



Collection and Conservation of Genetic Resources of Tropical Root and Tuber Crops for Sustainable Livelihood – A Status Report

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Abstract

Root and tuber crops are important subsidiary or subsistence food and nutritional crops in tropical and subtropical countries. India is a unique place for the production of diverse horticultural crops. Genetic diversity is needed to develop improved varieties through different breeding programmes. Collection and conservation of genetic resources of tropical root and tuber crops in India is carried out by National Bureau of Plant Genetic Resources (NBPGR), New Delhi, with its regional stations located in different agro-ecological regions and Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala with its regional centre at Bhubaneswar. The regional station of NBPGR at Thrissur is primarily meant to undertake plant genetic resources activities in the tropical humid regions of the country. Since 1977 this station has collected considerable genetic variability in these crops and their wild relatives from the southern region. A sizable number of collections of cassava, sweet potato, yams, aroids, Chinese potato, arrowroot and wild relatives of *Amorphophallus* and *Dioscorea*, made from different parts of Andhra Pradesh, Goa, Karnataka, Kerala, Tamil Nadu, Union Territories of Lakshadweep and Andaman and Nicobar Islands are being maintained in the Field Gene Bank (FGB). The germplasm of these crops were characterized and evaluated for different useful characters. Four accessions in four different species of *Dioscorea* (IC202328, 202370, 202382 and 202383) were registered for diosgenin content, a unique trait. Twelve accessions of *Dioscorea* are also being maintained under *in vitro* cultures at this station. A total of 1075 accessions of elephant foot yam (50), *Amorphophallus* spp. (6 spp., 30), Chinese potato (31), taro (415), lesser yam (64), greater yam (166), *Dioscorea* spp. (11 spp., 133), cassava (156) and cassava *in vitro* cultures (30) were transferred to CTCRI, Thiruvananthapuram. CTCRI has been identified as the National Active Germplasm Site (NAGS) for FGB maintenance and further utilization of these crops. In future, unexplored tribal areas of the region would be surveyed for new germplasm collections. The available germplasm of these crops and their wild relatives would be further exploited and used to develop new varieties with desirable superior traits through different crop improvement programmes for the sustainable livelihood of the farmers, tribal people and local population in this fast changing agro-climate scenario.

Key words: Collection, conservation, genetic resources, tropical root and tuber crops

Introduction

Tropical root and tuber crops have better adaptability to varying climatic conditions and play a significant role in meeting the food and feed requirements in the tropical

and subtropical regions of the world. They constitute a group of highly cross pollinated and vegetatively propagated plants. A vast amount of genetic variability exists in these crops. India is a unique place for the

production of diverse horticultural crops. The importance of any crop can be visualised by its germplasm wealth. In order to identify better potential types for commercial cultivation, it is necessary to collect, characterize, evaluate and conserve the divergence of indigenous as well as exotic genetic resources of a crop for crop improvement programmes. Collection, characterization, evaluation, conservation and supply of genetic resources of tropical root and tuber crops in India is carried out by National Bureau of Plant Genetic Resources (NBPGR), New Delhi and its regional stations located in different agro-ecological regions and Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala with its regional centre at Bhubaneswar (Hore and Sharma, 1995; Muralidharan and Velayudhan, 1985a; 1985b; Velayudhan and Muralidharan, 1985; Ghosh, 1988; Nayar et al., 1989; Singh and Naskar, 1989; Velayudhan et al., 1989a; Velayudhan et al. 1993; 1998). The present paper gives an account of collection, characterization, evaluation, conservation, supply and transfer of germplasm of tropical roots, tuber crops and their wild relatives.

Materials and Methods

Germplasm collection and augmentation of cultivated and wild relatives including both indigenous as well as exotic sources of tuber crops were made during 1978-2013 from the tribal dominated tracts of Andaman and Nicobar Islands, Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Maharashtra, Sikkim, Tamil Nadu, West Bengal and Union Territory of Lakshadweep holding different primitive cultivars, in the plains, mountains and islands inhabited by different ethnic groups. Several explorations and germplasm collection trips were undertaken individually or in collaboration with ICAR Institutes, Regional Stations of this Institute, SAUs or NGOs to enrich

genetic variability. Biased, Random and Selection methods were followed for collection. Field data, characters and indigenous traditional knowledge were noted down and documented. The collected germplasm were grown at this station for multiplication, characterization, evaluation, documentation and conservation. The vegetatively propagated germplasm were conserved *ex situ* in the Field Gene Bank (FGB) and *in vitro* conditions in tissue culture. Plant material developed through *in vitro* mode of multiplication were sent to the Tissue Culture and Cryopreservation Unit (TCCU), NBPGR, New Delhi and CTCRI, Thiruvananthapuram, a National Active Germplasm Site (NAGS), for further utilization and various genetic resources activities. A large number of accessions of different crops were also supplied to various indenters on request for research purpose under Material Transfer Agreement (MTA).

Results and Discussion

A total of 2700 collections comprising major tuber crops (2123 accessions), minor tuber crops (109 acc.) and wild relatives (468 acc.) were made from different areas of Andaman and Nicobar Islands, Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Maharashtra, Sikkim, Tamil Nadu, Union Territory of Lakshadweep and West Bengal (Tables 1 to 4). Out of these, 15, 2, 29, 26, 192, 2059, 6, 7, 218, 29 and 9 accessions of different tuber crops and their wild relatives were collected from these states, respectively. Maximum of 2059 acc. were collected from Kerala and minimum of 2 acc. were from Andhra Pradesh (Fig. 1.).

Major tuber crops

A total of 2015 collections comprising cassava (*Manihot esculenta* Crantz.: 265 acc.), Chinese potato (*Plectranthus rotundifolius* (Poir.) J.K. Morton: 137 acc.), elephant foot yam (*Amorphophallus paeoniifolius* var. *campanulatus* (Dennst.) Nicolson: 213 acc.), greater

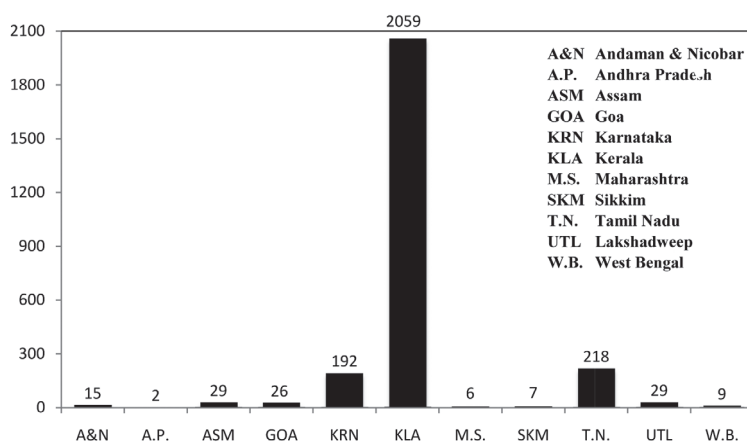


Fig. 1. State-wise exploration and collection of root and tuber crops

yam (*Dioscorea alata* L.: 295 acc.), lesser yam (*D. esculenta* Lour. Burk: 86 acc.), sweet potato (*Ipomoea batatas* L. Lam.: 32 acc.), tannia (*Xanthosoma sagittifolium* (L.) Schott.: 434 acc.) and taro (*Colocasia esculenta* (L.) Schott.: 553 acc.) were made from Andaman and Nicobar Islands (7), Andhra Pradesh (2), Assam (23), Goa (19), Karnataka (96), Kerala (1684), Maharashtra (3), Sikkim (7), Tamil Nadu (155), West Bengal (8) and Union territory of Lakshadweep (13) (Table 1). Out of the total 2123 collections, the major share of 1768 accessions belonging to cassava (224), Chinese potato (127), elephant foot yam (168), greater yam (248), lesser yam (79), sweet potato (15), tannia (389) and taro (434) were collected from Kerala. Only two accessions of greater yam were collected from Andhra Pradesh. In cassava, 1, 14, 224, 25 and 1 collections were made from Assam, Karnataka, Kerala, Tamil Nadu and Union Territory of Lakshadweep, respectively. Out of 137 collections of Chinese potato, 1, 5, 127 and 4 accessions were gathered from different parts of Goa, Karnataka, Kerala and Tamil Nadu, respectively. On the other hand, 2, 2, 11, 168, 1 and 29 collections of elephant foot yam were made from Andaman and Nicobar Islands, Goa, Karnataka, Kerala, Maharashtra and Tamil Nadu. In greater yam, 4, 2, 2, 6, 13, 248, 1, 13, 3 and 3 collections were made from Andaman and Nicobar Islands, Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, West Bengal and Union Territory of Lakshadweep, respectively,

while 3, 1, 79 and 3 collections of lesser yam were accumulated from different parts of Goa, Karnataka, Kerala and Tamil Nadu, respectively. Thirty two collections of sweet potato were gathered from different areas of Goa (4), Karnataka (6), Kerala (15), Tamil Nadu (5) and Union Territory of Lakshadweep (2). A total of 434 accessions of tannia germplasm were collected from Goa (1), Karnataka (17), Kerala (389), Sikkim (1), Tamil Nadu (21), Union Territory of Lakshadweep (4) and West Bengal (1), while 553 collections of taro were made from Andaman and Nicobar Islands (1), Assam (20), Goa (2), Karnataka (27), Kerala (434), Maharashtra (1), Sikkim (6), Tamil Nadu (55), West Bengal (4) and Union Territory of Lakshadweep (3).

Minor tuber crops

In total, 108 accessions of minor tuber crops comprising East Indian arrowroot (2), giant taro (22), Indian shot (75) and Fiji arrowroot (9) were collected from Andaman and Nicobar Islands, Assam, Karnataka, Kerala, Tamil Nadu and Union Territory of Lakshadweep (Table 1). Two collections of East Indian arrowroot were made, one each from Kerala and Tamil Nadu. Twenty two collections of giant taro were collected from Assam (2), Karnataka (1), Kerala (15) and Union Territory of Lakshadweep (4), while 75 collections of Indian shot were made from Karnataka (4), Kerala (68) and Tamil Nadu (3). In case of Fiji arrowroot, nine collections were made from Andaman and Nicobar Islands (1), Karnataka

Table 1. Collection of major and minor tuber crops from different states

S.No.	Crop	AS	GA	KA	KL	TN	UTL	Others	TOTAL
1	Cassava (<i>Manihot esculenta</i>)	1	..	14	224	25	1	..	265
2	Chinese potato (<i>Plectranthus rotundifolius</i>)	..	1	5	127	4	..	..	137
3	East Indian arrowroot (<i>Maranta arundinacea</i>)	..	..	..	1	1	..	..	2
4	Elephant foot yam (<i>Amorphophallus paeoniifolius</i> var. <i>campanulatus</i>)	..	2	11	168	29	..	3	213
5	Fiji arrowroot (<i>Tacca leontopetaloides</i>)	..	..	2	..	1	5	1	9
6	Giant taro (<i>Alocasia macrorrhiza</i>)	2	..	1	15	..	4	..	22
7	Greater yam (<i>Dioscorea alata</i>)	2	6	13	248	13	3	10	295
8	Indian shot (<i>Canna edulis</i>)	..	..	4	68	3	..	..	75
9	Lesser yam (<i>Dioscorea esculenta</i>)	..	3	1	79	3	..	..	86
10	Sweet potato (<i>Ipomoea batatas</i>)	..	4	6	15	5	2	..	32
11	Tannia (<i>Xanthosoma sagittifolium</i>)	..	1	17	389	21	4	2	434
12	Taro (<i>Colocasia esculenta</i>)	20	2	27	434	55	3	12	553
	Total	25	19	101	1768	160	22	28	2123

AS – Assam; GA – Goa; KA – Karnataka; KL – Kerala; TN – Tamil Nadu; UTL – Union Territory of Lakshadweep Islands

(2), Tamil Nadu (1) and Union Territory of Lakshadweep (5).

Wild relatives

In total, 469 collections of different wild species comprising *Alocasia* (1), *Amorphophallus* (11 spp.), *Colocasia* (3 spp.), *Dioscorea* (17 spp.), *Ipomoea* (6 spp.), *Manihot* (1 sp.) and *Xanthosoma* (1 sp.) were made (Tables 2 to 4). Out of 469 collections, 58 were *Amorphophallus* species such as *A. bonaccordensis* (1), *A. bulbifera* (10), *A. commutatus* (6), *A. dubius* (10), *A. hohenackeri* (8), *A. nicolsonianus* (2), *A. oncophyllus* (2), *A. paeoniifolius* (13), *A. smithsonianus* (1), *A.*

sylvaticus (4) and *A. sylvestris* (1); 376 belonged to *Dioscorea* species, namely *D. anguina* (1), *D. belophylla* (10), *D. bulbifera* (61), *D. glabra* (2), *D. hamiltonii* (25), *D. hispida* (18), *D. intermedia* (9), *D. oppositifolia* (81), *D. pentaphylla* (63), *D. pubera* (8), *D. spicata* (26), *D. tomentosa* (23), *D. trifolia* (1), *D. vexans* (2), *D. virosa* (1), *D. wallichii* (44) and *D. wightii* (1) and 35 were of *Alocasia indica* (1), *Colocasia affinis* (4), *C. antiquatica* (3), *C. gigantea* (2), *Ipomoea aquatica* (1), *I. denticulata* (1), *I. digitata* (2), *I. mauritiana* (3), *I. muricata* (3), *I. pescaprae* (3), *Manihot glassiovii* (1) and *Xanthosoma*

Table 2. Collection of wild species of *Amorphophallus*

Sl. No.	Species	AN	GA	KA	KL	TN	TOTAL
1	<i>A. bonaccordensis</i>	..	..	..	1	..	1
2	<i>A. bulbifera</i>	..	..	5	5	..	10
3	<i>A. commutatus</i>	..	..	5	1	..	6
4	<i>A. dubius</i>	..	..	2	8	..	10
5	<i>A. hohenackeri</i>	..	..	1	7	..	8
6	<i>A. nicolsonianus</i>	..	..	..	2	..	2
7	<i>A. oncophyllus</i>	1	..	..	1	..	2
8	<i>A. paeoniifolius</i>	..	1	7	4	1	13
9	<i>A. smithsonianus</i>	..	..	..	1	..	1
10	<i>A. sylvaticus</i>	..	..	..	3	1	4
11	<i>A. sylvestris</i>	..	..	..	1	..	1
	Total	1	1	20	34	2	58

AN – Andaman & Nicobar Islands; GA – Goa; KA – Karnataka; KL – Kerala; TN – Tamil Nadu

Table 3. Collection of wild species of *Dioscorea*

Sl. No.	Species	AN	AS	GA	KA	KL	MS	TN	UTL	TOTAL
1	<i>D. anguina</i>	..	..	..	..	1	..	..	..	1
2	<i>D. belophylla</i>	..	..	..	3	5	1	1	..	10
3	<i>D. bulbifera</i>	2	2	4	11	35	1	5	1	61
4	<i>D. glabra</i>	2	..	..	..	..	..	..	..	2
5	<i>D. hamiltonii</i>	..	..	..	2	22	..	1	..	25
6	<i>D. hispida</i>	..	..	..	..	17	..	1	..	18
7	<i>D. intermedia</i>	..	..	1	2	5	..	1	..	9
8	<i>D. oppositifolia</i>	..	..	..	17	45	..	18	1	81
9	<i>D. pentaphylla</i>	..	..	..	17	37	1	8	..	63
10	<i>D. pubera</i>	..	1	..	..	7	..	..	..	8
11	<i>D. spicata</i>	..	..	..	7	13	..	6	..	26
12	<i>D. tomentosa</i>	..	..	..	1	16	..	6	..	23
13	<i>D. trifolia</i>	..	..	..	..	1	..	..	..	1
14	<i>D. vexans</i>	2	..	..	..	..	..	..	..	2
15	<i>D. virosa</i>	..	..	..	..	..	..	1	..	1
16	<i>D. wallichii</i>	..	..	..	5	36	..	3	..	44
17	<i>D. wightii</i>	..	..	..	..	..	..	1	..	1
	Total	6	3	5	65	240	3	52	2	376

AN – Andaman & Nicobar Islands; AS – Assam; GA – Goa; KA – Karnataka; KL – Kerala; MS – Maharashtra; TN – Tamil Nadu; UTL – Union Territory of Lakshadweep Islands

Table 4. Collection of other wild relatives of tuber crops

Sl. No.	Species	AS	GA	KA	KL	TN	UTL	WB	TOTAL
1	<i>Alocasia indica</i>	..	..	1	..	..	..	..	1
2	<i>Colocasia affinis</i>	..	..	1	3	..	..	..	4
3	<i>C. antiquorum</i>	..	1	..	..	1	1	..	3
4	<i>C. gigantea</i>	..	..	..	..	2	..	..	2
5	<i>Ipomoea aquatica</i>	..	..	..	1	..	..	..	1
6	<i>I. denticulata</i>	..	..	..	..	..	1	..	1
7	<i>I. digitata</i>	..	..	..	2	..	..	..	2
8	<i>I. mauritiana</i>	..	..	1	1	..	1	..	3
9	<i>I. muricata</i>	..	..	..	3	..	..	..	3
10	<i>I. pescaprae</i>	..	..	..	1	..	2	..	3
11	<i>Manihot glassiovii</i>	..	..	..	..	1	..	..	1
12	<i>Xanthosoma violaceum</i>	1	..	3	6	..	..	1	11
	Total	1	1	5	17	4	5	1	35

AS – Assam; GA – Goa; KA – Karnataka; KL – Kerala; TN – Tamil Nadu; UTL – Union Territory of Lakshadweep Islands; WB – West Bengal

violaceum (11).

Germplasm characterization and evaluation

Out of 2123 collections of major tuber crops, 1101 accessions comprising cassava (168), Chinese potato (39), elephant foot yam (56), greater yam (182), lesser yam (64), tannia (37) and taro (555) were characterised for 43, 20, 17, 71, 14, 39 and 90 descriptors and evaluated at this station (Velayudhan and Asha, 1998; Velayudhan and Liji, 2002; 2004; Velayudhan et al., 1988; 1989a; 1989b; 1990; 1991a; 1991b; 2003; Amalraj et al., 1990; 1991; Asha and Nair, 2001; 2002; 2003; Asha et al., 2002; Lakhanpaul et al., 2003; Abraham et al., 2008; Lata and Murugesan, 2008) (Table 5). Minimal Descriptors of tubers was developed for easy and uniform characterisation (Abraham et al., 2006). Three scientific monographs were published (Velayudhan et al., 1991b; 1993; 2003).

Registration of genetic stocks

Based on the characterization and evaluation of germplasm, four accessions, one each of *Dioscorea hamiltonii*-IC202328, INGR No. 08064, *D. hispida*-IC202370, INGR No. 08063, *D. pubera*-IC202382, INGR No. 08061 and *D. spicata*-IC202383, INGR No. 08062 were registered for diosgenin ($3 \mu\text{g g}^{-1}$,

$57 \mu\text{g g}^{-1}$, $1220 \mu\text{g g}^{-1}$ and $305 \mu\text{g g}^{-1}$, respectively) contents during 2008 (Fig. 2).

Germplasm conservation

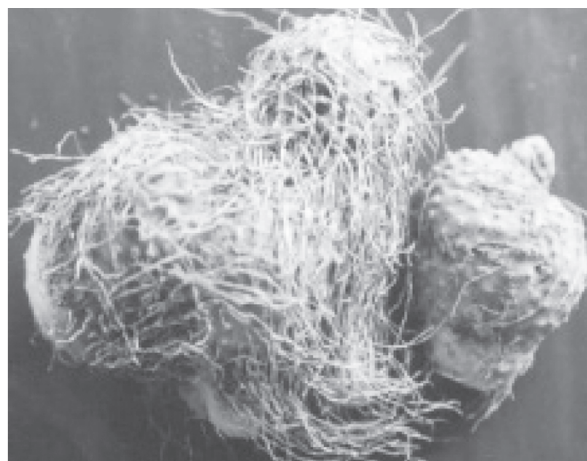
After transferring most of the collected germplasm, 589 accessions of different tropical tuber crops have been conserved by planting in different fields and pots and are being maintained in the FGB of this station for future plant genetic resources activities. These conserved and maintained germplasm comprises cassava (*Manihot esculenta*-166 acc.), Chinese potato (*Plectranthus rotundifolius*-28 acc.), East Indian arrowroot (*Maranta arundinacea*-5 acc.), elephant foot yam (*Amorphophallus paeoniifolius* var. *campanulatus*-47 acc.), giant taro (*Alocasia macrorrhiza*-2 acc.), greater yam (*Dioscorea alata*-173 acc.), Indian shot (*Canna edulis*-5 acc.), lesser yam (*Dioscorea esculenta*-61 acc.), tannia (*Xanthosoma sagittifolium*-12 acc.) and taro (*Colocasia esculenta*-

Table 5. Accessions characterised and the number of traits

Sl. No.	Crop	Accessions	Descriptors
1.	Cassava (<i>Manihot esculenta</i>)	168	43
2.	Chinese potato (<i>Plectranthus rotundifolius</i>)	39	20
3.	Elephant foot yam (<i>Amorphophallus paeoniifolius</i> var. <i>campanulatus</i>)	56	17
4.	Greater yam (<i>Dioscorea alata</i>)	182	71
5.	Lesser yam (<i>Dioscorea esculenta</i>)	64	14
6.	Tannia (<i>Xanthosoma sagittifolium</i>)	37	39
7.	Taro (<i>Colocasia esculenta</i>)	555	90



Dioscorea hamiltonii – IC202328 (INGR No. 08064)



Dioscorea hispida– IC202370 (INGR No. 08063)



Dioscorea pubera - IC202382 (INGR No. 08061)



Dioscorea spicata - IC202383 (INGR No. 08062)

Fig. 2. Registered genetic stocks of *Dioscorea*

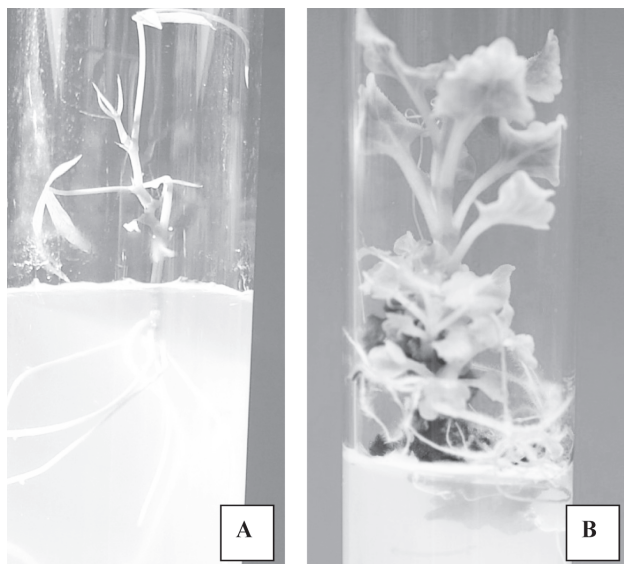


Fig. 3. *In vitro* cultures of cassava (A) and Chinese potato (B)

90 acc.). Besides these, 17 accessions consisting of *Manihot esculenta* (5), *Dioscorea belophylla* (1), *D. bulbifera* (2), *D. intermedia* (1), *D. oppositifolia* (1), *D. pentaphylla* (3), *D. pubera* (2), *D. tomentosa* (1) and *D. wallichii* (1) are being maintained under *in vitro* condition at this station.

Augmentation of tuber crop germplasm

Exotic: Eight exotic accessions belonging to *Colocasia esculenta* (1 acc.) ‘INHANE’ from Brazil; *Dioscorea* spp. (2 acc.), one each from Nigeria and Taiwan, *Ipomoea batatas* (2 acc.) from USA; *Manihot epruinosa* (1 acc.) from Central America; *Xanthosoma riedlieianum* (1 acc.) from Brazil and *X. sagittifolium* (1 acc.) from Brazil were received through NBPGR, New Delhi.

Indigenous: In total, 240 accessions belonging to canna (*Canna edulis*-2 acc.), elephant foot yam (*Amorphophallus paeoniifolius* var. *campanulatus*-24

acc.), greater yam (*Dioscorea alata*-40 acc.), taro (*Colocasia esculenta*-154 acc.) and wild *Dioscorea* spp. (*D. bulbifera*-10 acc., *D. hispida*-1 acc., *D. oppositifolia*-5 acc. and *D. pentaphylla*-5 acc.) were received from NBPGR, New Delhi and its regional stations located at Akola, Maharashtra; Cuttack, Orissa; Hyderabad, Andhra Pradesh; Ranchi, Jharkhand; Shimla, Himachal Pradesh and Shillong, Meghalaya for regeneration and conservation.

Germplasm sent to NBPGR, New Delhi for *in vitro* conservation

In total, 648 accessions comprising cassava (3 acc.), Chinese potato (20 acc.), elephant foot yam (78 acc.), greater yam (186 acc.), lesser yam (43 acc.), tannia (1 acc.), taro (294 acc.), wild *Colocasia* (1 acc.) and wild *Dioscorea* (12 spp., 22 acc.) have been sent to Tissue Culture and Cryopreservation Unit, NBPGR, New Delhi for *in vitro* conservation (Fig. 3).

Germplasm transferred to NAGS

A total of 1075 accessions consisting of major cultivated tuber crops (912 acc.), wild species of *Amorphophallus* (30 acc.) and *Dioscorea* (133 acc.) were transferred to Central Tuber Crops Research Institute, Thiruvananthapuram, the NAGS, in a phased manner for future programmes. About 186, 31, 50, 166, 64 and 415 accessions of cassava (cuttings of 156 acc. and *in vitro* developed 30 acc.), Chinese potato, elephant foot yam, greater yam, lesser yam and taro, respectively, were transferred. One hundred and sixty three accessions of different wild species transferred were *Amorphophallus bulbifera* (2 acc.), *A. commutatus* (11 acc.), *A. dubius* (1 acc.), *A. oncophyllus* (1 acc.), *A. paeoniifolius* var. *campanulatus* (wild) (11 acc.), *A. paeoniifolius* var. *paeoniifolius* (4 acc.), *Dioscorea belophylla* (3 acc.), *D. bulbifera* var. *bulbifera* (12 acc.), *D. bulbifera* var. *virosa* (1 acc.), *D. floribunda* (1 acc.), *D. hamiltonii* (3 acc.), *D. hispida* (14 acc.), *D. intermedia* (4 acc.), *D. oppositifolia* (21 acc.), *D. pentaphylla* (28 acc.), *D. pubera* (7 acc.), *D. spicata* (5 acc.), *D. tomentosa* (8 acc.) and *D. wallichii* (26 acc.).

The available germplasm of these crops and their wild relatives may further be exploited and used to develop new varieties with desirable superior traits for the sustainable livelihood of the farmers, tribal people and local population of the region through different crop

improvement programmes in the fast changing agro-climate scenario.

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