DIVERSITY AND GENETIC RESOURCES OF TARO IN INDIA

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ABSTRACT

India being one of the centres of origin of taro (*Colocasia esculenta* (L.) Schott) is blessed with an immense genetic wealth of the crop. Taro is cultivated through out the country for the use of its corms, cormels and the leaves as vegetable.The Central Tuber Crops Research Institute, Trivandrum is the sole research Institute in India engaged in the genetic upgradation of all tropical tuber crops including taro. This Institute possesses the richest germplasm wealth of 424 edible genetic stocks of taro in its HQ at Trivandrum in the south and 120 in its Regional Centre at Bhubaneswar in east India. Genetic resources of taro are also collected and maintained by the National Bureau of Plant Genetic Resources (New Delhi) in its Regional Station at Trichur, Kerala and the research centers /agricultural universities located in different agro climatic zones in India under the All India Coordinated Research Project on Tuber Crops. At the CTCRI, the genetic stocks are maintained in the field gene bank for enabling the studies of plant characters, pre-breeding studies and directed crosses in addition to *in vitro* conservation of the same. Cytological and morphological screening of the genetic stocks has been done and yield attributes identified. The frequency and distribution of the different ploidy types in India were also ascertained. Characterization based on morphological features of individual genotype was undertaken as per modified IPGRI descriptor for taro. The data revealed the prevalence of a wide spectrum of variability among the Indian collections with regard to several characters. Two superior selections isolated from the germplasm were released (1987) for general cultivation from CTCRI under the names ‘Sree Reshmi’ and ‘Sree Pallavi’. Another variety ‘Mukthakesi’ released (in 2001) from Regional Centre of CTCRI is tolerant to *Colocasia* leaf blight, a serious disease in certain parts of the country. Several economically desirable important genetic stocks identified from the germplasm are under advanced stages of evaluation. Also, studies are in progress on the application of genetic and molecular markers for the characterization of germplasm to confirm the results obtained by systematic and morpho-agronomic descriptors.

INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is a traditional crop with a long history of cultivation in Asia and the Pacific. It is widely used as a tuber 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, petiole and leaves serve the important purpose as an instant vegetable. Eventhough there is no statistical data available on the area and production of taro in India, it is a fact that taro commands a higher price than cassava or sweet potato. Despite the importance of this crop, its cultivation anywhere in India is generally a subsistent to semi-commercial crop. Though preference of the different plant parts of taro as a vegetable was realized in India long back, efforts rendered towards its genetic upgradation are still meagre. The Central Tuber Crops Research Institute (CTCRI), India under the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture, Department of Agricultural Research Education has included taro as a mandatory crop from its very inception in 1963. Because cassava and sweet potato were more importantly grown for food, these were given high priority for research at the CTCRI initially. Later, germplasm collections of the crop were assembled from various parts of the country and research programmes were initiated mainly on conservation and basic research programmes. From the end 80s when the germplasm bank got enriched with several morphologically distinct types of taro, prioritized research projects were initiated at the CTCRI for the upliftment of this crop in the Indian agricultural scenario. Thus, two research projects, viz. (1) Collection, conservation and evaluation of the germplasm and (2) Genetic improvement programme in edible taro are in operation and have made substantial progress.

There are several kinds of taro: swamp taro (*Cyrtosperma chamissonis*), tannia (*Xanthosoma sagittifolium*), giant taro (*Alocasia macrorrhiza*) and ordinary or true taro (*Colocasia esculenta*) prevalent in India, of which tannia is the most similar to the ordinary taro, and is characterized by relatively large, sagittate leaves, a large main corm and several cormels, which are used as food. Ordinary taro is the most important species in the group. There exists differing opinions regarding the original home of the crop as well as its taxonomy and common names (Spier 1951; Mehta, 1959; Coursey, 1968; Harian, 1975; Plucknett, 1970, 76; Onwume, 1978; Kuruvilla and Singh, 1983; Jos and Sreekumari, 1990 and Sreekumari, 1993). According to FAO, 2001 taro is cultivated in more than 1.08 million hectares in the world. The taro genetic resources and the extent of diversity prevalent among Indian taros are discussed.

Collection strategy

Researchers dealing with germplasm will be educated for the conduct of exploratory trips and collection criteria by conducting short-term training courses at the National Bureau of Plant Genetic Resources Institute, New Delhi, a sister Institute under ICAR, meant for germplasm collection, exchange, conservation and evaluation. The NBPGR organizes field collection trips for all crops including tropical tuber crops. Since CTCRI is the sole research institute in India dealing with research and development programmes of tropical tuber crops, the concerned researchers and technical staff of the Institute will join in such trips arranged for tuber crops collection. Several collection trips have so far been undertaken resulting in the procurement of a total of 4210 genetic stocks of various tuber crops including taro at the CTCRI.

Germplasm collections

The germplasm collections and the zones from which collected are summarized in Table I.

Table 1. Number and source of taro germplasm collections maintained at CTCRI

Sl. No.	**Zone**	**No. of collections**
1	South India	148
2	Central India	78
3	North India	84
4	North-East India	119

Altogether 424 indigenous collections were procured representing genetic stocks from all over the Indian sub continent.

Conservation and characterization

The genetic stocks brought in the form of corms / cormels will be raised initially in the nursery and later transplanted to field. In the *ex situ* conservation, 5-10 plants per accession will be maintained usually to the field. Necessary irrigation, weeding, earthing up, etc will be given as and when found necessary and the gene bank is maintained afresh by timely transplanting to the field. The collections were characterized morphologically based on revised IPGRI descriptors for taro (Unnikrishnan *et. al.*, 1987, 1988). The morpho-agronomic characterization and the variation obtained are presented in Table II. The descriptions for each of the taro germplasm material were kept in a database.

Table II. Distribution (%) of morpho-agronomic traits in Indian taros

Sl. No.	Character	Trait	Percentage
1	Germplasm type	Cultivated Wild	95.3 4.7
2	Botanical variety	Dasheen Eddoe Intermediate	28.6 55.5 15.9
3	Plant type	Erect Spreading	65.3 34.7
4	Stem girth	High (> 20 cm) Medium (10-24 cm) Low (< 10 cm)	24.4 60.6 15.0
5	Tillering Nature	High (> 6) Medium (3-6) Low (1-3)	2.8 25.3 71.9
6	Leaf arrangement	Clockwise Anti-clockwise	55.7 44.3
7	Leaf orientation	Semi erect Drooping Cup-shaped	52.3 31.5 16.2
8	Leaf margin	Entire Undulate	39.9 60.1

9	Leaf margin colour	Green Purple	78.1 21.9
10	Sinus colour (upper)	Yellow Purple	56.6 43.4
11	Sinus colour (lower)	Yellow Purple	19.3 80.7
12	Petiole colour	Green Purple (different shades)	54.4 45.6
13	Sheath colour	Green Purple Mixed	47.9 23.6 28.5
14	Flowering nature	Flowered Not flowered	14.0 86.0
15	Maturity	Early (<25 weeks) Normal (26-28 weeks) Late (> 29 weeks)	18.7 56.3 25.0
16	Corm shape	Cylindrical Round Conical Club-shaped Elliptical Multishaped Rhizhomatous	41.3 7.7 14.0 8.0 0.3 28.0 0.7
17	Cormel yield	Low (200 g) Medium (200-400 g) High (> 400 g)	39.7 41.0 19.3
18	Corm yield	Low (> 300 g) Medium (300-500 g) High (> 500 g)	21.6 63.2 15.2
19	Cooking quality of corms	Good Poor	18.1 81.9
20	Cooking quality of cormels	Good Poor	68.3 31.7
21	Keeping quality of corms	Low (< 15 days) Medium (15-30 days) Long (> 30 days)	71.3 15.2 14.5

22	Keeping quality of cormels	Low (< 15 days) Medium (15-30 days) Long (> 30 days)	21.5 58.4 20.1
23	Tolerance of *Colocasia* leaf blight	Susceptible Tolerant Resistant	60.6 39.4 0 .0

Of the two groups distinguished, wild forms were only nominal (4.7%). The cultivated forms dominated which include dasheen, eddoe and intermediate types. The first two types are already recognized among the cultivated forms. The main difference between dasheen and eddoe is in shape and size of main corm and cormels. Dasheen genotypes are characterized with larger central main corm and smaller side cormels. Eddoe genotypes usually have relatively smaller central and fibrous corms and well developed side cormels. Accessions could be clearly differentiated into dasheen (28.6%) or eddoe types (55.5%) and 15.9 per cent were intermediate types. These accessions could be hybrids between the two botanical varieties or accessions that are difficult to classify because of the unusual shape of their corms. Among the Indian taros, dasheen and eddoe types were found distributed all parts the country.

Wide spectrum of variability was evident with regard to almost all characters (Table II). Lebot, *et al*., (2000) has reported that taro genetic stocks although morphologically very variable, showed a narrow genetic base with limited allelic variation. It is probable that sexual recombination among the cultivars are very rare and the few naturally set seeds might be due to self pollination. Through human selection also, numerous morphotypes might have generated, in addition to somatic mutations. Even though pigmentations on different parts of the plant vary a lot, it is assumed that very few genes are involved in anthocyanin pigmentation resulting in various petiole and leaf colours. Moreover, identical morphotypes have different names in different collocations within the country. Numerous vernacular languages are prevalent in India and the common (local) name of taro in different parts of the country are: arvi (Hindi), chempu (Malayalam), seppan kizhangu (Tamil), kachchi (Kannada), chamadumpa (Telugu), alu (Marathi) and kachu (Bengali).

Ploidy level

Chromosome counts taken from well spread metaphase plates of root tip cells revealed that diploids ($2n = 28$) and triploids ($2n = 42$) occur in Indian taros in almost equal proportion. The frequency of the ploidy types showed clear difference in ploidy-wise distribution in the different zones of the country. Although both the types occur in all the regions, the diploids predominate in South India over the triploids (Table III) while the triploids convincingly out-numbered the diploids in the north (Sreekumari and Mathew, 1991). Several factors are known to influence the frequency of polyploids in different eco-geographical regions. Zeven (1980) pointed out that polyploids in general have larger dimensions and greater adaptability which apparently enable them to thrive better in a wide range of higher latitudinal and altitudinal zones. As in the case of Indian taros, Zang and Zang (1990) also observed a greater percentage of triploid forms in higher altitude regions of China.

Table III. Distribution of diploid and triploid taros (%) in different zones in India

Ploidy level	South India	Central India	North India	North-East India
Diploid	33.37	11.29	1.67	3.76
Triploid	13.85	14.64	7.11	14.18

The data indicate that in Indian taros, triploids are endowed with better adaptability in higher altitudes and they enjoy a wider distributional tendency than their diploid cousins.

Chromosomal variations

Karyomorphological analysis revealed that in addition to numerical variation, structural differences of chromosomes were also apparent in many collections. The data of chromosome size showed that along with autotriploid evolution, chromosome size has not undergone noticeable degree of change. However, considerable degree of heterogeneity exists in regard to distribution of various chromosome types viz. m, sm, st & t-types (Sreekumari,1993).

Comparative performance of diploids and triploids

Initial screening of the germless accessions for tuber yield revealed the superiority of triploids compared to diploid accessions in several characters such as plant height , tillering habit , number and size of leaves, corm and cormel yield. To confirm this, field experiments were conducted and it was established that triploids in general differ significantly from diploids. They were superior with regard to seven of the nine characters studied. The corm and cormel yield showed very promising and impressive increase in the higher ploidy types. This implies that for selecting high yielding types in taro, it is desirable to consider the triploids rather than diploids (Sreekumari and Thankamma Pillai, 1993). The same was found to be true in another tuber crop viz. cassava which showed significant increase in tuber yield and starch content in the artificially produced triploids which might be due to triploidy *per se* (Sreekumari et al., 1999).

Flowering

Flowering was scarce, irregular and seasonal in taro. However, frequency of flowering was high among diploids and started by middle of June and lasted till the middle of September (Sreekumari and Thankamma Pillai, 1994). The inflorescence of diploid and triploid plants could be distinguished easily by the size and length of sterile appendage, both larger in triploids. Diploids were fertile and natural seed setting observed rarely. The cause of sterility of the triploids was studied in detail (Sreekumari and Mathew, 1993).

Tolerance to *Phytophthora colocasiae*

Taro leaf blight caused by *Phytophthora colocasiae* is the most serious disease but its occurrence is correlated with weather conditions. It usually is not a threat to the taro cultivation especially in the southern states. However, in extended periods of rainfall and high humidity, the disease spreads causing considerable damage. Majority of the accessions were tolerant to leaf blight but none was found to be resistant.

Agro-economic evaluation and variety release

Elite cultivars are selected from the germ plasm by conducting field evaluation trials. The desirable ones based on specific characteristics (early maturity, ideal plant type, good cormel shape, disease tolerance, good cooking quality etc.) will be selected for further evaluation.

A set procedure is followed for the release of elite varieties for general cultivation, the sequence of which is given below: -

- Identification of desired type through germless evaluation
- Un replicated row trial (20-30 plants per row)
- Replicated row trial (20-30 plants per row per replication)
- Preliminary yield trial (RBD, 3 replications)
- Advanced yield trial (RBD, 3 replications, 2seasons)
- On farm trial within the state (10 locations, 2 seasons, local variety as check)
- Approval from Scientific Research Committee (SRC), CTCRI (appropriate name to be given for the variety)
- Submitting the details before the State Variety release Committee for consideration for release
- Approval of the Committee
- Multiplication for generating sufficient planting material
- Official release of the variety for general cultivation within the state

For release of the variety at the national level, uniform regional trials are to be conducted at different zones (usually undertaken by AICRP on tuber crops) and approval to be obtained from the Central Variety Release Committee. It generally takes 5-6 years for an elite germplasm to reach the variety release stage. Based on the procedure for state level release, four varieties were released in taro in the country. They are two high yielding good cooking quality triploid selections viz. Sree Reshmi and Sree pallavi from the CTCRI, Trivandrum, one blight tolerant variety Muktakeshi from the Regional Centre of CTCRI at Bhuvaneswar, India and another high yielding variety Kovur from the Andhra Pradesh Agricultural University, India.

The released varieties are triploids indicating that although esculenta (diploids) forms are available, these would be preferred in areas where Colocasia is a staple food as in the South Pacific Islands and the Carribeans. Esculenta forms are not popular in areas where cereals form the staple food probably due to their large size and low keeping quality in contrast to smaller size and better keeping quality of var. *antiquorum* (Velayudhan, et al.,1998). In India, selection during cultivation would have been for more and more number of cormels as only cormels are used mostly as vegetable in this country as cereals form the staple food. It is therefore probable that the nature of staple food of the people determines the preponderance of one form over the other in areas of cultivation of this crop, which is true as far as cultivation of taro in India is considered.

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