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DUS Characters in Tropical Tuber Crops, Farmers Friendly Tools for Food, Nutrition and Livelihood Security

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ABSTRACT: *The tropical tuber crops viz. cassava, sweet potato, taro and elephant foot yam are most important as source of food, nutrition and livelihood for more than 500 million people across the globe. The DUS criteria serve as a guideline to protect breeders and farmers interests in many agri horticultural crops. To develop DUS standards, tropical tuber crops are equally important like other food and vegetative crops. Some of these are GI crops of our country. The potential of tropical tuber crops as cash crop and to meet required food and nutrition demands especially in fragile zones have been revalidated in recent years. Varieties of commercial, food, ethnic and medicinal importance of these important tuber crops species need to be characterized or rather to be DUS tested to cater post PPVFRA, 2001 IPR regimes. DUS testing criteria and varietal gene bank have been established for cassava, sweet potato, taro and elephant foot yam. DUS testing also initiated in yam bean and greater yam. Among these, taro and elephant foot yam with higher yield (20-50 t/ha) growing well with minimum inputs in diverse agro conditions can curb the rising food and nutrition insecurity with changing climate. On the other hand, greater yam is the common vegetable and source of herbal medicine in tribal dominated districts of Madhya Pradesh, Chattisgarh and Odisha. The primary characters of taro and elephant foot yam are discussed in detail to satisfy DUS standards not only to facilitate livelihood of farmers but also to comply trade security of GI crop species of our country.*

Keywords: *DUS, tropical tubers, farmers, livelihood security.*

INTRODUCTION

To develop DUS standards, tropical tuber crops *viz.* cassava, sweet potato, taro, elephant foot yam and yams are equally important like other food and vegetable crops. Some of these are GI crops of our country. Varieties of commercial, food, ethnic and medicinal importance of these important tuber crops species need to be characterized or rather to be DUS tested to cater post PPVFRA, 2001 IPR regimes. Unlike cereals, DUS testing in many such valuable foods cum vegetable crops are lacking. Among the tropical tuber crops, cassava, sweet potato, taro, elephant foot yam, yams and yam bean are most important. Moreover those are grown mostly by marginal and tribal farmers of our country. DUS testing and varietal gene bank establishment are essential to boost them morally and to strengthen their livelihood. Hence, DUS testing need to be extended to all these wide adaptive food and nutritionally enriched crops which are farmers and tribal friendly. The DUS criteria will serve as a guideline to protect breeders and farmers interests. India is one of the centres of origin for taro and elephant foot yam, thus harbors considerable diversity of both these crops. Taro is cultivated throughout the country, mainly in tropical and sub-tropical low lands. Though it grows well in marshy lands, varieties have been developed at

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ICAR-CTCRI which can give good yield even in high lands. Elephant foot yam is fast gaining importance as a vegetable crop. It grows well in diverse agro-ecological conditions. Varieties with biotic and abiotic stress tolerance have been developed to fit in different cropping systems. These crops with higher yield (20-25 t/ha) growing well with minimum inputs and diverse conditions can curb the rising food and nutrition insecurity with changing climate (Mukherjee *et al* 2015). On the other hand greater yam is most common vegetable in tribal dominated states of our country. Taro and elephant foot yam have high starch along with other nutrients can supplement required food, nutritional demands. Many improved varieties in taro have been released *viz*. Muktakeshi, Panisaru-1, Panisaru-2, Sree Palavi, Sree Reshmi, Sree Kiran. In elephant foot yam the varieties released are Sree Athira, Gajendra, Bidhan Kusum, Santragachi, NDA-9. Many more promising lines are already in all India recommended trials and to be released for both the crops. These improved lines along with those developed by farmers are to be characterized to bring them under IPR regime. Post TRIPS, IPR related issues are being the growing concern among plant breeders and farmers. As a WTO signatory, India has enacted PPVFRA, 2001 to comply the TRIPS related issues. PPVFRA was being enacted on a model of benefit sharing. Any improved, extant or farmers variety has to conform to PPVFRA based guidelines so as to enable their efficient protection. Few years before, there was no such DUS testing criteria or Centres available for tuber crops. ICAR-CTCRI is now recognized as nodal Centre of tropical tuber crops for DUS testing with support of PPV and FRA, Govt. of India, New Delhi.

The characteristics of most varieties are based on IPGRI descriptors with modifications of certain phenological observations. The varietal gene banks of most of the tuber crops have been established at ICAR-CTCRI based on description of released varieties (James *et al* 2012).

The primary characters recorded based on morphological characters to ease DUS criteria in taro and elephant foot yams are discussed in present communication.

MATERIALS AND METHODS FOR DUS CHARACTERIZATION ON TARO AND ELEPHANT FOOT YAM

Planting Material Required

The quantity of plant material used for taro was 36 tubers of 30-40g each for each variety. The minimum quantity of plant material used for elephant foot yam was 36 tubers 250-300g each for each variety.

The plant materials used were visibly healthy, not lacking in vigor, nor affected by any important pest or disease.

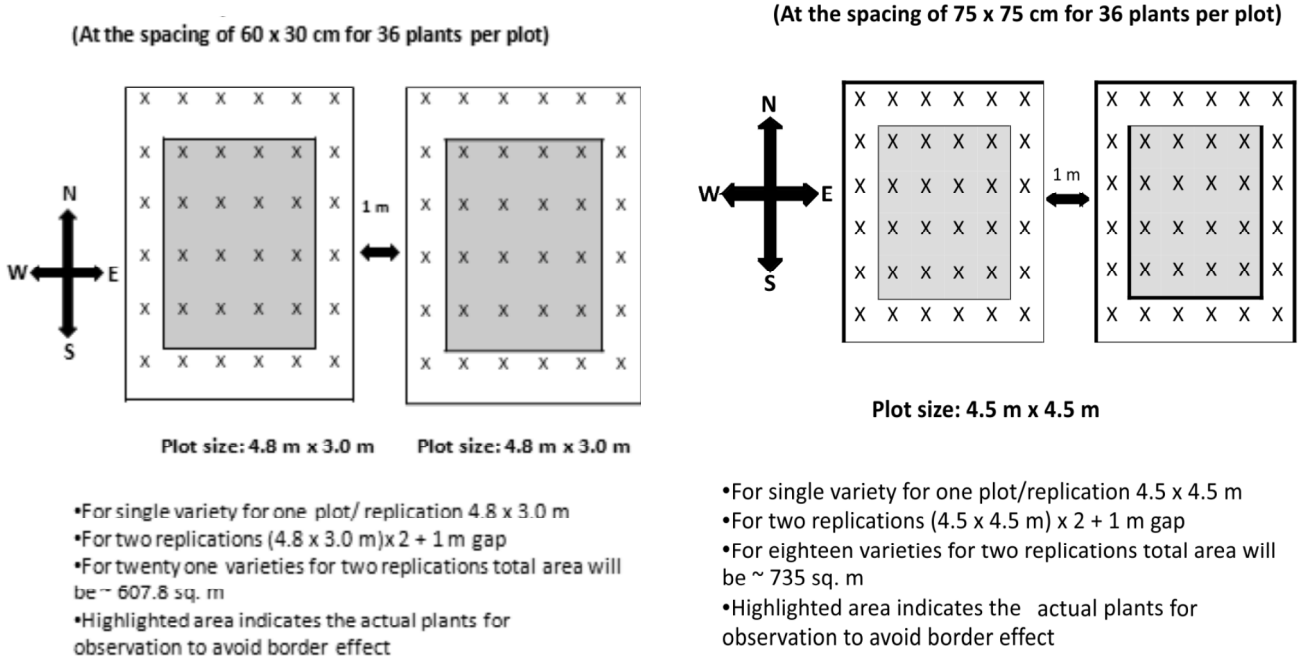


Figure 1(a) and (b): Field layout of taro (a) and elephant foot yam (b) for DUS trial

Table 1
Serial code of varieties of Taro

Sl. No.	*Varieties*
1.	BCC-22
2.	BCC-39
3.	KCS-3
4.	IGCOL-8
5.	SATAMUKHI
6.	KCS-2
7.	SREE RESHMI
8.	JHANKRI
9.	MUKTAKESHI
10.	TELIA
11.	BCC-35
12.	PANISARU-1
13.	SONAJULI
14.	PANISARU-2
15.	BCC-38
16.	SREE KIRAN
17.	SREE PALLAVI
18.	AAVCOL-46
19.	BCC-1
20.	BCC-47
21.	KSS-2

Table 2
Serial code of varieties of elephant foot yam

Sl. No.	*Varieties*
1.	BCA-3
2.	APPAKUDAL
3.	SREEPADMA
4.	GAJENDRA
5.	BCA-5
6.	BIDHAN KUSUM
7.	BCA-2
8.	BCA-4
9.	IGAM-2
10.	SREE ATHIRA
11.	NDA-9
12.	KOVVUR
13.	TRC BADMA
14.	AC-28
15.	IGAM-1
16.	AC-14
17.	NDA-5
18.	NDA-4

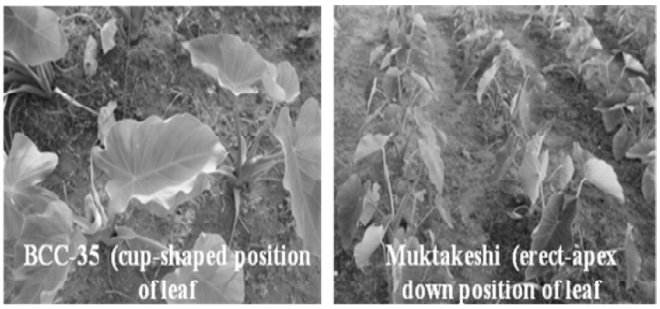


Figure 2(a) and (b): Group and individual distinctness in taro Cup shaped sinuate leaf margin of cv. Jhankri (a), Erect apex, down position and undulate leaf margin in cv. Muktakeshi (b)

Figure 3(a) and (b): Purple leaf blade margin in cv. Telia (a) and yellow margin in cv. Sonajuli

Conduct of Tests

Tests were conducted in two independent similar growing seasons with two consecutive plantings, the second being a replanting with same plant material.

Each test in taro included about 36 plants in the plot size of (4.8 × 3.0 m) with planting space of (60 × 30 cm) as specified schematically in figure (1 a). In elephant foot yam each test included about 36 plants in the plot size of (4.5 × 4.5 m) with planting space of (75 × 75 cm) as specified schematically in figure (1.b)

All the replications were done under similar environmental conditions. The design was done to ease observational records of the plants or parts of plants without affecting the continuous observations till to the end of the growing cycle (180-200 days in taro, 200-220days in elephant foot yam).

The fertilizers used were FYM @ 10t/ha and N: P_2O_5:K_2O; 120:60:100kg/ha for both the crops.

METHODS AND OBSERVATIONS

For the assessment of Distinctiveness and Stability, observations were made on at least 36 plants or parts of 36 plants, which were equally divided among three replications and any other observations made on all plants in the test, disregarding any off-type plants. For the assessment of Uniformity, a population standard of 1% and an acceptance probability of at least 95% were considered. For the assessment of all colour characteristics, the latest Royal Horticultural Society (RHS, 1996) colour chart was used.

The primary characteristics recorded in two growing season are presented in the Tables of characters in respective sections. The identified characters can be used for the testing of varieties for

Table 3
Primary essential characters of taro

Sl. No.	*Characters*	*Characters expression with rank or measurement unit*	*Growth stage*	*Methods of assessment*
1.	Plant height	3: Low Ex. of varieties (sl. nos. 1-21 = Twenty one) 5: Intermediate Ex. of varieties (none) 7: High Ex. of varieties (none)	Height of entire plant at the maximum growing stage (100-120 days), low: less than 119 cm, intermediate: 120-149, high: more than 150 cm	MS
2.	Growth habit	1: Non-fasicate Ex. of varieties (8, 11, 13, 16, 18, 19, 20 = Seven) 9: FasicateEx. of varieties (1-7, 9, 10, 12, 14, 15, 17, 21 = fourteen)	Shoot growth at the maximum growing stage	MS
3.	Shape of leaf tip	3: Pointed, Ex. (16, 17, 7, 8, 3, 20, 18, 11 = Eight) 4: Slightly pointed, Ex. (14, 9, 10, 5, 6, 19, 21 = Seven) 5: Intermediate (none)6: Slightly round, Ex. (12, 1, 15 = Three) 7: Round, Ex. (2, 4, 13 = Three)	Shape of tip of the largest leaf at the maximum growing stage	VS
4.	Position of leaf	3. Cup shaped, Ex. (8, 11 = Two) 5. Erect-apex down, Ex. (1-7, 9, 10, 12-21 = Nineteen)	At maximum growing stage	VG
5.	Leaf blade margin pattern	3. Sinuate, Ex. (8 = One) 2. undulate, Ex. (1-7, 9-21=Twenty)	At maximum growing stage	VG
6.	Leaf vein pattern	1. V type, Ex.(3, 4, 9, 10, 11, 12, 14, 15, 16, 18,19 = Eleven) 3. Y type, Ex. (1, 2,5,6,7,8,13,17,20,21=Ten)	At maximum growing stage	VG
7.	Petiole bent at lamina junction	1: Almost none, Ex.-(none) 2: Very low, Ex. (1-3, 5, 7 = Five) 3: Low, Ex. (4, 6 = Two) 4: Slightly low, Ex. (9, 15, 18-20 = Five) 5: Intermediate, Ex. (12, 14, 16, 17, 21 = Five) 6: Slightly high, Ex. (10) 7: High, Ex. (8, 11, 13) 8: Very high, Ex. (none) 9: Extremely high, Ex. (none)	At maximum growing stage	VS
8.	Petiole junction colour	1. Yellow, Ex. (2, 3, 5-10, 12, 13, 14, 17-21 = Sixteen) 2. Purple, Ex. (1, 4, 11, 15, 16 = Five)	At maximum growing stage	VG
9.	Petiole color	1: Green, Ex. (1-9, 11-14, 16-21 = Nineteen) 2: Dark umber, Ex. of varieties (none) 3: Reddish purple, Ex. of varieties (10, 15 = Two) 9: Other (none)	Petiole color at the maximum growing stage	VS
10.	Shape of central corm	1: Flaty round, Ex. of varieties (none) 2: Round, Ex. (3, 6, 7, 9, 10, 15-18, 20,21 = Eleven) 3: Spindle, Ex. (1, 2, 4, 5, 8, 11-14, 19 = Ten) 4: Cylindrical, Ex. (exotic taros viz.BL/SM/152,120) 5: Massive, (none) 9: Other (none)	Shape of central corm (tuber) at harvest stage (150-200 days after planting)	VS
11.	Shape of secondary corms	1: Spherical, Ex.(8, 9, 11 = Three) 2: Oblong (Cylindrical), Ex. (1-7, 10, 12-21 = Eighteen) 3: Short shrimp, (none) 4: Shrimp, (none) 9: Other (none)	Shape of side corms attached (growing) on the central corm at harvest stage)	VS
12.	Number of secondary corms	3: Few, (none) Ex. (exotic dasheen types) 5: Intermediate, Ex. (1, 2, 4-21 = Twenty) 7: Many, Ex. (3 = One)	Number of side corms attached (growing) on the central corm at harvest stage. Few 7 >, intermediate: 7-14, Many: 15 <	MS

Table 4
Primary essential characters of elephant foot yam

Sl. No.	*Characters*	*Characters expression with rank or measurement unit*	*Growth stage*	*Methods of assessment*
1.	Plant type	3. Upright Example of varieties (3, 5, 8, 10, 13, 14 = Six) 5. Semi upright Example of varieties (1, 2, 7, 9, 11, 15, 16, 17, 18 = Nine) 7. Horizontal Example of varieties (4, 6, 12 = Three)	Plant type of the 2nd year plants at the maximum growth stage (120-160 days after planting)	VG
2.	Leaf blade petiole ratio	Low (0.6-0.7) Example of varieties (8 and 17 = Two) Medium (0.8-0.9) Example of varieties (3, 6, 9, 10, 11, 12, 13, 15, 16 = Nine) High (0.96 and more) Example of varieties (1, 2, 4, 5, 7, 14, 18 = Seven)	At the maximum growth stage	MG
3.	White spots/speckles on petio	0. Absent (None) 3. Very few Example of varieties (1, 10, 12 = Three) 4. Few Example of varieties (3, 4, 6, 17 = Four) 5. Intermediate Example varieties (2, 5, 8, 9, 11, 14, 16, 18 = Eight) 6. Many Example varieties (7, 13, 15 = Three) 7. Very many (None)	At the maximum growth stage	VG
4.	Distribution of petiole speckles	0. Absent (None) 5. Spotty Example of varieties (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 = Eighteen) 6. Contiguous (None)	Presence of white speckles on petiole at the maximum growth stage	VG
5.	Leafing date	1. Within 30 days Example of varieties (1, 2, 3, 4, 9, 15 = Six) 3. More few 30 days Example of varieties (5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18 = Twelve)	Date when approximately 50% of plants in plot have leaved	VG
6.	Maturing date	1. Early (150-160 days) Example of varieties (3, 4, 13, 18 = Four) 2. Medium (170-180 days) Example of varieties (1, 2, 6, 7, 8, 10, 11, 12, 14, 15, 17 = Eleven) 3. Late (More than 180 days) Example of varieties (5, 9, 16 = Three)	Lodging date in approximately 80% of plants having yellow leaves and wilted petioles	VG
7.	Corm shape	1. Globular (cm dia) Small (12-14 cm) Example of varieties (1, 3, 5, 7, 9.10, 11, 12, 13 = Nine) 2. Large (15-20 cm) Example of varieties (2, 4, 6, 8, 14, 15, 16, 17, 18 = Nine) 3. Spatualate (None)	Distribution of white speckles at the maximum growth stage	MS
8.	Cormlet shape	1. Globular Example of varieties (1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18 = Seventeen) 2. Clubbed Example of varieties (9 = One)	Shape at harvest time	MS
9.	Abscission layer in cormlet	0. Absent Example of varieties (9 = One) 9. Present Example of varieties (1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18 = Seventeen)	Presence of abscission layer at harvest time	VG
10.	Corm flesh color	1. Light pinkExample of varieties (4) 2. Light yellow Example of varieties (Rest all)	After harvest	VS

Table 5
Group and individual distinctness in taro

Sl. No.	*Character*		*Individual distinctness*	*Group distinctness*
1.	Position of leaf			
	(a) Cup-shaped	(3)	—	Jhankri, BCC-35
	(b) Erect-apex down	(5)	–	Rest all
2.	Leaf blade margin pattern			
	(a) Sinuate	(3)	Jhankri	–
	(b) Undulate	(2)	–	Rest all
3.	Petiole junction colour			
	(a) Purple	(4)	–	BCC-22, IGCOL-8, BCC-35, BCC-38, Sree Kiran
	(b) Yellow	(1)	–	Rest all
4.	Sap colour of leaf blade tip			
	(a) Yellow	(2)	BCC-22	
	(b) Pink	(3)	BCC-47	
	(c) Whitish (transparent)	(1)	–	BCC-39, KCS-3, IGCOL-8, Satamukhi, KCS-2, Sree Rashmi, Jhankri, BCC-35, Sonajuli, AAVCOL-46, KSS-2
	(d) Brownish	(6)	–	Muktakeshi , Telia, Panisaru-1, Panisaru-2, BCC-38, Sree Pallavi, Sree Kiran, BCC-1
5.	Petiole basal ring colour			
	(a) Purple	(5)	–	Telia, BCC-38
	(b) Green or green yellow	(2)	–	Rest all
6.	Leaf sheath colour			
	(a) Light green	(3)	–	BCC-22, Satamukhi, Jhankri, BCC-35, Sree Pallavi
	(b) Red purple	(4)	–	
	(c) Brownish	(5)	–	
7.	Leaf waxiness			
	(a) Low	(3)	–	BCC-22, BCC-39, IGCOL-8, Satamukhi, KCS-2, Sonajuli,
	(b) Medium	(5)	–	Sree Kiran, BCC-47, KSS-2, Telia, Panisaru-1, Panisaru-2,
	(c) High	(7)	–	MuktakeshiKCS-3, Sree Rashmi, Sree Pallavi, BCC-1, AAVCOL-46, BCC-35Jhankri, BCC-38
8	Leaf blade colour			
	(a) Dark green	(4)	–	Telia, BCC-38
	(b) Yellow/yellow green	(2)	-	Muktakeshi, Sonajuli
	(c) Green	(3)	–	Rest all
9.	Leaf blade margin colour			
	(a) Yellow	(2)	–	IGCOL-8, Jhankri, Muktakeshi, Panisaru-1, Sonajuli, Sree Kiran, Panisaru-2
	(b) Green	(4)	–	BCC-22,Satamukhi, KCS-2, BCC-35, BCC-1, BCC-47
	(c) Purple	(7)	–	BCC-39, KCS-3, Sree Rashmi, Telia, BCC-38, Sree Pallavi, KSS-2
10.	Leaf main vein colour			
	(a) Purple	(8)	–	BCC-39, KCS-2, Muktakeshi, Telia
	(b) Green	(4)	–	Rest all
11.	Vein pattern			
	(a) V type	(1)	–	KCS-3, IGCOL-8, Muktakeshi, Telia, BCC-35, Panisaru-1, Panisaru-2, BCC-38, Sree Kiran, BCC-1, AAVCOL-46
	(b) Y type	(3)	–	Rest all
12.	Petiole colour			
	(a) Purple	(8)	–	Telia, BCC-38
	(b) Yellow	(2)	–	AAVCOL-46, BCC-47
	(c) Green	(5)	–	Rest all

Table 6
Individual distinct characters of different eddo type taro varieties

Varieties/ breeding lines	*Individual distinct characters*
BCC-38	Leaf vein colour is green but petiole colour is violet
Muktakeshi	No. of side tubers are maximum
BCC-39	Maximum of corm size and cross section area of lower part of the plant
Jhankri	Sinuate type of leaf-blade margin pattern
BCC-22	High number of suckers and stolons
BCC-39	Green petiole with brownish leaf sheath colour
BCC-47	Pink coloured sap of leaf-blade tip

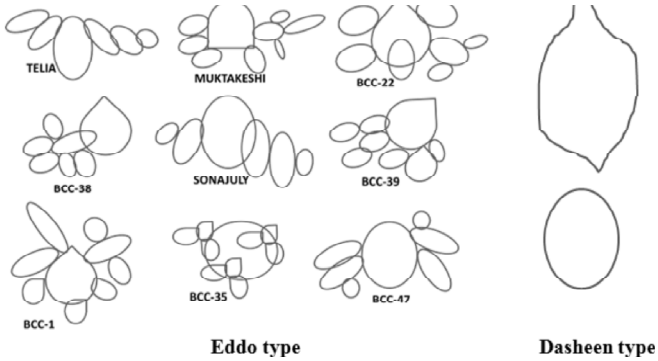


Figure 4: Morphometrics analysis
Morphometrics is a quantitative analysis of *form*, a concept for size and shape.

their DUS test. All observations on the shoot were made on at least 5 plants per replication / replications. Stem and leaf characters were recorded as the average expression of the character observed in a group of 5 plants during maximum growing phase (100-120 days) in case of taro and 120 to 160 days in elephant foot yam. All observations on the tubers were made at the time of harvest based on varietal maturity timings.

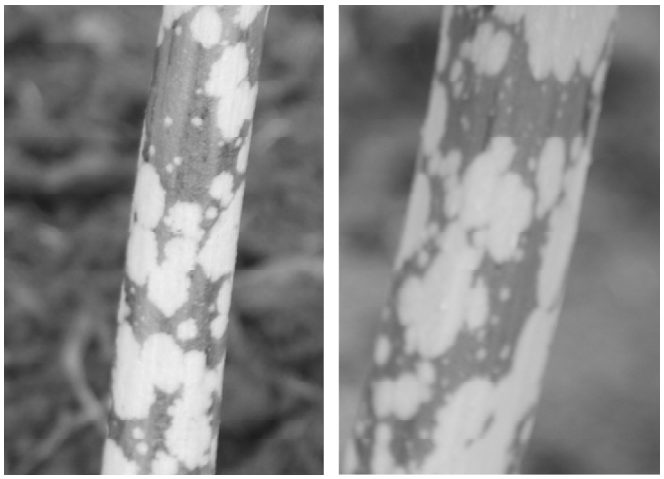


Figure 5(a) and (b): NDA-5 , Stem with purplish spots (a) and IGAM 2, Dark green stem with white spots

Table 7
Group distinct characters of exotic dasheen taro

SL. No.	*Groups according to colour of petiole*	*Exotic Accessions*	*Plant type*	*Edible parts*
1.	Purple petiole	BL/HW/08	Tall Dasheen	All parts
2.		BL/IND/14	Tall Dasheen	All parts
3.		BL/SM/80	Tall Dasheen	All parts
4.	Dark/Light green petiole with purple sheath	BL/SM/116	Tall Dasheen	Tuber
5.	Dark/Light green petiole with purple tip	BL/IND/32 Tolerant to TLB	Medium intermediate	Non edible
6.		CE/IND/06	Medium intermediate	All parts
7.		CE/IND/07	Tall intermediate	leaf
8.		CE/IND/12	Tall intermediate	Non edible
9.		BL/PNG/11 Resistant to TLB	Tall Dasheen	All parts
10.		BL/SM/111	Tall Dasheen	Tuber
		BL/SM/151	Tall Dasheen Stoloniferous	Tuber
		BL/SM/152	Tall Dasheen	All parts
		BL/SM/120	Medium Dasheen	All parts
14.	Dark/Light Purplish green petiole	CE/MAL/06	Medium intermediate	All parts
15.		CE/IND/10	Tall Dasheen	All parts
16.		BL/PNG/12	Tall Dasheen	All parts
17.		BL/SM/158	Tall Dasheen	All parts
18.		BL/SM/143	Tall Dasheen	Tuber
19.	Cream colour petiole	CE/MAL/12	Tall Dasheen	All parts
20.	Dark/ light green petiole	CE/MAL/14	Tall Dasheen	All parts
21.		BL/PNG/10 Tolerant to TLB	Tall Dasheen	Non edible
22		BL/SM/134	Tall Dasheen	All parts

(Source: INEA, India)

GROUPING OF VARIETIES

Varieties can be grouped based on following key characters in taro and elephant foot yam

The following characteristics were used for grouping of taro varieties:

(i) Plant type (height, growth habit)

(ii) Leaf (shape of leaf tips, position, leaf blade margin)

(iii) Petiole (colour, bending at lamina junction, petiole junction colour)

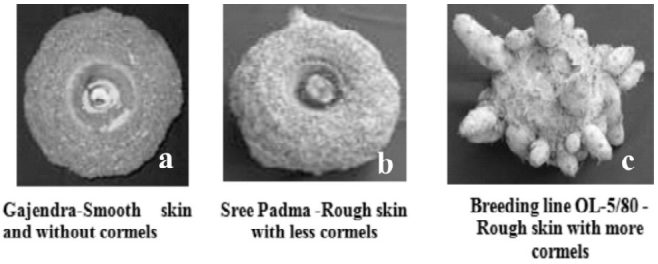
Table 8
Individual and group distinct characters of some elephant foot yam varieties

Sl. No.	*Character*	*Individual distinctness*	*Group distinctness*
1.	*Stem/Pseudostem colour*		
	(a) Dark green with white patches	IGAM-2	–
	(b) Dark green with purplish spots	NDA-5	–
	(c) Green with white patches	–	Rest all
2.	*Rachis colour*		
	(a) Green with white patches and purple spots	NDA-5	–
	(b) Green with white patches	–	Rest all
3.	*Rachis junction colour*		
	(a) Green with white patches and purple spots	NDA-5	–
	(b) Green with white patches	–	Rest all
4.	*Main stem texture*		
	(a) Smooth	–	Gajendra, Kovur, Sree Athira, Bidhan Kusum
	(b) Rough	–	Rest all
5.	*Leaflet colour*		
	(a) Yellow/yellow green	–	NDA-5, Gajendra
	(b) Green with yellow spots	–	Rest all
6	*Leaflet vein colour*		
	(a) Green	–	Gajendra
	(b) White	–	Rest all
7	*Leaf waxiness*		
	(a) Low	–	Sree Athira, AC-28, Appakudal, IGAM-2, Bidhan Kusum, BCA-5, TRC-Badma, AC-14, IGAM-1, Sree Padma, BCA-4, BCA-2, NDA-9
	(b) Medium		NDA-4, NDA-5, BCA-3, Gajendra, Kovur

Figure 6(a) (b): V type rachis (a) in Kovur and Y type rachis (b) in NDA-5

Table 9
Individual distinct characters of some elephant foot yam varieties

Varieties/ breeding lines	*Individual distinct characters*
GAJENDRA	Green stem with white patches, smooth stem texture, yellowish green leaflet color
NDA-4	Regular white patches on stem with small white spot on green rachis junction
NDA-5	White patches on stem with rare purple spots
BCA-4	Small, irregular white spot on green stem but rough stem texture



Figures 7(a-c): Morphological distinctness of corms of different varieties Gajendra (a), Sree Padma (b), breeding line (c)

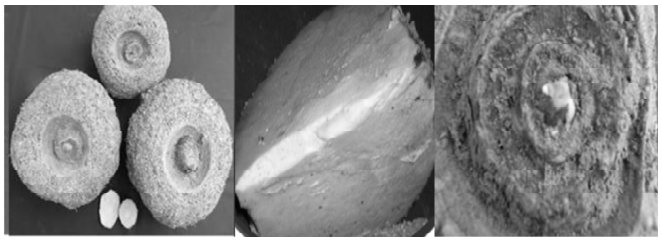


Fig.8 (a-c). Individual corm distinctness of elephant foot yam cv.Gajendra corm morphology(a), light pink flesh colour(b), abscission layers 2-3, pink bud colour (c)

(iv) Shape of central corm
(v) Shape of secondary corm
(vi) Number of secondary corms/cormels
(vii) Corm skin surface
(viii) Corm flesh colour

In case of elephant foot yam varieties the following characteristics were recorded for grouping:
(i) Plant type
(ii) Stem (texture, speckles/spots, rachis pattern)
(iii) Leaflet (size, number, color)
(iv) Corm shape
(v) Cormlet shape
(vi) Leafing date
(vii) Maturity date
(viii) Epidermal color of corm
(ix) Flesh color of corm

Characteristics with Rank or Measurement

To assess Distinctiveness, Uniformity and Stability, the characteristics (2nd col.) and its stages of growth were given in the table of characters in results and discussions section. However, in case of quantitative characteristics with 5 or more stages, an abbreviated scale was used to minimize the size of the table of characteristics. Serial code were used for varieties (Tables 1 and 2) to squeeze the table of characters, its explanations etc.

Types of assessment of characteristics indicated in column 5th of table of characteristics are as follows:

MG: Measurement by a single observation of a group of plants or parts of plants

MS: Measurement of a number of individual plants or parts of plants

VG: Visual assessment by a single observation of a group of plants or parts of plants

VS: Visual assessment by observations of individual plants or parts of plants.

RESULT AND DISCUSSION

To isolate distinct, uniform and stable character, its stage of expression for each characteristic is needed to harmonize the descriptions. Expression given with rank in 3rd col. of the tables indicates the stage of growth of each character. In the case of qualitative and pseudo-qualitative characteristics, all relevant states of expressions are presented (Tables 3 and 4).

The primary essential characters of taro and elephant foot yam in the present study indicates grouping of varieties based on morphological characters (Tables 3 and 4). Group distinct and individual distinct characters are explained further in tables 5 to 8 for both the crops.

To identify DUS characters and formulate criteria, expression of characters is the most important aspect. Characteristics observed during every growing season on all varieties were validated and then recorded in the description of the variety. In case of primary essential characters, specific characteristics validated are defined in each column with rank or measurement. The optimum stage of plant growth for assessment of each characteristic has also been indicated in the 4th column of the tables of primary essential characteristics (Table 3 and 4). Such explanations are essential to develop DUS criteria.

Individual and group distinctness of dasheen taros (*Colocasia esculenta* var. *esculenta),* qualitative plant shoot characteristics mostly like eddoe types (*Colocasia esculenta* var. *antiquorum)* except the size of plant, leaf, petioles etc. The key characteristics of dasheen taro accessions are bigger than eddoe types. Plants are tall, erect and also spreading types. The key morphological feature differences between eddoe and the dasheen are tuber/corm characteristics. Mother corms are 2-3 times bigger than eddoe type corms, solitary or with few cormlets in contrast to clustering of corms in eddoe. Shape varies from round, conical, cylindrical to elliptical types as mostly found in exotic taros introduced in India under "International Network for Edible Aroids (*INEA*)" project coordinated through SPC, Fiji (www.ediblearoids.org).

The group distinctness through petiole colour of dasheen exotic taro (Table 7) is another unique feature not only to group the varieties but also to characterize the taro genetic resources irrespective of their variable ecological niche. Such unique features are well explained by Unnikrishnan *et al* (2015) for different exotic taros under INEA, India project. The individual and group characteristics studied here are observed to be ideal to identify the unique types and their core group sources as have been explained earlier by Poddar *et al.* (2015); Poddar and Mukherjee (2015). In fact, morphological polymorphism explained here are in conformity with the studies made by Poddar *et al* (2015).Such phenotypic variability is essential to identify DUS characters.

A cross section of all characters and their dendrogram analysis can also help to eliminate the duplicates in simplest way.

CONCLUSION

Of the different characteristics discussed here, the tuber characteristics of eddoe, dasheen and petiole colors observed to be unique distinct group characteristics in taro. Leaf characteristics are also unique to represent the groups as well as individual distinctness in taro. Similarly in case of elephant foot yam the stem texture, speckles, rachis as well as corm characteristics are quite distinct to isolate a particular variety. Dendrogram analysis of morphological DUS characters (morphological markers) can help to eliminate duplicates as well as to identify the core groups. The said morphomarkers specifically the DUS characters are 'user' rather 'farmers friendly'. Such tools based on morphological parameters are quite convincing to common public like growers,

farmers including a major section of tribal farmers. The endeavor of PPV& FRA Government of India to create awareness and enact rights of growers, farmers is a unique and unparallel step. However to prevent biopiracy and to maintain authenticity, DNA marker tools need to be supplemented to strengthen the present DUS criteria of all crops including the tribal friendly tuber crops.

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