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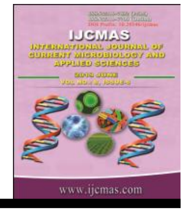

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Morphological Characterization of Some Upland Taro (*Colocasia esculenta* L. Schott) Cultivars of North-East India

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A B S T R A C T

Morphological markers were used to characterize 22 taro cultivars collected from four North Eastern states of India. The experiment was laid out in Randomized Block Design with three replications during 2016 and 2017. Results of principal component analysis interpreted that morphological characters like plant height, plant span, leaf area index, number of suckers, number of inflorescence/leaf axis, corm length, corm diameter, corm weight, number of cormels, cormel diameter and yield/plant contributed maximum to the variation among the cultivars and can be used as minimum descriptors for characterizing taro cultivars. The dendrogram summarizing the existence of diversity and similarities among the cultivars revealed that the cultivars were clustered mainly by plant height, petiole colour and corm weight. The cultivars were grouped into two main clusters i.e. 'CL-I' and 'CL-II'. The CL-I consisted of cultivars collected from Assam, Nagaland and Kerela viz. Takali, Muktakesh, Sree Kiran, AAU-Col-32, JCC-31, Damor Dema, Boga Ahina, Kaka, Panch Mukhi, Red Garo, Naga, AAU-Col-39, Ghoti and AAU-Col-5. The CL-II consisted of cultivars collected from Meghalaya, Arunachal and Assam like Garo, Makhuti, AAU-Col-46, Arunachal-2, Koni, Ahina, Karbi Anglong and Bor-Kochu. It was found that geographical origin of the cultivars did not bear any relationship with the cultivar classification. In addition to supporting breeding and germplasm conservation, the data can serve as a baseline for correlation with other types of markers.

Keywords

Taro, Morphological, Markers, Cultivar and diversity

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Introduction

Taro (*Colocasia esculenta* L. Schott.) is an important tuber crop belonging to the monocotyledonous family, Araceae. Worldwide production is on the increase, with a production of 10.13 million ton/annum and is now the fifth most-consumed tuber vegetable worldwide (FAOSTAT, 2016).

The knowledge of variability of *Colocasia esculenta* is limited. Morphological study on genotypes of taro becomes a necessity because morphological characters are the strongest tools used in taxonomic classification of plants, and this makes its application very crucial (Ezeabara *et al.*, 2015). Of all the available markers, morphological markers are relatively simple and cheap to exploit. These markers can also increase the resolving power of genetic diversity and the baseline data generated can be correlated to other types of molecular markers.

Morphological analysis can also help to identify clones and reduce duplication in cultivar collections maintained for conservation and breeding purposes (Bammite *et al.,* 2018). Germplasm characterization and evolutionary process in viable populations are important links between the conservation and utilization of plant genetic resources (Mandal *et al.*, 2013).

North East India is one of the centres of origin of colocasia and both morphological and physiological variations are found in colocasia of North East India. Though a good amount of work has been carried out in the Pacific and South-east Asian gene pools, however very less systemic studies have been carried out in colocasia in North East India with respect to morpho-physiological characters. Therefore, a thorough study was conducted to morphologically characterize some upland taro cultivars of North-East India.

Materials and Methods

Site of cultivar collection

The taro cultivars were collected from four states of North-East India (Assam, Meghalaya, Arunachal and Nagaland) with focus on potential production areas (Table 1). Two of the cultivars were also obtained from Central Tuber Crops Research Institute at Thiruvananthapuram, Kerela- India.

Location

The experimental site was located at an altitude of 86.8 m above the mean sea-level, with the geographical location of 26°45′N latitude, 94°12′E longitude.

Details of the experiment

The twenty-two taro cultivars collected were used as treatments which were replicated thrice for two years (i.e. 2016 and 2017) to conduct the experiment. Spacing of 0.60 m x 0.45 m was maintained. The proper recommended cultivation practices were followed to raise a good crop.

Morphological characterization

The taro cultivars were morphologically characterized using the descriptors developed by IPGRI, 1999. The vegetative data were taken 110 DAP and the subterranean parameters were recorded 210 to 270 DAP. The parameters recorded are as follows:

Plant habit: Plant span, plant height and number of sucker

Leaf characters: Leaf area index, leaf base shape, predominant position (shape) of leaf lamina surface, leaf blade margin, leaf blade colour, leaf blade margin colour, vein pattern, petiole colour, petiole junction pattern and cross-section of lower part of petiole,

Floral character: Flower formation, number of inflorescence per leaf axis, number of floral clusters per plant and spathe shape at male anthesis

Corm and cormel characters: Number of corms and cormels, corm and cormel length, corm branching, corm and cormel shape, diameter of corm and cormel, corm and cormel weight and yield per plant

Data analysis

The qualitative data for two years were subjected to pooled analysis. Subsequently, the pooled mean values of both the experimental years were subjected to further statistical analysis. Multivariate analysis was carried out using Principal component analysis (PCA). Characteristics that contributed most to variability were determined on the basis of those traits that have the greatest value and positive feature vector. The mean values from the highest and lowest eigenvectors were used as the threshold for the selection of the most contributing variables (Fundora *et al.,* 1992). Cluster analysis was done for fifteen quantitative characters to generate a dendrogram with the help of Ward's linkage method.

Results and Discussion

Variation in plant habit

The twenty two taro cultivars under the study showed high levels of significant variability for plant growth habit. The cultivar Bor was recorded with the highest plant span of 70.80 cm, 68.06 cm and 69.43 cm for 1st year, 2nd year and pooled data respectively (Table 2). On the contrary, during first and second experimental years as well as pooled data, the minimum plant height (42.66 cm, 41.13 cm and 41.90 cm) was recorded for cultivar Panch Mukhi. A documentation of the data indicated that the highest plant height was also recorded in cultivar Bor and cultivar Naga was recorded to be the lowest (Table 3). This suggested that a large number of cultivars under investigation will need medium spacing to perform well. These characteristics are important as they also determine the maturity period of cocoyam plants (Mwenye, 2009). Prana (2000) found a strong correlation in plant height and corm maturity. Dwarf types matured early (<6 months) and medium plants were ready between 6-9 months whilst giant/tall types took 9-12 months to mature. These results are in corroboration with studies done by Mbouobda *et al.,* 2007; Mwenye, 2009; Boampong *et al.,* 2018 and Lebot *et al.,* 2010.

In terms of sucker formation, the highest number of suckers was noted from cultivar Ghoti and the cultivar with the least number of suckers was found in Kaka (Table 3). This corroborated with researches conducted by Sivan (1977 and 1980) and Akwee (2015). Also suckers are important in taro production as sources of planting materials.

Variation in leaf characters

There was significant variation in leaf area index among the taro cultivars. The interaction effect between the cultivars and environment was significant (Table 3) for leaf area index because the size of taro leaf is strongly influenced by the environment as taro plants have a high requirement for moisture for their production because of their large transpiring surfaces (Lebot *et al.,* 2010).

All the twenty two (100%) taro cultivars had peltate leaf base shape (Table 2). The predominant position of leaf lamina surface among the cultivars was erect-apex down except for 'Ahina' which showed cup-shaped leaf position (Table 2 and 4). Majority of the cultivars i.e. 86.36 percent exhibited undulate leaf blade margin and 13.64 percent expressed sinuate margin (Table 2 and 4). The variation in leaf blade colour and leaf blade margin colour among the cultivars (Table 2 and 4) may be due to the increased levels of chlorophyll a and b (Taiz and Zeiger, 1991) or may be because of genetic reasons as the colour of leaf is genetically controlled and represents one of the most useful traits for describing genotypes (Lebot *et al.,* 2010). The formation of various vein patterns (Table 3) may be due to the presence of different pigments in each taro cultivar. These results are in line with the works done by Mbouobda *et al.,* 2007; Trimanto *et al.,* 2010; Lebot *et al.,* 2010 and Paul *et al.,* 2011.

Except for the cultivar JCC-31 and Panch Mukhi which expressed medium plant height with high leaf area index, the majority of the tall cultivars (viz. Ghoti, Bor and Ahina) with dark green leaf blade colour exhibited high leaf area index (Table 2 and 4). This suggests that the height of the plant (petiole length) is directly proportional to the size of the leaf because the leaf photosynthetic capacity is associated with the plant height (Bishop, 1991). The resultant effect of leaves having higher leaf area index may be due to early rate of establishment, higher plant height, better canopy development, efficient capture of solar radiation and hence more vigour. This is further supported by the significant positive correlation that was observed amongst plant height, leaf area and yield. The findings of this study are consistent with the reports of Tumuhimbise *et al.*, (2009), Tsedalu *et al.*, (2014) and Lewu *et al.,* (2017). In case of JCC-31 and Panch Mukhi, it must be because of the differences in the genetic make-up among the cultivars.

Except for cultivar Bor, it was observed that the three cultivars viz. Garo, Arunachal-2 and Ahina which exhibited purple colour in the middle third part of the petiole also extended to the top third and basal third part denoting that the presence of pigment that was responsible for exhibiting purple colour may be continuous throughout the entire petiole (Table 5). In correlation of the petiole characters with the leaf characters and plant habit, it was deduced that the three cultivars that expressed purple colour throughout the entire petiole also exhibited dark green coloured leaf blade with undulate leaf margin and were tall except for cultivar Garo which had medium plant height. Therefore these cultivars were more robust than the remaining cultivars. This might be due to the variation in genetic makeup among the different cultivars or due to the presence of the pigment anthocyanin which is responsible for the purple colour.

Variation of petiole characters

Fifty percent of the cultivars possessed yellow coloured petiole of top third (Table 2). However, 40.91 percent showed purple colour on the top third of the petiole (Table 2). Only 9.1 percent of the cultivars i.e. Bor and AAU-Col-32 showed green petiole colour of top third (Table 2 and 5). The taro cultivars exhibited a wide array of colour on the middle portion of the petiole (Table 5). About 59.1 percent of the cultivars which is the majority expressed green colour, 13.64 percent exhibited yellow colour and 18.18 percent of the cultivars displayed purple colour on the middle portion of the petiole (Table 2 and 5). However cultivars like Ghoti and Boga Ahina manifested light green colour on the middle portion of the petiole. Moderate variation was observed in the colour of basal third of the petiole. Only one cultivar i.e. Kaka exhibited light green colour while the majority (68.18%) displayed green colour except for few cultivars (27.27%) possessed purple coloured petioles on basal third portion (Table 2 and 5).

The leaves having ‘small’ petiole junction pattern were majority i.e. 45.46 percent, whereas 27.27 percent of the leaves showed ‘medium’ junction pattern (Table 5). About 27.27 percent of the cultivars had ‘large’ petiole junction pattern (Table 2 and 5). The cross-section of lower part of the petioles of all the taro cultivars collected was ‘open’ except for the cultivar ‘Arunachal-2’ whose cross-section was closed (Table 5).

The results clearly indicate that all the cultivars that possessed large petiole junction pattern had green colour in the middle third and basal third portion of the petioles. It was noted that majority of the cultivars that possessed medium petiole junction pattern also had green coloured petiole in the middle third and basal third portion except for cultivar Ahina.

This finding is consistent with other reports based on morphological analysis (Beyene, 2013; Vinutha *et al.,* 2015; Manzano *et al.,* 2018 and Bammite *et al.,* 2018).

Variation in floral characters

Majority of the taro cultivars (72.73%) were categorized under 'Flowering' and the remaining cultivars i.e. 27.27% were grouped under 'Rarely flowering' (Table 2). Taro is a very sensitive species characterized by rare and erratic flowering (Taro Network for Southeast Asia and Oceania, 2002) and so maybe this particular character might be genetically controlled as six of the cultivars rarely flowered in spite of the suitable weather conditions in the first experimental year.

The cultivar with the highest number of inflorescence per leaf axis was recorded in the cultivar Arunachal-2 with 2.66, 3.00 and 2.83 (for 1st year, 2nd year and pooled data) and the lowest was found in cultivar Kaka and AAU-Col-32 i.e. 0.66, 1.00 and 0.83 (for 1st year, 2nd year and pooled data) (Table 6).

The pooled analysis indicated that the interaction effect between the various cultivars and environment showed significant effect on the number of inflorescence per leaf axis. This might be because the number of inflorescence per leaf axis was lower in the first year (2016) than in the second year (2017).

In all the three cases (i.e. 1st year, 2nd year and pooled data), the highest number of floral clusters per plant i.e. 1.33, 1.66 and 1.50 was recorded in cultivars Red Garo and Arunachal 2 (Table 6). The lowest number of floral clusters was recorded in cultivar Karbi Anglong viz. 0.66 in both the year and pooled data. The comparison of the data also revealed that there was variation in the number of floral clusters between the two experimental years as the cultivars produced lesser floral clusters in 2016 than in 2017.

This may be because of the difference in the weather conditions between the two experimental year as it was recorded that during the first experimental year (2016), from the month of May to August (flower initiation stage) the rainfall was continuous with low bright sunshine hours which hindered the production of flowers. This result is in confirmation with the study conducted by Ivancic and Lebot (2000) where they concluded that for normal flowering and seed set, taro requires an optimal environment and in situations of heavy rains or continuous rainy weather, or large deviations of ambient air temperatures, plants do not flower or produce sterile flowers. Majority of the cultivars (77.27%) displayed keeled spathe shape whereas 22.73 percent of the cultivars had flat shaped spathe (Table 2 and 4).

Apart from the odour of the flower which is obviously the most important pollinator attractant, the shape of the spathe also plays an important part in the pollination of the flower (Ivancic *et al.,* 2004). The cultivars with flat spathe are beneficial for insect and wind pollination as it has a fully exposed male portion. Whereas those cultivars which possessed keeled shaped spathe are important for breeders for hybridization programmed because their spadix were partially covered by the spathe and so insect and wind pollination can be avoided to some extent.

Table.1 Place of taro cultivar collection

Sl. No.	Cultivars	State	District
1.	Kaka	Assam	Jorhat
2.	Garo	Meghalaya	Resubelpara- North Garo Hills
3.	Makhuti	Assam	Kokrajhar
4.	Ghoti	Assam	Jorhat
5.	Boga Ahina	Assam	Jorhat
6.	Koni	Assam	Jorhat
7.	Red Garo	Meghalaya	Garobadha- West Garo Hills
8.	Karbi Anglong	Assam	Karbi Anglong
9.	Bor Kochu	Assam	Dibrughar
10.	AAU-Col-46	Assam	Karbi Anglong
11.	Arunachal 2	Arunachal	Pasighat
12.	Panch Mukhi	Assam	Jorhat
13.	Naga	Nagaland	Mokokchung
14.	JCC-31	Assam	Karbi Anglong
15.	Damor Dema	Assam	Goalpara
16.	AAU-Col-5	Assam	Karbi Anglong
17.	Ahina	Assam	Jorhat
18.	AAU-Col-32	Assam	Karbi Anglong
19.	Takali	Assam	Jorhat
20.	AAU-Col-39	Assam	Karbi Anglong
21.	Muktakesh	Kerela	CTCRI- Thiruvananthapuram
22.	Sree Kiran	Kerela	CTCRI- Thiruvananthapuram

Table.2 Percentage distribution of vegetative traits in taro cultivars

Sl. No.	Characters	Traits	Percentage of cultivar (%)
1.	Plant span	Narrow (<50cm)	9.09
		Medium (50-100cm)	90.91
2.	Plant height	Medium (50-100cm)	72.73
		Tall (>100cm)	27.27
3.	Number of suckers	1 - 5	4.54
		6 - 10	86.36
		11-20	9.0
4.	Leaf base shape (LBS)	Peltate	10
5	Predominant position of leaf lamina surface (PPLLS)	Erect-apex down	95.6
		Cup shaped	4.4
6	Leaf blade margin (LBM)	Undulate	86.36
		Sinuate	13.64
7	Leaf blade colour (LBC)	Green	45.46
		Dark green	54.55
8	Leaf blade margin colour (LBMC)	Yellow	63.64
		Green	27.27
		Purple	9.1
9.	Vein pattern (VP)	V pattern	22.73
		Y pattern	72.73
		Y pattern and extending to secondary veins	4.55
10.	Petiole colour of top third (PCTT)	Yellow	50
		Green	9.1
		Purple	40.91
11.	Petiole colour of middle third (PCMT)	Yellow	13.64
		Light green	9.1
		Green	59.1
		Purple	18.18
12.	Petiole colour of basal third (PCBT)	Light green	4.55
		Green	68.18
		Purple	27.27
13.	Petiole junction pattern (PJP)	Small	45.46
		Medium	27.27
		Large	27.27
14	Flower formation (FF)	Rarely flowering	27.27
		Flowering	72.73
15	Spathe shape at male anthesis (SSMA)	Keeled	77.27
		Flat	22.73
16	Corm length	Short (1-8 cm)	9.09
		Intermediate (9-12 cm)	45.45
		Long (13-18 cm)	45.45
17	Corm branching (CB)	Unbranched	9.1
		Branched	90.91
18	Corm shape (CS)	Conical	9.1
		Round	54.55
		Cylindrical	18.18
		Elliptical	9.1
		Elongated	9.1
19	Corm weight	Low (0.01-0.5 kg)	49.50
		Intermediate (0.51-2 kg)	49.50
20	Number of cormel	Less than 5	4.54
		5 to 10	45.45
		More than 10	49.99
21	Shape of cormel (SCL)	Conical	9.1
		Round	36.36
		Cylindrical	18.18
		Elliptical	22.73
		Elongated	9.1

Table.3 Mean plant span, plant height, number of suckers and leaf area index of taro cultivars

Sl. No.	Plant span (cm)			Plant height (cm)			No. of suckers			Leaf area index		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Kaka	52.88	53.33	53.08	95.90	92.23	94	5.00	4.33	4.67	1.65	1.63	1.64
Garo	61.16	59.30	60.23	80.83	73.83	77.33	9.33	8.33	8.83	1.77	1.75	1.76
Makhuti	59.90	58.40	59.15	91.20	89.86	90.53	5.33	5.1	5.17	2.14	2.12	2.13
Ghoti	53.23	55.13	54.18	145.80	136.43	141.12	13.0	12.00	12.50	2.60	2.50	2.40
Boga Ahina	54.20	56.73	55.46	83.90	80.66	82.28	8.66	7.66	8.16	1.27	1.25	1.26
Koni	57.40	54.73	56.06	89.20	86.20	87.65	10.00	9.00	9.50	1.9	1.7	1.80
Red Garo	52.63	56.40	54.51	82.23	80.00	81.11	7.33	7.00	7.16	1.56	1.54	1.55
Karbi Anglong	54.73	55.56	55.15	145.03	133.96	139.50	10.00	9.00	9.50	1.43	1.41	1.42
Bor	70.80	68.06	69.43	155.3	151.00	153.15	9.00	10.00	9.50	3.48	3.46	3.47
AAU-Col-46	53.63	55.06	54.34	110.46	111.13	110.80	9.00	8.00	8.50	2.88	2.86	2.87
Arunachal 2	56.83	53.40	55.11	123.3	107.53	115.43	8.00	7.00	7.50	1.75	1.73	1.74
Panch Mukhi	42.66	41.13	41.90	57.93	57.06	57.50	7.33	7.00	7.16	3.20	3.18	3.19
Naga	52.16	51.46	51.81	58.00	56.86	57.43	6.66	6.66	6.66	1.48	1.46	1.47
JCC-31	48.06	44.40	46.23	72.17	69.96	71.06	9.66	9.66	9.66	3.50	3.48	3.49
Damor Dema	57.83	53.40	55.61	60.43	59.63	60.03	5.33	6.00	5.66	1.73	1.71	1.72
AAU-Col-5	56.56	55.93	56.25	84.96	80.13	82.55	9.66	8.66	9.17	1.23	1.21	1.22
Ahina	53.30	51.96	52.63	143.66	135.60	139.63	12.00	11.00	11.50	3.20	3.00	3.10
AAU-Col-32	56.86	53.33	55.10	88.33	77.56	82.95	10.00	9.33	9.67	1.76	1.74	1.75
Takali	51.76	50.46	51.11	93.50	87.96	90.73	8.66	7.66	8.17	1.77	1.75	1.76
AAU- Col-39	53.50	51.76	52.63	98.93	95.80	97.36	6.33	5.33	5.83	1.76	1.75	1.75
Muktakesh	52.76	53.93	53.35	95.46	92.90	94.18	6.00	5.33	5.67	1.57	1.55	1.56
Sree Kiran	56.23	51.06	53.65	80.26	93.166	86.71	7.00	6.00	6.50	2.75	2.77	2.76
C.D (0.05%)												
Cultivars	7.97	7.40	5.36	9.59	14.28	8.48	1.94	1.57	1.23	0.20	0.15	0.16
Environment	-	-	NS	-	-	NS	-	-	N.S	-	-	NS
Interaction	-	-	7.59	-	-	11.99	-	-	1.74	-	-	0.19

Table.4 Variation in leaf base shape, predominant position of leaf lamina surface, leaf blade margin, leaf blade colour, leaf blade margin colour, vein pattern, flower formation and spathe shape at male anthesis of different taro cultivars

Sl. No.	Cultivars	Leaf base shape	Predominant position of leaf lamina surface	Leaf blade margin	Leaf blade colour	Leaf blade margin colour	Vein pattern	Flower formation	Spathe shape at male anthesis
1	Kaka	Peltate	Erect-apex down	Undulate	Green	Yellow	V pattern	Flowering	Keeled
2	Garo	Peltate	Erect-apex down	Undulate	Dark Green	Purple	Y pattern	Flowering	Keeled
3	Makhuti	Peltate	Erect-apex down	Undulate	Dark Green	Green	Y pattern	Flowering	Keeled
4	Ghoti	Peltate	Erect-apex down	Sinuate	Green	Green	Y pattern	Flowering	Keeled
5	Boga Ahina	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	Y pattern	Rarely flowering	Keeled
6	Koni	Peltate	Erect-apex down	Undulate	Green	Green	Y pattern	Rarely flowering	Keeled
7	Red Garo	Peltate	Erect-apex down	Sinuate	Green	Yellow	Y pattern	Flowering	Flat
8	Karbi Anglong	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	Y pattern	Rarely flowering	Keeled
9	Bor Kochu	Peltate	Erect-apex down	Undulate	Dark Green	Green	Y pattern	Flowering	Keeled
10	AAU Col-46	Peltate	Erect-apex down	Sinuate	Green	Yellow	V pattern	Flowering	Flat
11	Arunachal 2	Peltate	Erect-apex down	Undulate	Dark Green	Green	Y pattern	Flowering	Keeled
12	Panch Mukhi	Peltate	Erect-apex down	Undulate	Green	Yellow	V pattern	Flowering	Keeled
13	Naga	Peltate	Erect-apex down	Undulate	Green	Yellow	Y pattern and extending to secondary veins	Flowering	Keeled
14	JCC-31	Peltate	Erect-apex down	Undulate	Dark Green	Green	Y pattern	Flowering	Keeled
15	Damor Dema	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	Y pattern	Flowering	Keeled
16	AAU Col-5	Peltate	Erect-apex down	Undulate	Green	Yellow	Y pattern	Flowering	Keeled
17	Ahina	Peltate	Cup-shaped	Undulate	Dark Green	Purple	Y pattern	Flowering	Flat
18	AAU Col-32	Peltate	Erect-apex down	Undulate	Green	Yellow	Y pattern	Rarely flowering	Keeled
19	Takali	Peltate	Erect-apex down	Undulate	Green	Yellow	Y pattern	Rarely flowering	Keeled
20	AAU Col-39	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	Y pattern	Rarely flowering	Keeled
21	Muktakesh	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	V pattern	Flowering	Flat
22	Sree Kiran	Peltate	Erect-apex down	Undulate	Dark Green	Yellow	V pattern	Flowering	Flat

Table.5 Variation in petiole colour of top third, petiole colour of middle third, petiole colour of basal third, petiole junction pattern, cross-section of lower part of petiole, corm branching, corm shape and shape of cormel of different taro cultivars

Sl No.	Cultivars	Petiole colour of top third	Petiole colour of middle third	Petiole colour of basal third	Petiole junction pattern	Cross-section of lower part of petiole	Corm branching	Corm shape	Shape of cormel
1	Kaka	Purple	Yellow	Light green	Small	Open	Branched	Cylindrical	Elliptical
2	Garo	Purple	Purple	Purple	Small	Open	Branched	Conical	Elliptical
3	Makhuti	Purple	Purple	Purple	Small	Open	Unbranched	Elongated	Elongated
4	Ghoti	Yellow	Light green	Green	Large	Open	Unbranched	Round	Round
5	Boga Ahina	Yellow	Light green	Green	Large	Open	Unbranched	Round	Elliptical
6	Koni	Yellow	Green	Green	Large	Open	Unbranched	Round	Cylindrical
7	Red Garo	Yellow	Green	Green	Medium	Open	Unbranched	Cylindrical	Round
8	Karbi Anglong	Purple	Green	Purple	Large	Open	Unbranched	Round	Round
9	Bor	Green	Green	Green	Large	Open	Unbranched	Cylindrical	Cylindrical
10	AAU Col-46	Purple	Green	Green	Small	Open	Unbranched	Cylindrical	Round
11	Arunachal 2	Purple	Purple	Purple	Small	Closed	Unbranched	Elongated	Elongated
12	Panch Mukhi	Yellow	Green	Green	Medium	Open	Unbranched	Round	Round
13	Naga	Purple	Green	Green	Small	Open	Unbranched	Elliptical	Conical
14	JCC-31	Yellow	Yellow	Green	Medium	Open	Unbranched	Round	Round
15	Damor Dema	Yellow	Green	Green	Small	Open	Unbranched	Round	Cylindrical
16	AAU Col-5	Yellow	Green	Green	Medium	Open	Unbranched	Round	Conical
17	Ahina	Purple	Purple	Purple	Large	Open	Unbranched	Elliptical	Cylindrical
18	AAU Col-32	Green	Green	Purple	Small	Open	Unbranched	Round	Round
19	Takali	Yellow	Green	Green	Small	Open	Unbranched	Round	Round
20	AAU Col-39	Yellow	Yellow	Green	Small	Open	Unbranched	Round	Conical
21	Muktakesh	Yellow	Green	Green	Medium	Open	Unbranched	Round	Elliptical
22	Sree Kiran	Purple	Green	Green	Medium	Open	Unbranched	Conical	Elliptical

Table.6 Mean number of inflorescence per leaf axis, number of floral clusters per plant and yield/plant of taro cultivars

Sl. No.	No. of inflorescence/leaf axis			No. of floral clusters/plant			Yield/plant (kg)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Kaka	0.66	1.00	0.83	0.66	1.00	0.83	0.91	0.90	0.90
Garo	1.33	1.66	1.50	1.00	1.33	1.16	1.19	1.18	1.18
Makhuti	2.00	2.66	2.33	1.00	1.00	1.00	1.35	1.35	1.35
Ghoti	1.00	2.66	1.83	1.00	1.66	1.33	0.64	0.63	0.64
Boga Ahina	1.00	1.33	1.16	0.66	1.33	1.00	0.47	0.46	0.46
Koni	1.00	1.66	1.33	0.66	1.00	0.83	2.02	1.95	1.99
Red Garo	1.50	2.50	2.00	1.33	1.66	1.50	1.14	1.11	1.13
Karbi Anglong	1.00	1.00	1.00	0.66	0.66	0.66	1.49	1.46	1.48
Bor	1.33	1.33	1.33	1.00	1.33	1.16	1.58	1.57	1.57
AAU-Col-46	2.00	2.33	2.16	1.00	1.00	1.00	1.28	1.26	1.27
Arunachal 2	2.66	3.00	2.83	1.33	1.66	1.50	1.30	1.28	1.29
Panch Mukhi	2.00	2.66	2.33	1.00	1.00	1.00	1.83	1.13	1.16
Naga	1.00	1.33	1.16	0.66	1.00	0.83	0.70	0.71	0.70
JCC-31	1.66	1.66	1.66	1.00	1.00	1.00	0.63	0.66	0.65
Damor Dema	1.50	2.50	2.00	1.00	1.00	1.00	0.57	0.56	0.57
AAU Col-5	1.33	2.00	1.66	1.00	1.00	1.00	0.72	0.70	0.71
Ahina	1.00	1.33	1.16	1.00	1.00	1.00	1.52	1.50	1.51
AAU-Col-32	0.66	1.00	0.83	0.66	1.00	0.83	0.85	0.87	0.86
Takali	1.33	1.66	1.50	0.66	1.33	1.00	0.61	0.59	0.60
AAU-Col-39	1.00	1.66	1.33	0.66	1.00	0.83	0.59	0.58	0.58
Muktakesh	1.33	2.33	1.83	0.66	1.00	0.83	0.54	0.54	0.54
Sree Kiran	1.66	2.00	1.83	1.00	1.33	1.16	0.58	0.57	0.58
C.D (0.05%)									
Cultivars	NS	NS	0.98	NS	NS	NS	0.14	0.11	0.90
Environment	-	-	NS	-	-	0.14	-	-	NS
Interaction	-	-	1.38	-	-	0.66	-	-	0.13

Table.7 Mean number of corms, corm length, diameter of corm and corm weight of taro cultivars

Sl. No.	No. of corms			Corm length (cm)			Diameter of corm (cm)			Corm weight (g)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Kaka Kochu	1.00	1.00	1.00	17.33	13.50	15.41	6.56	6.13	6.35	568.33	600.00	584.16
Garo	1.00	1.00	1.00	10.46	10.20	10.33	7.50	7.96	7.73	804.00	827.00	815.50
Makhuti	1.66	1.66	1.66	30.33	29.66	30.00	4.90	5.10	5.00	778.33	790.66	784.50
Ghoti	1.00	1.00	1.00	6.23	8.23	7.23	4.76	4.53	4.65	489.0	489.66	489.33
Boga Ahina	1.00	1.00	1.00	7.43	6.23	6.83	5.56	5.66	5.61	269.66	291.33	280.50
Koni	2.33	2.33	2.33	11.03	12.56	11.80	7.50	6.53	7.01	1079.00	966.33	1023.22
Red Garo	1.00	1.00	1.00	15.06	14.26	14.66	8.03	7.63	7.83	579.66	586.66	583.166
Karbi Anglong	1.00	1.00	1.00	13.26	13.93	13.60	8.96	8.73	8.85	1052.33	1111.33	1081.83
Bor Kochu	1.00	1.00	1.00	14.44	16.63	15.00	9.73	9.30	9.51	1081.00	1153.66	1116.40
AAU-Col-46	1.00	1.00	1.00	11.83	12.10	11.96	6.80	6.73	6.76	778.66	799.33	789.00
Arunachal 2	1.66	2.00	1.83	24.90	24.166	24.53	4.86	4.73	4.80	977.33	920.00	948.66
Panch Mukhi	1.00	1.00	1.00	11.86	15.33	13.60	7.80	7.63	7.71	608.33	609.33	608.83
Naga Kochu	1.00	1.00	1.00	13.63	16.26	14.95	6.93	6.76	6.85	375.00	383.33	379.16
JCC-31	1.00	1.00	1.00	10.40	10.53	10.46	8.09	7.86	7.98	304.33	365.00	334.66
Damor Dema	1.00	1.00	1.00	9.46	11.36	10.41	6.70	7.03	6.86	306.66	359.33	333.00
AAU-Col-5	1.00	1.00	1.00	9.36	10.83	10.10	5.86	5.70	5.78	497.00	488.33	492.66
Ahina	1.00	1.00	1.00	12.76	14.93	13.85	7.06	6.83	6.95	1055.66	1039.33	1047.50
AAU-Col-32	1.00	1.00	1.00	9.23	10.10	9.66	7.83	7.83	7.83	405.00	471.00	438.00
Takali	1.00	1.00	1.00	9.16	9.09	9.13	7.43	7.66	7.55	316.66	306.66	311.66
AAU-Col-39	1.00	1.00	1.00	10.20	10.26	10.23	4.90	5.43	5.16	295.00	283.33	289.16
Muktakesh	1.00	1.00	1.00	11.30	11.40	11.35	6.23	5.80	6.01	305.00	312.33	308.67
Sree Kiran	1.66	2.00	1.83	13.63	12.90	13.26	6.50	6.53	6.51	320.33	323.33	321.67
C.D (0.05%)												
Cultivars	0.41	0.29	0.24	3.12	2.90	2.10	0.62	0.63	0.43	72.40	116.203	67.52
Environment	-	-	NS	-	-	NS	-	-	NS	-	-	NS
Interaction	-	-	0.35	-	-	2.97	-	-	0.62	-	-	95.49

Table.8 Mean number of cormel, cormel length, diameter of cormel and cormel weight of taro cultivars

Sl. No.	No. of cormel			Cormel length (cm)			Diameter of cormel (cm)			Cormel weight (g)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Kaka Kochu	4.33	5.00	4.67	16.23	17.40	16.81	4.43	4.46	4.45	330.00	380.00	355.00
Garo	10.00	11.00	10.50	8.36	9.20	8.78	5.59	5.15	5.37	382.00	418.33	400.166
Makhuti	5.33	6.66	6.00	21.80	22.10	21.95	4.13	4.10	4.11	499.33	413.33	460.00
Ghoti	29.00	28.33	28.67	5.63	5.36	5.55	3.30	3.37	3.33	170.66	204.00	186.00
Boga Ahina	10.00	9.00	9.50	6.33	5.86	6.10	3.66	3.76	3.71	153.33	193.33	173.33
Koni	37.33	36.00	36.67	8.30	7.30	7.80	5.02	5.50	5.26	378.33	537.00	457.66
Red Garo	5.33	6.67	6.00	6.23	6.40	6.31	4.06	3.83	3.95	545.66	425.66	485.66
Karbi Anglong	30.66	29.00	29.83	6.23	6.80	6.51	5.13	5.53	5.33	456.00	300.00	378.00
Bor Kochu	6.33	7.67	7.00	10.26	11.60	10.93	7.36	7.06	7.21	572.66	753.33	662.99
AAU Col-46	18.00	17.33	17.67	8.36	8.66	8.51	5.33	4.76	5.05	277.66	303.66	290.66
Arunachal 2	7.00	7.00	7.00	11.10	12.13	11.61	4.46	4.63	4.55	316.66	355.66	336.16
Panch Mukhi	8.00	8.00	8.00	6.93	6.53	6.73	5.03	5.11	5.07	550.00	252.00	401.00
Naga Kochu	6.33	7.33	6.83	10.13	10.33	10.23	4.19	4.06	4.12	311.66	434.33	373.00
JCC-31	11.33	10.33	10.83	6.16	6.63	6.40	4.06	4.70	4.38	253.33	279.00	266.16
Damor Dema	4.66	5.66	5.17	5.73	6.19	5.91	4.10	4.26	4.18	220.00	338.00	279.00
AAU Col-5	26.00	24.00	25.00	6.00	6.53	6.26	4.12	4.08	4.10	215.00	375.66	295.33
Ahina	13.33	11.33	12.33	10.93	10.30	10.61	3.78	4.23	4.00	901.66	314.66	608.16
AAU Col-32	16.33	15.67	16.00	5.66	6.40	6.03	4.03	4.43	4.23	354.66	486.33	420.50
Takali	5.33	6.33	5.83	8.20	7.16	7.68	4.25	4.40	4.32	285.66	283.33	284.50
AAu Col-39	6.66	7.67	7.17	7.03	6.50	6.76	4.13	4.33	4.23	293.00	300.00	296.50
Muktakesh	14.33	14.00	14.17	7.56	7.86	7.71	2.80	2.73	2.76	261.66	298.33	280.00
Sree Kiran	11.66	12.00	11.83	8.09	6.73	7.41	3.76	3.63	3.70	281.00	310.00	295.50
C.D (0.05%)												
Cultivars	3.56	1.87	1.99	2.11	1.78	1.36	0.64	0.64	0.44	79.55	77.26	54.69
Environment	-	-	NS	-	-	NS	-	-	NS	-	-	NS
Interaction	-	-	2.81	-	-	1.92	-	-	0.63	-	-	77.35

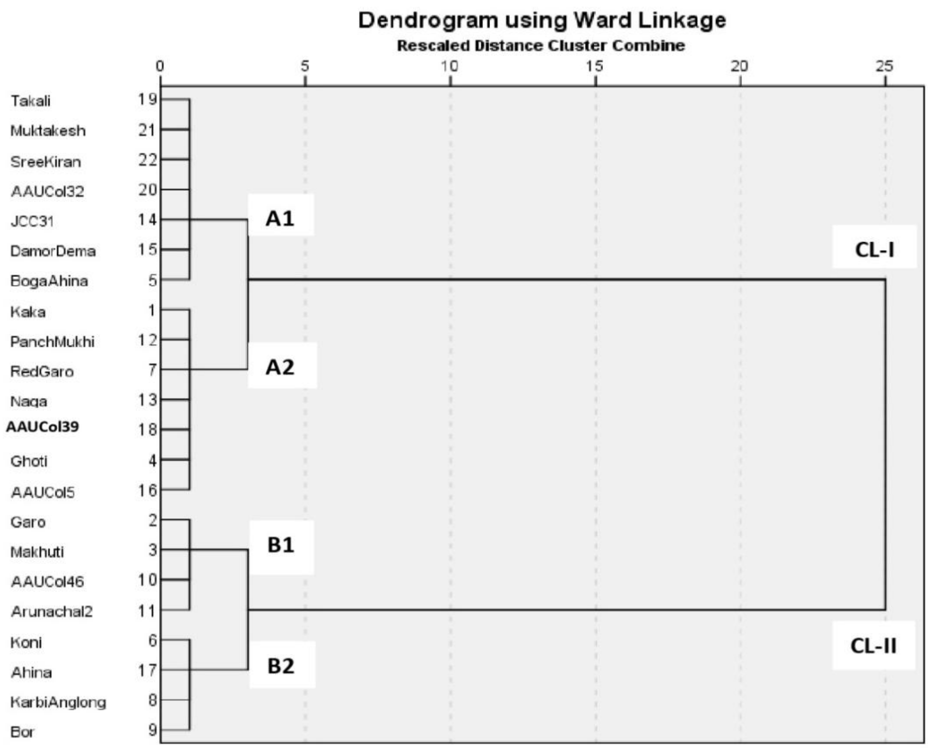
Table.9 Eigen values, variance, cumulative variance and component scores of the first seven principal components for qualitative traits in fifteen taro cultivars

Principal Components		PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Eigen vector		**6.69**	**3.75**	**3.14**	**2.25**	**1.63**	**1.24**	**1.02**	**0.82**
% Variation		**29.09**	**16.30**	**13.66**	**9.78**	**7.10**	**5.41**	**4.44**	**3.57**
Cumulative Variation		**29.09**	**45.39**	**59.06**	**68.83**	**75.93**	**81.34**	**85.78**	**89.36**
1	Plant height	0.02	<u>0.39</u>	0.18	0.01	0.26	0.16	<u>0.30</u>	0.15
2	Plant span	-0.10	0.29	-0.17	<u>0.37</u>	0.10	-0.33	0.02	-0.09
3	Leaf area index	<u>0.38</u>	0.02	-0.08	0.06	-0.04	-0.05	0.01	-0.07
4	No. of suckers	<u>0.33</u>	0.07	0.17	0.13	-0.03	-0.17	0.16	-0.25
5	No. of inflorescence per leaf axis	<u>0.34</u>	0.09	-0.13	-0.09	0.00	-0.02	0.04	-0.06
6	No. of floral cluster per plant	-0.19	0.31	0.19	-0.07	-0.05	-0.21	0.24	-0.23
7	No. of corms	0.32	0.08	-0.07	-0.16	0.14	-0.09	-0.15	-0.06
8	Corm length	-0.22	0.24	-0.20	-0.18	0.12	0.20	<u>0.34</u>	0.20
9	Diameter of corm	-0.06	0.04	<u>0.29</u>	0.14	-0.50	<u>0.24</u>	-0.39	0.03
10	Corm weight	0.08	<u>0.46</u>	0.10	0.02	0.08	0.14	-0.16	0.09
11	No. of cormels	0.10	0.08	<u>0.39</u>	-0.04	<u>0.37</u>	-0.20	-0.12	0.02
12	Cormel length	0.10	0.01	-0.45	-0.03	0.20	0.01	-0.10	0.25
13	Diameter of cormel	-0.05	<u>0.35</u>	0.25	0.05	0.12	0.03	-0.35	0.09
14	Cormel weight	-0.35	-0.07	0.01	-0.13	0.23	0.01	-0.09	0.01
15	Yield/plant	-0.01	0.15	-0.04	<u>0.41</u>	-0.24	<u>0.25</u>	<u>0.44</u>	0.38

Table.10 List of clustered cultivars using UPGMA based on morphological relationship among twenty-two taro cultivars

Cluster	Sub-cluster	No. of cultivar	Cultivars
I	A1	7	Takali, Muktakesh, Sree Kiran, AAU-Col-32, JCC-31, Damor Dema and Boga Ahina
	A2	7	Kaka, Panch Mukhi, Red Garo, Naga, AAU-Col-32, Ghoti and AAU-Col-5
II	B1	4	Garo, Makhuti, AAU-Col-46 and Arunachal-2
	B2	4	Koni, Ahina, Karbi Anglong and Bor

Fig.1 Hierarchical clustering of twenty-two taro cultivars based on morphological and bio-chemical characterization using the ward's linkage



Variation in corm characters

The difference in number of corm among the cultivars was significant as cultivars produced multiple corms while the remaining cultivars were recorded with single corm (Table 7). There was an equal percentage of long (45.45%) and intermediate corms (45.45%) whereas only 9.09 percent of the cultivars produced short corms (Table 2). The cultivar with the longest corm was recorded in Makhuti while the cultivar Boga Ahina produced the shortest corm (Table 7).

Corm branching was observed in two cultivars viz. Kaka and Garo while the remaining 90.1 percent of the cultivars produced unbranched corms (Table 2 and 5). The predominant shape among the corms was 'Round' as 54.55 percent of the cultivars possessed round shaped corms (Table 2 and 5). The cultivars viz. Kaka, Red Garo, Bor and AAU-Col-46 expressed 'Cylindrical' corm shape. While cultivars like Garo and Sree Kiran produced conical shaped corms; Makhuti and Arunachal-2 was found to have elongated shaped corms and Naga and Ahina revealed elliptical shaped corms (Table 2 and 5).

The longest corm diameter was recorded in Bor, and Ghoti was recorded with the shortest corm diameter (Table 7). The cultivar Bor was recorded with the highest corm weight i.e. 1153.66 g, 1081 g and 1116.40g for the 1st year, 2nd year and pooled data (Table 7). While the lowest corm weight was recorded from cultivar Boga Ahina i.e. 291.33 g, 269.66 g and 280.50 g for the 1st year, 2nd year and pooled data (Table 7). A perusal of the study revealed that the cultivars like Bor, Makhuti, Ahina, Karbi Anglong and Koni which had high corm weight were also recorded with long corm diameter and long corm, signifying that these characters also contributed to the individual corm weight. In correlation of corm characters with the plant habit, it was evident that cultivars like Bor, Ahina, Karbi Anglong and Koni which were recorded with high corm weight were all tall. These could be due to a greater quantity of dry matter having been translocated to the corm, combined with a higher rate of yield-attributing characters, viz., plant height, LAI, etc. throughout the growth period (Onwueme, 1978; Parthasarthy *et al.*, 1989 and Angami *et al.*, 2015). Similar findings were also reported by Akwee *et al.*, (2015), where the heights of most of the Pacific Islands taro collections were much higher than the Kenyan accessions and was recorded with the maximum yield.

Variation in cormel characters

Majority of the cultivars (49.99%) produced more than 10 numbers of cormels, 45.45 percent of the cultivars produced 5 to 10 numbers and only 4.54 percent produced less than five numbers of cormels (Table 8). The cultivar Koni was recorded with the highest number of cormels and the lowest number of cormels was recorded in the cultivar Kaka (Table 8). The longest cormel (22.10 cm, 21.80 cm and 21.95 cm for the 1st year, 2nd year and pooled data) was recorded in cultivar Makhuti and the shortest (viz. 5.63cm, 5.36cm, 5.55cm for the 1st year, 2nd year and pooled data respectively) was measured in Ghoti (Table 8).

It is apparent from the data displayed in table 2 that the greater part of the cultivars (36.36%) displayed round cormels whilst the second dominant shape (22.73%) among the cultivars was 'Elliptical'. The third most dominant cormel shape (18.18%) was 'Cylindrical' which was found in cultivars like Koni, Bor, Damor Dema and Ahina. Cormel shapes like 'Conical' (for cultivars AAU-Col-5 and AAU-Col-39) and 'Elongated' (Makhuti and Arunachal-2) were also recorded (Table 5). This variation in cormel shape among the cultivars may be primarily due to varietal differences.

The longest cormel diameter was also recorded in the cultivar Bor while the shortest was recorded in Ghoti Kochu (Table 8). The highest cormel weight (753.33 g, 572.66 g and 662.99 g for 1st year, 2nd year and pooled data respectively) was recorded in Bor and the lowest was observed in Boga Ahina (193.33 g, 153.33 g and 173.33 g for 1st year, 2nd year and pooled data respectively) (Table 8). The characters like the number of cormels, length and diameter of the cormel significantly contributed to the weight of the cormel because the cultivar Bor which was recorded with the highest cormel weight was also recorded with the highest cormel diameter and, moderate cormel length and number of cormels.

The weight of the cormels is also related with the plant vigour and the characters of the corms because the tall cultivars like Bor, Ahina and Koni which were recorded with higher corm weight also produced cormels with higher weights. The main planting material in taro being the cormels, the yield of the cormels is very important because the amount of food reserves contained in planting material is one of the factors which determines the quality of the material. These results are in line with the experiments performed by Sitompul and Guritno (1995), Angami *et al.*, (2015), Pratiwi *et al.*, (2014) and Luwe *et al.*, (2017).

Yield per plant

The highest yield was recorded in Bor i.e. 1.58 kg, 1.57 kg and 1.57 and the lowest yielder was Boga Ahina viz. 0.47 kg, 0.46 kg and 0.46 kg for 1st year, 2nd year and pooled data respectively (Table 5). It could be that increased leaf area, plant height and plant span observed in the best performing taro cultivars like Bor, Ahina and Makhuti intercepted more light leading to increased production of photosynthates effecting the food reserves in the corms and cormels and these corroborates findings of Pratiwi *et al.,* (2014) and Mukherjee *et al.,* (2016). The morphological characters like diameter and weight of corm and cormels also directly affected the yield, as cultivar Bor was recorded the highest corm and cormel diameter and weight. Paul and Bari (2012) and Akwee *et al.,* (2015) also found out that the phenotypic characters such as plant height, petiole length and number of suckers has a direct effect on yield per plant at the genotypic level.

Principal component analysis

Ordination among the cultivars revealed eight principal components (Table 8). The last component i.e. PC8 was not selected as it had Eigen vector less than one (1). The first component "PC1" elucidated 29.09 % of the total variation and was associated with characters like leaf area index, number of suckers and number of inflorescence per leaf axis (Table 8 and 9). The second principal component "PC2" explained 16.30 percent of the total variation and corresponded with characters like plant height, corm weight and diameter of cormel (Table 8).

About 13.66 percent of the total variation was interpreted by the third principal component "PC3" and was related with characters like diameter of corm, number of cormel and diameter of cormel (Table 8). The fourth component "PC4" deciphered 9.78 percent of the total variation and was linked with characters like plant span and yield per plant (Table 8). The fifth "PC5" and sixth "PC6" principal component accounted 7.10 percent and 5.41 percent of the total variation. Fifth principal component was attributed to the character number of cormels (Table 8). Whereas sixth principal component was connected to characters like diameter of corm and yield per plant. About 4.44 percent of the total variation was explained by the seventh component "PC7" and characters like plant height, corm length and yield per plant contributed to the variation in the 7th component (Table 8).

The morphological and characters like plant height, plant span, leaf area index, number of suckers, number of inflorescence per leaf axis, corm length, diameter of corm, corm weight, number of cormels, diameter of cormel and yield per plant are important in distinguishing the various taro cultivars and can be used as minimum descriptors for characterizing the taro cultivars especially in North East India. These results are in line with works done by Mbouobda *et al.,* (2007); Boampong *et al.,* (2018); Kathayat *et al.,* (2018) and Manzano *et al.,* (2018).

Cluster analysis

The dendrogram developed, grouped the twenty-two cultivars into two main clusters i.e. 'CL-I' and 'CL-II'. The first cluster (CL-I) was further divided into two sub-clusters viz. A1 and A2. The sub-cluster A1 consisted of five cultivars collected from Assam and Kerela viz. Takali, Muktakesh, Sree Kiran, AAU-Col-32, JCC-31, Damor Dema and Boga Ahina. Cultivars collected from Assam and Nagaland like Kaka, Panch Mukhi, Red Garo, Naga, AAU-Col-39, Ghoti and AAU-Col-5 grouped under sub-cluster B1 (Fig. 1). The second main cluster i.e. CL-II was also divided into two sub-clusters viz. B1 and B2, each containing four cultivars. The sub-cluster B1 consisted of cultivars like Garo, Makhuti, AAU-Col-46 and Arunachal-2 while cultivars like Koni, Ahina, Karbi Anglong and Bor grouped under the sub-cluster 'B2'(Table 10 and Fig. 1).

The cluster analysis indicates the extent of diversity that is practical for use to breeders (Sultana *et al.,* 2006). The dendrogram summarizing the existence of diversity and similarities among the taro cultivars revealed that the cultivars were clustered mainly by plant height, petiole colour and corm weight. Similar results were also observed by Mwenye (2009) and Boampong *et al.,* (2018).

It was also observed that geographically closer cultivars were grouped under different clusters. Cultivars like Muktakesh and Sree Kiran from Kerela were grouped with cultivars from Assam under sub-cluster "A1". Also cultivar from Nagaland viz. Naga was grouped with cultivars from Meghalaya and Assam under sub-cluster "A2". Likewise, cultivar from Arunachal viz. Arunachal-2 was clustered along with cultivars from Assam under sub-cluster "B1".

These results suggest that the geographical origin of the taro cultivars does not bear any relationship with the morphological characterization. This is in conformity with other reports based on morphological analysis by Zubair *et al.,* (2007), Ahmad *et al.,* (2008), Ali *et al.,* (2008) and Vinutha *et al.,* (2015). The variation between the cultivars maybe due to the heterogeneous nature of the plant which, according to Morton (1972) and Ivancic and Lebot (2000) may be due to large variation in chromosome structure and number leading to the morphological differences among the cultivars. This variation may also be associated with mutations and intensive selection by isolated human communities in diverse environments, followed by continuous vegetative propagation which resulted in the phenotypic diversity (Mwenye, 2009).

In conclusion, the morphological characterization of the twenty-two taro cultivars revealed a wide level of variation. The fourteen descriptors (plant height, plant span, leaf area index, number of suckers, number of inflorescence per leaf axis, corm length, diameter of corm, corm weight, number of cormels, diameter of cormel and yield per plant) that contributed maximum to the variability amongst the cultivars can be used in future research programmme as minimum descriptors for characterizing the taro cultivars. The taro cultivars were diverse even within their location as they were not grouped according to their geographic origin. The insights into the relative genetic diversity using morphological markers among taro cultivars would be useful in making a core collection, thus enhancing its use in plant breeding and *ex-situ* conservation of plant genetic resources.

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