percentage	Low (< 25 per cent)	258
	Medium (25-30 per cent)	889
	High (> 31 per cent)	171
Kernel count/lb.	Low (< 210)	82
	Medium (210-320)	798
	High (> 320)	436

Table 6 : Variability recorded for some of the characters in the germplasm accessions (seedling progenies).

Character	Range
Flowering season	October-January
Flowering duration	40-127 days
Harvesting duration	30-105 days
No. of fruits/panicle	1-8
Apple weight	30-150 g
Nut weight	2.4-18.0 g
Apple : Nut ratio	4:1-12:1
Shelling percentage	19.0-35.0
Kernel weight	0.5-4.5 g
Kernel count/lb.	100-900
Shell thickness	1.5-5.0 mm
Mean yield/plant/year (10 years mean)	0.50-11.75 kg

In order to quantify the variability for various characters and to select the superior clones which have comparatively better yield, an attempt was made based on the yield data for 12 years (1977 to 1988) by Swamy *et al.* (1990). In this characterization, 10 trees which have an yield of 150 per cent more than population mean were identified with the nut size of over 7 g (medium to bold types). Similarly shelling percentage which is one of the important criteria for realising the higher outturn of kernels was considered and minimum shelling per cent of 30 and yield not less than 5 kg/tree was fixed as standard. With this selection criteria 10 trees which meet this standard were identified. Most of these collections were made from Andhra Pradesh. Similarly an attempt was also made to identify trees having not less than 70 g apple weight and over 4 kg mean yield (population mean yield was 2.79 kg). Ten trees which were also collected from Andhra Pradesh were identified for these characters. Early flowering is one of the advantageous characters in cashew and in the collections available at Vittal, 12 trees which flower during November and produce 50-75 per cent of the nuts during February were identified. These trees can be classified as early types and yield range in this group was from 3.56-9.38 kg. Cluster bearing types usually are high yielders as number of fruits per panicle are high in these trees. In the screening for the trees with five and more fruits/panicle the yield in this group of 12 trees was found to be 8 to 9 kg/tree. Among the vegetative characters plants with medium height, with a bushy and compact canopy are important factors which will facilitate high density planting/unit area. In the collection, 11 trees with these desirable characters were identified in which the yield ranged between 3.4-8.2 kg and the nut size ranged between 5.4-8 g. The details of the accession with the desirable characters enumerated above are listed in Table 7.

These elite materials listed along with some of the diverse material collected from 1986-93 were clonally multiplied and planted in the National Cashew Gene Bank of NRC-Cashew, Puttur (Karnataka). So far 300 clonal accessions have been planted in the Gene Bank (Table 8). The germplasm collection also includes, related species

Table 7 : Promising accessions with desirable characters and high yield.

Sl. No.	Character	Standard	Yield range (kg/tree)	Accessions (Nos.)
1.	Medium to bold nuts	Over 7.0 g	4.20-11.48	13/2, 30/4, 40/1, 50/2, 59/2, 92/2, 105/2, 107/3, 118/4 II, 155 L.
2.	High shelling percentage	Over 30.0 per cent	4.98-9.84	27/4, 57/1 II, 69/1, 79/1, 97/2, 99/3, 100/4, 101/2, 108/4, 135/4
3.	Big sized apple	Over 70.0 g	4.20-8.43	22/3, 30/4, 92/2, 105/2, 107/3, 133/4, 139/4, 146/1, 146/4, 155 L
4.	Early maturity	Over 50 per cent nut collection would be over by February	3.56-9.38	27/2, 50/2, 50/4, 52/4 II, 128/2 II, 130/3, 134/1, 136/1, 141/3, 141/4, 145/4, 155 L
5.	Cluster bearing	Over 5 fruits/panicle	6.00-9.35	30/2, 39/3, 50/2, 51/1, 52/1 II, 57/1, 59/2, 105/2, 107/3, 119/4, 141/3, 144/4
6.	Bushy/medium plants with compact/medium canopy	4-5 m height	3.41-8.25	12/3, II, 19/2 II, 20/3 II, 26/4 II, 30/2, 30/3, 47/1 II, 52/1 II, 68/2 II, 90/1 II, 141/3 II.

Table 8 : Clonal germplasm accessions planted in the National Cashew Gene Bank.

Source of collection	No. of accessions
I. Elite and diverse material selected from the germplasm accession from:	
i) Vittal	69
ii) Shantigodu	75
II. Primary collections from:	
i) Karnataka	54
ii) Andhra Pradesh	26
iii) Tamil Nadu	9
iv) Goa	40
v) Maharashtra	14
vi) Orissa	9
vii) West Bengal	1
viii) Kerala	3
Total	300

such as *A. microcarpum*, *A. pumilum* and *A. orthonianum*, bold nut types, less vigorous types, cashew nut shell liquid (CNSL) free types, purple plant genotype, high shelling per cent types, cluster bearing types, big sized apple types, early maturing types and others.

Screening of germplasm has resulted in the selection of two high yielding types, namely, VTH 107/3-I and 40/1-I which were recommended for release as NRC Cashew Selection-1 and 2 respectively (Table 2) (Swamy and Thimmappaiah, 1989).

5.3 Evaluation for Special Characters

5.3.1 *Evaluation for Quality Parameters*

At present no emphasis is placed on the quality aspects of cashew kernel. But with increasing competition from African countries in the international market it is essential to breed varieties with superior quality. Data collected so far from defatted kernel flour indicated that there is considerable variability for protein ranging from 32-44 g per cent, lysine 35-73 µg/mg protein, Vitamin-C 144-274 mg per cent and kernel sugars 10-19 g per cent. It is felt desirable to identify the varieties with the protein level of over 35 g per cent, lysine level of over 50 µg/mg protein and sugar content not more than 14 g per cent (Bhagavan, 1986).

5.3.2 *Evaluation for Tea Mosquito Tolerance*

Laboratory screening of 27 cashew accessions to tea mosquito tolerance has indicated that two accessions/types, namely, G 11/6 and VTH 153/1, are relatively tolerant than the susceptible check and some of the test accessions (Nagaraja *et al.* 1990).

6. CONSERVATION

In situ conservation of cashew germplasm is done only in the Amazon forests of Brazil (original home of cashew) and this is not a common method of germplasm conservation. However, *ex situ* conservation is generally being followed in cashew. Like in all other tree crops, the cashew germplasm is maintained as an active collection in the field which locks up the land for a long time. Further, field maintenance also has the inherent danger of loosing the valuable collections during the natural calamities (as it often happens in the East Coast, especially at Bapatla centre due to cyclones). In order to overcome this danger as well as to effectively utilize the land for other field experiments, suitable *in vitro* preservation/cryopreservation methods with the aid of biotechnology are to be developed. An effort in this direction is being made by establishing Biotechnology laboratory at NRC-Cashew during the VIII Plan period.

In the National Cashew Gene Bank of NRC-Cashew, so far 300 clonal germplasm accessions have been planted @ 6 softwood grafts/accession by adopting a closer spacing of 6 m × 6 m and are being maintained as active collections in the field. Similarly, clonal germplasm conservation blocks have been established by the AICCIP centres such as Bapatla, Madakkathara, Vengurala, Vridhachalam and Jhargram (Table 1).

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