Journal of Root Crops, 2013, Vol. 39 No. 2, pp. 51-56
Indian Society for Root Crops
ISSN 0378-2409

Analysis of Genetic Diversity in Edible Aroid Accessions of India Based on Morphological Characters

A. Asha Devi, G. Suja and J. Sreekumar

Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram 695 017, Kerala, India
Corresponding author: A. Asha Devi, e-mail: ashadevi05@gmail.com
Received: 14 September 2013; Accepted: 14 December 2013

Abstract

The family Araceae includes the important edible aroids like *Amorphophallus peaoniifolius* var. *campanulatus* (elephant foot yam), *Colocasia esculenta* (taro), *Xanthosoma sagittifolium* (tannia) etc. Most of these root crops are important source of food in many tropical countries, primarily grown for their corms and cormels, although sometimes the leaves are also used as vegetable. The Araceae family is highly heterogeneous, with enormous variation in morphology, chromosome structure and number. The Central Tuber Crops Research Institute, Thiruvananthapuram, India, is maintaining about 590 taro and 183 elephant foot yam accessions, which represent genotypes collected from different parts of India and forms the backbone of the variability existing within the country. However, there is chance of duplicates being present in the above collection. Hence morphological characterization is resorted to identify the duplicates. National Bureau of Plant Genetic Resources (NBPGR) descriptors were used for both taro and elephant foot yam for this purpose. In the present paper, diversity analysis using cluster package (R package) was done for 45 taro accessions on the basis of six tuber characters and 26 elephant foot yam accessions on the basis of 14 above ground characters. The results showed that five clusters were formed in taro based on six tuber characters, whereas, in elephant foot yam, six major clusters were formed. No duplicates could be identified within the accessions screened.

Key words: Elephant foot yam, taro, variability, morphological characterization, descriptors

Introduction

Root and tuber crops were first domesticated thousands of years ago, but none became significant until after the end of the 16th century. However, today, many of the tropical root and tuber crops like cassava, sweet potato, yams and aroids are staple food for poor people around the world. Among tuber crops, edible aroids form an important group constituting mainly of taro (*Colocasia esculenta* (L.) Schott), tannia (*Xanthosoma sagittifolium* (L.) Schott), giant taro (*Alocasia macrorrhiza* (L.) Schott), swamp taro (*Cyrtosperma* spp. Griff.), elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) etc. Most of these crops are important sources of food in many tropical countries. They are primarily grown for their corms and cormels, although sometimes the leaves are also used as vegetable. Most edible aroids belong to the family Araceae, which consists of about 110 genera with over 2500 species (Bown, 1988). The family is highly heterogeneous with enormous variation in morphology, chromosome structure and number. The main centres of origin are considered to be tropical America and tropical Asia. Besides, some aroid species can be found only in the Mediterranean and Africa. Another possible centre of origin for some species is Australia and Papua New Guinea (Ivancic and Lebot, 2000).

The common elephant foot yam, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, is a native of India and Sri Lanka, which originated in South-East Asia and enjoys a wide distribution. According to Willis (1955), around 90 species of *Amorphophallus* are present in the tropics. However, according to Hay (1990), the genus *Amorphophallus* includes some 100 species from Africa, India and Malaysia to Australia. Wild form exists in Sri Lanka, Philippines, Malaysia, Indonesia, and other South-East Asian countries. Around 15 species are endemic to India. In India, elephant foot yam is grown mostly in West Bengal, Kerala, Andhra Pradesh, Maharashtra and Orissa. It is a cross pollinated crop, which is vegetatively propagated through corm pieces. It is a tuberous herb with leafy aerial pseudostem and exists as diploids with 2n = 26, 28. Elephant foot yam is an upcoming and important cash crop due to its production potential and popularity as a vegetable in various delicious cuisines. In India, it has attended the status of a cash crop and the area under its cultivation is increasing fast (Nedunchezhiyan et al., 2006).

Taro (*Colocasia esculenta* (L.) Schott) is an important root crop especially in the humid tropics and sub-tropics. It is one of the few crops that can adapt well to different agro-climatic conditions (Asha Devi, 2012). Taro is grown mostly as a vegetable for its edible starchy corm and as a leafy vegetable in India. However, it attains the importance of a staple in many African, Oceanic and Asian cultures. Taro is thought to have been originated in the Indo-Malayan region probably in North-Eastern India and Bangladesh. Wild forms occur in various parts of South-Eastern Asia (Purseglove, 1972). However, some studies suggest that there exists a parallel Pacific gene pool for taro, quite distinct from the Asian one (Lebot, 1999; Ivancic and Lebot, 2000). Taro exists either as a diploid (2n = 28) or triploid (2n = 42), naturally. Other ploidy levels were also observed with 2n = 22, 26, 36, 38, 44, 46, 48 (Yen and Wheeler, 1968; Ramachandran, 1978; Coates et al., 1988). Two main botanical varieties exists in taro, eddoe (*Colocasia esculenta* var. *antiquorum*) and dasheen (*Colocasia esculenta* var. *esculenta*) types.

One of the important steps in any crop improvement programme is the assessment of diversity existing within that crop. The germplasm collection represents the wide variability present in the crop and descriptors are available to characterize the same. Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, India, has been identified as the National Active Germplasm Site (NAGS) for tuber crops. More than 800 accessions of edible aroids are maintained in the CTCRI genebank, which comprises 589 taro, 183 elephant foot yam, 27 tannia, one swamp taro and two giant taro accessions. Variability from all over the country is passed on to CTCRI from the various centres of the All India Co-ordinated Research Project on Tuber Crops (AICRP-TC) for conservation and future utilization. Due to this pooling of germplasm from various parts of the country, there is every chance of duplicates being present in the germplasm. Only after characterization would we be able to assess the extent of variability and duplicates present in the collection. This will pave the way for the development of a core collection comprising the maximum variability present in a crop, which can be utilized for future breeding programmes as well as *in vitro* conservation. Two main descriptors are available for characterization, the International Plant Genetic Resources Institute (IPGRI)/National Bureau of Plant Genetic Resources (NBPGR) descriptors. The present study was thus initiated with the aim to morphologically characterize the two major edible aroids, elephant foot yam and taro based on NBPGR descriptors to assess the extent of diversity present and also to identify duplicates, if any.

Materials and Methods

Variability, especially genetic variability forms the basis of any crop improvement programme. A wide variability of both elephant foot yam and taro are being maintained at the Central Tuber Crops Research Institute, Thiruvananthapuram, India. The variability maintained here are collected from various parts of the country as well as abroad. This wide collection renders way to the presence of many duplicates being maintained under different or the same name. One of the easiest ways to identify them is through morphological characterization. Two descriptors are mainly followed, the IPGRI (taro) and the NBPGR (elephant foor yam and taro). In the present study NBPGR descriptor was followed for both the crops.

Twenty six elephant foot yam (*Amorphophallus paeoniifolius* var. *campanulatus*) accessions and 45 taro (*Colocasia esculenta*) accessions (Table 1) maintained at the Central Tuber Crops Research Institute field gene

Table 1. List of elephant foot yam and taro accessions used for morphological characterization

Elephant foot yam accessions	Taro accessions	Taro accessions
NL	TCR 919	IC526654
Am-87	TCR 385	IC446910
Am-93	TCR 683	IC012593
Am-42	TCR 652A	IC419621
Am-77	TCR 835	IC420568
Am-82	TCR 696	IC416937
Am-85	U 7	IC330382
Am-97	IC265045	IC419621
Am-71	TCR 125	IC089611
Am-84	TCR 151	U 23
Am-91	TCR 860	U 5
Am-100	TCR 887B	VRS
Am-88	BHS 27	TCR 609B
H-64	TCR 104	TCR 514
Am-59	TCR 902	IC089560
Am-24	IC122159	IC204239
Am-104	TCR 204	IC023575
S-1	TCR 118	IC420409
Am-90	IC524623	IC310104
Am-37	IC211587	TCR 474
Athira	IC420620	
Am-73	IC420562	
Am-1	IC039565	
Am-78	IC087944	
Am-21	IC435899	
S-5		

bank was used for the study. In the case of *Amorphophallus,* 18 above ground characters were recorded at the maximum growth period (Table 2), whereas in the case of taro, six below ground tuber characters viz., corm/cormel number, weight and shape was considered for characterization.

For the analysis of morphological diversity and grouping of the accessions into different clusters, the hclust program of the cluster package (R platform) was used.

Results and Discussion

In *Amorphophallus paeoniifolius*, of the 18 above ground characters taken into consideration, four characters viz., pseudostem colour, presence or absence of leaf spot, leaflet stalk and rachis nature showed no variability in the 26 accessions screened and hence were not used for analysis. Pseudostem was green mottled; leaf spot and leaflet stalk were absent and rachis was winged in all 26 accessions screened (Fig. 1). All the other traits showed

Table 2. List of traits used for morphological characterization

Above ground characters of elephant foot yam	Pseudostem height (cm) (recorded at full foliage); number of primary, secondary, tertiary partitions; length and breadth of primary partition (cm); number of leaflets per primary partition; length and breadth of largest leaflet (cm); leaflet nature; leaflet margin; surface of pseudostem; thickness of pseudostem base (mm); pseudostem colour; leaf spot; stalk leaflet; nature and shape of rachis
Below ground characters of taro	Corm/cormel number, weight (g) and shape

Fig. 1. Psuedostem, leaf and rachis characters of elephant foot yam. a. Green mottled pseudostem; b. Absence of leaf spot; c. Winged rachis

variability. Shirly (2012) and Shirly et al. (2011; 2013) screened 17 wild elephant foot yam (*Amorphophallus paeoniifolius*) collections from South-West India and found that variation was present in the different cultivars used. They also studied the variation present in morphology, cytology, isozyme profile and the molecular level. They found that wide variability existed between the 17 lines studied. Very few reports are available for *Amorphophallus* morphological characterization, probably because this is a crop restricted to mostly the Indian sub continent as well as Sri Lanka. Though the crop is an upcoming one, in India, it has achieved the status of a cash crop and the area under its cultivation is increasing fast (Nedunchezhian et al., 2006). It is a crop of South-East Asian origin, growing wild in the Philippines, Malaysia, Indonesia and South-Eastern Asian countries. Hence, diversity will be more here and characterization as well as assessment of the extent of diversity present is very much essential for all future breeding programmes.

Based on hclust, the 26 accessions were grouped under six major clusters (Fig. 2). One accession, S-5, a selfed material grouped separately. Cluster V had the maximum number of accessions, eight (Table 3). This was followed by Cluster II having six and Cluster III having five accessions, each. Sree Athira, a hybrid variety of elephant foot yam grouped along with Am-59, Am-73 and Am-91.

Table 3. List of elephant foot yam accessions grouped under different clusters

Cluster	Accessions	Number of accessions
Cluster I	Am-59, Sree Athira, Am-91, Am-73	4
Cluster II	Am-77, Am-24, Am-1, Am-97, Am-82, Am-37	6
Cluster III	Am-100, Am-21, Am-88, Am-90, Am-78	5
Cluster IV	Am-104, S-1	2
Cluster V	Am-87, Am-93, Am-84, Am-42, Am-85, Am-71, H-64, NL	8
Cluster VI	S-5	1

Taro (*Colocasia esculenta* (L.) Schott), on the other hand is a traditional crop with a long history of cultivation in Asia and the Pacific. It is widely used as a tuberous vegetable in India, whereas it is the staple food and also very closely associated with culture in many of the South Pacific islands. Taro is ordinarily grown in the homestead garden and its cormels, petioles and leaves serve the important purpose as an instant vegetable. Having originated in the North-Eastern parts of India and Bangladesh, variability is very high in this crop, especially in the NEH region (Purseglove, 1972). Morphological variability has been studied by many workers (Lakhanpaul et al., 2003; Lebot et al., 2004; Quero-Garcia et al., 2004; Trimanto et al., 2010; Singh et al., 2011). In the

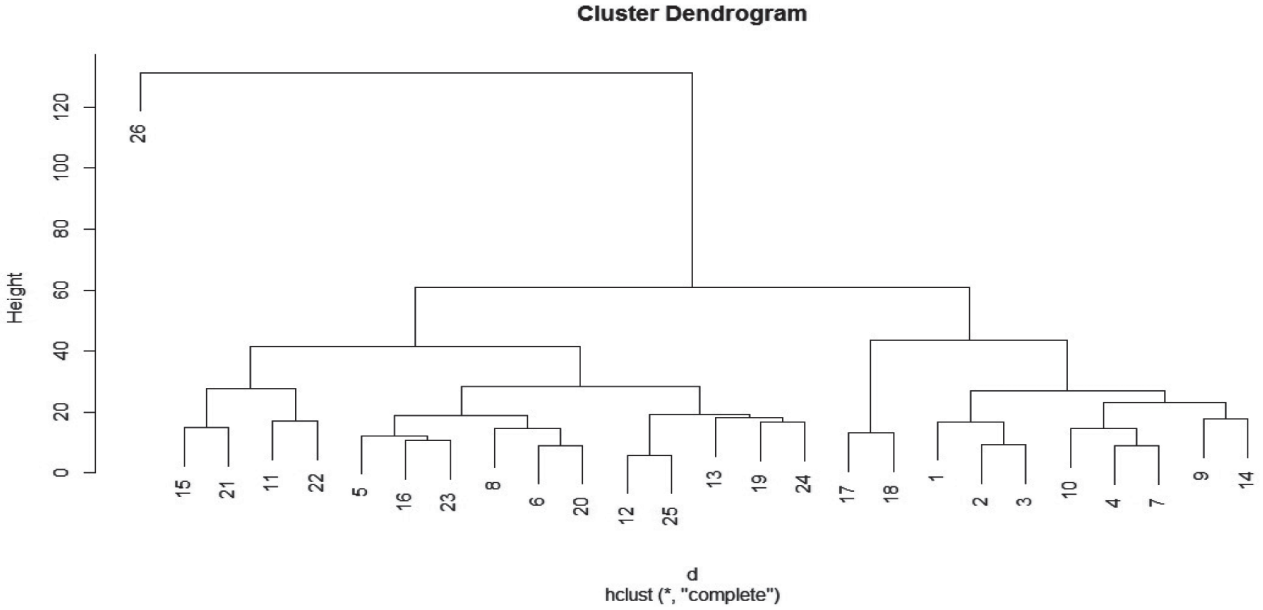

Fig. 2. Dendrogram showing the grouping of 26 elephant foot yam accessions based on 18 above ground characters

present study also morphological characters in the form of tuber traits were analysed for diversity. Varied corm and cormel shapes were observed, which ranged from cylindrical, elongated, round, stoloniferous, etc. (Fig. 3). Based on these characters, 45 accessions were characterized and grouped using hclustal. The resultant dendrogram showed that five major clusters were formed with Cluster II being the largest one with 25 accessions (Fig. 4, Table 4) followed by Cluster IV with 13 accessions. Cluster V had only one accession, IC023575.

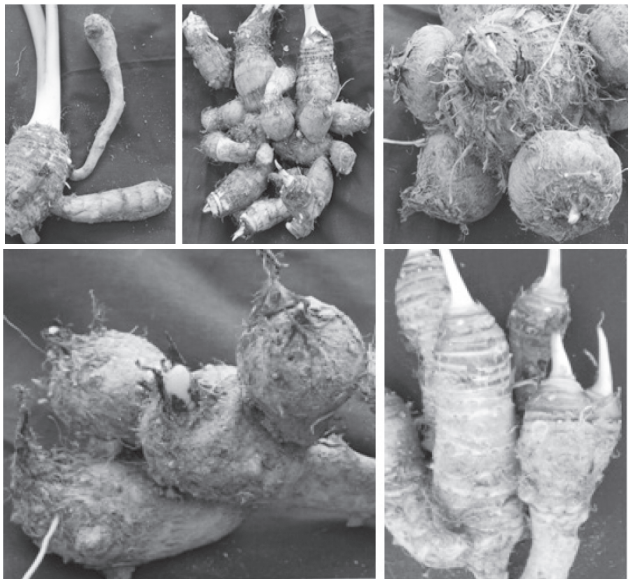

Fig. 3. Variability in tuber shapes exhibited by taro

Table 4. List of taro accessions grouped under different clusters

Cluster	Accessions	Number of accessions
Cluster I	TCR 835, BHS-27, U-23	3
Cluster II	IC265045, TCR 860, IC420409, TCR 125, IC435899, U-7, TCR 151, TCR 696, TCR 683, TCR 652A, TCR 204, IC122159, TCR 887B, IC420562, IC419621, TCR 514, IC012593, TCR 118, TCR 385, TCR 902, TCR 919, TCR 609B, TCR 104, U-5	25
Cluster III	IC420568, IC087944, IC089560	3
Cluster IV	IC416937, IC446910, TCR 474, IC089611, IC524623, IC204239, IC211587, IC310104, IC526654, IC330382, IC039565, IC420620, VRS	13
Cluster V	IC023575	1

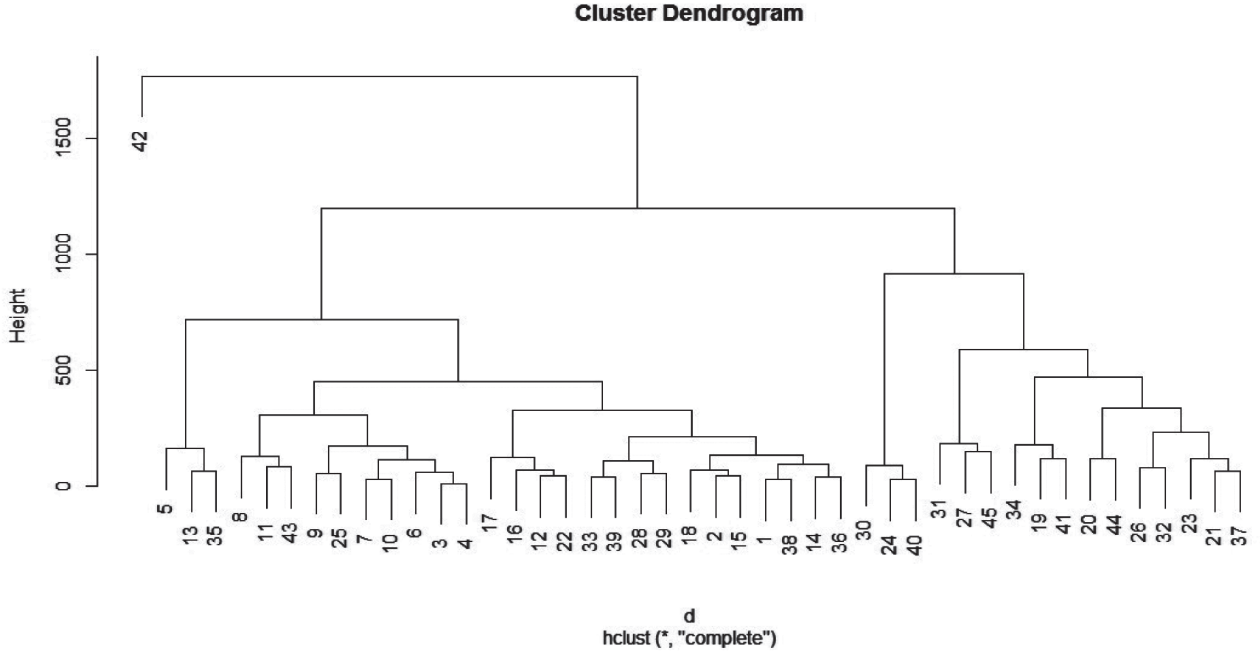

Fig. 4. Dendrogram showing the grouping of 45 taro accessions based on tuber characters

From the results it is evident that based on morphological characterization, wide variability was observed in both the crops. This variability can be accounted by the fact that both the crops have originated in the Indian subcontinent. Being the Centre of origin, it is also the Centre of diversity and this variability needs to be conserved for all future improvement programs.

References

Asha Devi, A. 2012. Genetic diversity analysis in taro using molecular markers – an overview. *J. Root Crops*, **38**(1): 15-25.

Bown, D. 1988. *Aroids. Plants of the Arum Family*. London, UK, Century Hutchinson Ltd.

Coates, D. J., Yen, D. E. and Gaffey, P. M. 1988. Chromosome variation in taro, *Colocasia esculenta*: Implications for origin in the Pacific. *Cytologia*, **53**: 551 – 560.

Hay, A. 1990. Aroids of Papua New Guinea. Madang, Papua New Guinea, Christensen Research Institute.

Ivancic, A. and Lebot, V. 2000. *The Genetics and Breeding of Taro*. CIRAD Publication Series, France.

Lakhanpaul, S., Velayudhan, K. C. and Bhat, K. V. 2003. Analysis of genetic diversity in Indian taro (*Colocasia esculenta* (L.) Schott) using random amplified polymorphic DNA (RAPD) markers. *Genet. Resour. Crop Evol.*, **50**: 603 – 609.

Lebot, V. 1999. Biomolecular evidence for plant domestication in Sahul. *Genet. Res. Crop Evol.*, **46**: 619 – 628.

Lebot, V., Prana, M. S., Kreike, N., van Heck, H., Pardales, J., Okpul, T., Gendua, T., Thongjiem, M., Hue, H., Viet, N. and Yap, T. C. 2004. Characterisation of taro (*Colocasia esculenta* (L.) Schott) genetic resources in Southeast Asia and Oceania. *Genet. Resour. Crop Evol.*, **51**: 381 – 392.

Nedunchezhiyan, M., Saurabh, A. and Ranasingh, N. 2006. Elephant foot yam: a commercial crop for Orissa. *Orissa Rev.*, August 2006: 71-72.

Purseglove, J.W. 1972. *Tropical Crops. Monocotyledons*. Longman London.

Quero-Garcia, J., Noyer, J. L., Perrier, X., Marchand, J. L. and Lebot, V. 2004. A germplasm stratification of taro (*Colocasia esculenta*) based on agro-morphological descriptors, validation by AFLP markers. *Euphytica*, **137**: 387 – 395.

Ramachandran, K. 1978. Cytological studies in South Indian Aracea. *Cytologia*, **43**: 289 – 303.

Shirly, R. A., Siril, E. A. and Beevy, S. S. 2011. Morphological variability in 17 wild elephant foot yam (*Amorphophallus paeoniifolius*) collections from southwest India. *Genet. Res. Crop Evol.,* **58**:1263-1274.

Shirly, R. A., Siril, E. A. and Beevy, S. S. 2013. Diversity analysis in *Amorphophallus* using isozyme markers. *Int. J. Veg. Sci.*, DOI: 10.1080/19315260.2013.803509.

Shirly, R. S. 2012. Characterization and assessment of variability in wild and cultivated species of *Amorphophallus* Blume ex Decne. *Ph. D Thesis*. University of Kerala. 250 p.

Singh, S., Singh, D. R., Faseela, F., Kumar, N., Damodaran, V. and Srivastava, R. C. 2011. Diversity of 21 taro (*Colocasia esculenta* (L.) Schott) accessions of Andaman islands. *Genet. Resour. Crop Evol.,* **59**(5): 821-829.

Trimanto, Sajidan. and Sugiyarto. 2010. Characterization of taro (*Colocasia esculenta*) based on morphological and isozymic patterns markers. *Nusantara Biosci.*, **2**(1): 7 – 14.

Willis, J. C. 1955. *A Dictionary of the Flowering Plants and Ferns*. Cambridge, UK. Cambridge University Press.

Yen, D. E. and Wheeler, J. M. 1968. Introduction of taro into the Pacific: the indications of the chromosome numbers. *Ethnology*, **7**: 259 – 267.