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Screening and morphological characterization of taro (*Colocasia* sp.)

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ABSTRACT

Eight genotypes of *Colocasia esculenta* var. *antiquorum* and one genotype of *C. gigantea* collected from different localities were studied for their morphological differences and genetic variability. Based on the International Plant Genetic Resources Institute descriptors for taro, with some modifications, twelve morphological traits were evaluated to analyze the nature and extent of variability in the edible germplasm of *C. esculenta* var. *antiquorum* and *C. gigantea*. Significant differences, together with wide ranges of variation observed in most genotypes, indicate the existence of variability among the genotypes. The highest yield per plant was observed in genotype CE-2, followed by CE-4, while the lowest yield was recorded in CE-3. Genotypic variance and the coefficient of variation for most traits were remarkably higher than their corresponding phenotypic variances, suggesting the existence of inherent genetic variation.

Key words: *Colcasia esculenta, Colocasia gigantea*, *salad Kachu*, *mukhikachu*, diversity.

INTRODUCTION

Taro (*Colocasia* sp.) belongs to the Araceae family and is one of the oldest cultivated tuber crops in the world (Jane, 9). It is endemic to Bangladesh and Eastern India and originated in the Indo-Malayan region (Ramdeen *et al*., 24). This plant is grown worldwide for its underground corms (Njintang *et al*., 15). *Colocasia esculenta* has a botanical variation that includes *C. esculenta* var. *antiquorum*, referred to as *Mukhikachu* in the Bangladeshi local dialect. *C. gigantea* is another significant species, verified as an edible aroid by the National Herbarium of Bangladesh and well known in the Bandarban districts (Hilly area), where it is called *Salad Kachu*. *Mukhikachu* is a vegetable that grows throughout Bangladesh; during August and September, when vegetable supplies are lean, it provides markets with an ample supply of bulky vegetables (Ahmed and Rashid, 1). Similar to *Alocasia macrorhizos*, *Colocasia gigantea* is believed to be the progeny of a spontaneous crossing between *A. macrorhizos* and *C. esculenta* (Ivancic *et al*., 8). The leaves of *Colocasia* are eaten as a vegetable and are rich in immune-stimulating, antihypertensive, anti-diabetic, and neuroprotective properties (Gupta *et al*., 7). The leaves of the *Colocasia esculenta* plant have been proven to contain a greater proportion of the dietary contents of the tubers than potatoes. Additionally, these leaves have a greater quantity of nutrients, protein, minerals (calcium, phosphorus, iron, potassium, manganese), vitamins (vitamin C, thiamine, riboflavin, vitamin B6, niacin) and zinc (Melese and Negussie, 13). Malnutrition affects Bangladesh's rural populations not due to their socio-economic standing, but because they are unable to receive enough nutrients from the readily available, nutrient-dense vegetables to meet their daily needs. Therefore, using taro could improve food security, reduce zinc deficiency, and contribute financially to the nation's income. Taro production has doubled in recent years and it is now the sixth most consumed tuber crop globally (FAO, 11). Even though taro (*Mukhikachu*) is still an underutilized crop in Bangladesh and worldwide, it holds significant potential. Taro is cultivated by small-scale farmers, particularly poor women in Nigeria (Eze and Nwofia, 5) and Bangladesh. Diversifying agricultural production by cultivating a wide range of crops, especially those that are not fully utilized, is a different approach to addressing food security and alleviating poverty in rural areas (Akwee *et al*., 2). Despite its immense potential, taro remains in a vulnerable state due to a lack of thorough and objective assessment. The research on taro's agronomic cultivation, management techniques, and relevance in Bangladesh is still quite limited.

As the world's population continues to rise, there is a growing need for food diversity and higher crop productivity. Taro could significantly contribute to meeting this need. According to Bammite *et al.* (3), morphological parameters are important distinguishing characteristics for differentiating among germplasm. They may also serve as genetic markers, enabling and expediting selection in crop improvement initiatives. The gathered germplasm can be used in future breeding initiatives or research projects to improve varietals. The yield of corms is

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a quantitative attribute influenced by various factors that contribute to yield. The present study aimed to characterize and evaluate the collected germplasm, analyzing their genetic variability using morphological characteristics.

MATERIALS AND METHODS

The collected genotypes were planted at the Fruit Tree Improvement Project (FTIP), Germplasm Center, Department of Horticulture, Bangladesh Agricultural University (BAU), Mymensingh. Eight genotypes of *Colocasia esculenta* var. *antiquorum* were collected from various localities: CE-1 from Chittagong, CE-2 from Bandarban, CE-3 from Sathkhira, CE-4 from Bhola, CE-5 from Meherpur, CE-6 from Iswardi, and CE-7 and CE-8 from Gazipur. Additionally, *Colocasia gigantea* CE-9 was collected from Bandarban. The Bangladesh National Herbarium identified these genotypes. The experiment was set up followed by Randomized Complete Block Design (RCBD) with three replications. For cultivation, specific plant propaguless such as tiny corms, cormels, and suckers were employed. The terrain was medium-high, with soil that belonged to the Brahmaputra alluvium and Madhupur tract. The texture of Madhupur tract has sandy loam with a pH of 6.5. Unit plots size 3.0 m × 3.0 m, with a 60 cm × 40 cm spacing. The agronomical management recommendations were adhered to. Five randomly chosen plants from each replication's plot were used to record the data, with some adjustments made to the International Plant Genetic Resources Institute's taro descriptors.

Statistical analysis was done to determine the statistical significance of the experimental results based on the data collected on different parameters. The collected data were analyzed by Statistix-10 program and means were evaluated by LSD.

RESULTS AND DISCUSSION

Qualitative and quantitative growth performance characteristics were considered for describing taro genotypes. The qualitative characteristics include leaf colour, petiole colour, growing condition, leaf shape, corm shape, colour of corm pulp, spathe shape, and spathe colour, all of which were used as parameters (Table 1).

Leaf colour varied from deep green to light green, depending on the genotypes (Table 2). CE-9 was deep green and waxy in colour. The petioles of CE-1 and CE-3 to CE-8 were light green, whereas CE-2 and CE-9 were deep green. CE-1 to CE-8 had a peltate leaf shape. CE-2 had a heart shape, and CE-9 was a hastate. The corm shape of CE-1 and CE-3 to CE-8 was conical/round, whereas CE-2 and CE-9

Table 1. Morphological characterization of *Colocasia* sp. collected from different districts.

Name of group	Germ-plasm number	Growing condition	Growth habit	Plant size	Petiole colour	Leaf colour	Leaf shape	Eating quality	Corm shape	Colour of corm pulp	Spathe shape	Spathe colour
Mukhikachu	CE-1	Upland	Erect, semierect	Shorter	Light green	Deep green	Peltate	Acceptable	Conical	White		
	CE-2	Upland	Erect, semierect	Medium	Dark green	Deep green	Heart shaped	Acceptable	Dumb-bell	Slightly pink	Hooded	Deep yellow
	CE-3	Upland	Erect, semierect	Medium	Light green	Deep green	Peltate	Acceptable	Conical round	White		
	CE-4	Upland + Saline soil	Erect, semierect	Shorter	Light green	Deep green	Peltate	Acceptable	Conical round	White		
	CE-5	Upland	Erect, semierect	Medium	Light green	Deep green	Peltate	Acceptable	Conical round	Slightly yellow		
	CE-6	Upland	Erect, semierect	Medium	Light green	Deep green	Peltate	Acceptable	Conical round	White		
	CE-7	Slightly Wetland	Erect, semierect	Tall	Light green	Deep green	Peltate	Acceptable	Conical round	White		
	CE-8	Upland	Erect, semierect	Tall	Light green	Deep green	Peltate	Acceptable	Conical round	White		
Salad Kachu	CE-9	Upland	Erect, semierect	Tall	Dark green	Deep green + Waxy	Hastate	Acceptable	Round	White		

Table 2. Morphological characteristics of *Colocasia* germplasm.

Germplasm (No.)	Plant height (cm)	Petiole length (cm)	Leaf No.	Leaf length (cm)	Leaf breadth (cm)	Corm length (cm)	Corm breadth (cm)	Corm weight (g)	Cormel No.	Cormel length (cm)	Cormel weight (g)	Yield Plant^{-1} (g)
CE-1	106.71	54.03	3.94	30.49	20.47	9.53	6.43	214.07	7.42	6.64	133.46	347.53
CE-2	109.42	61.74	3.63	27.95	23.42	9.37	6.34	218.87	7.98	7.59	143.75	362.62
CE-3	104.92	61.72	4.20	26.62	23.64	3.45	4.68	47.15	3.48	2.55	62.57	109.72
CE-4	87.08	51.25	3.95	22.09	19.29	5.33	3.88	54.82	7.50	5.37	134.97	189.79
CE-5	76.49	61.75	3.47	23.99	21.09	6.77	4.47	62.48	3.84	6.40	69.09	131.58
CE-6	96.11	51.80	4.14	29.46	26.15	7.53	7.08	86.30	8.00	6.43	143.96	230.26
CE-7	109.08	40.44	5.07	31.24	31.10	7.22	6.75	174.42	6.64	5.32	119.54	293.96
CE-8	108.81	66.72	3.47	31.72	27.20	14.06	11.27	246.48	0.77	1.57	5.69	252.17
CE-9	132.16	122.88	7.63	35.37	39.21	9.56	5.52	230.38	0.83	1.48	5.79	236.17
$LSD_{(0.05)}$	5.226	2.646	0.379	1.516	2.312	2.359	0.543	1.028	1.273	0.273	0.628	14.123

were round. The colour of the corm pulp was white for CE-1, CE-3, CE-4, and CE-6 to CE-9. CE-2 had a slightly pink corm pulp, while CE-5 had a slightly yellow corm pulp. The spathe's shape was hooded and deep yellow.

All *mukhikachu* plants were very short, with CE-2 having the maximum height (109.42 cm) and CE-5 having the lowest (74.49 cm). CE-9 (*Colocasia gigantea*) attained a height of 132.16 cm (Table 2). Genotype CE-9 recorded the longest petiole, measuring 122.88 cm. Among the eight *mukhikachu*, the highest petiole length was 66.72 cm in CE-8, and the lowest was 40.44 cm in CE-7. CE-9 had the highest number of leaves (7.63), while CE-5 and CE-8 had the lowest number (3.47). The longest leaf length was in CE-9 (35.37 cm), followed by CE-8 (31.72 cm), and the smallest in CE-4 (22.09 cm). Genotype CE-9 had the largest leaf breadth (39.21 cm), followed by CE-7 (31.10 cm), and CE-4 (19.29 cm) had the smallest.

The maximum corm length was recorded in CE-8 (14.06 cm), and the minimum corm length in CE-3 (3.45 cm). The corm breadth was also highest in CE-8 (11.27 cm), while the lowest (3.88 cm) was in CE-4. The highest corm weight was observed in CE-8 (246.48 g), and the lowest in CE-3 (47.15 g). CE-6 yielded the highest number of cormels (8.00), while CE-8 yielded the lowest number (0.77). The longest cormel length was recorded in CE-2 (7.59 cm), and the shortest in CE-9 (1.48 cm). Genotype CE-2 had the highest cormel weight (143.75 g), while CE-8 had the lowest (5.69 g). The highest yield plant^{-1} was obtained from CE-2 (362.62 g), and the lowest yield per plant was in CE-3 (109.72 g) (Plate 1).

The study's findings showed that all of the traits under investigation had substantial variation in their germplasm. The highest plant height was obtained from CE-9 (132.16 cm) and the lowest plant height (87.08 cm) was observed in CE-4. Among the nine *Colocasia* genotypes, CE-4, CE-5, CE-6 and CE-9 have no flower. The highest inflorescence number was found in CE-2 (4.67). CE-2 had the highest corm weight, cormel number, cormel length, cormel weight, and yield plant^{-1} (362.62 g), while CE-3 had the lowest yield per plant (109.72 g). This was attributed to high food reserves in large cormels, which ultimately contributed to high yield and served in large cormels through increased vegetative growth and rapid development of cormels with higher numbers. Both the weight of the mother corm and the yield per plant showed significant variance. The findings of Padmakshi *et al*. (16), Khatemenla *et al*. (11) and Thakur *et al*. (19) closely align with our results.

According to Deshmukh *et al*. (4), phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values greater than 20% are

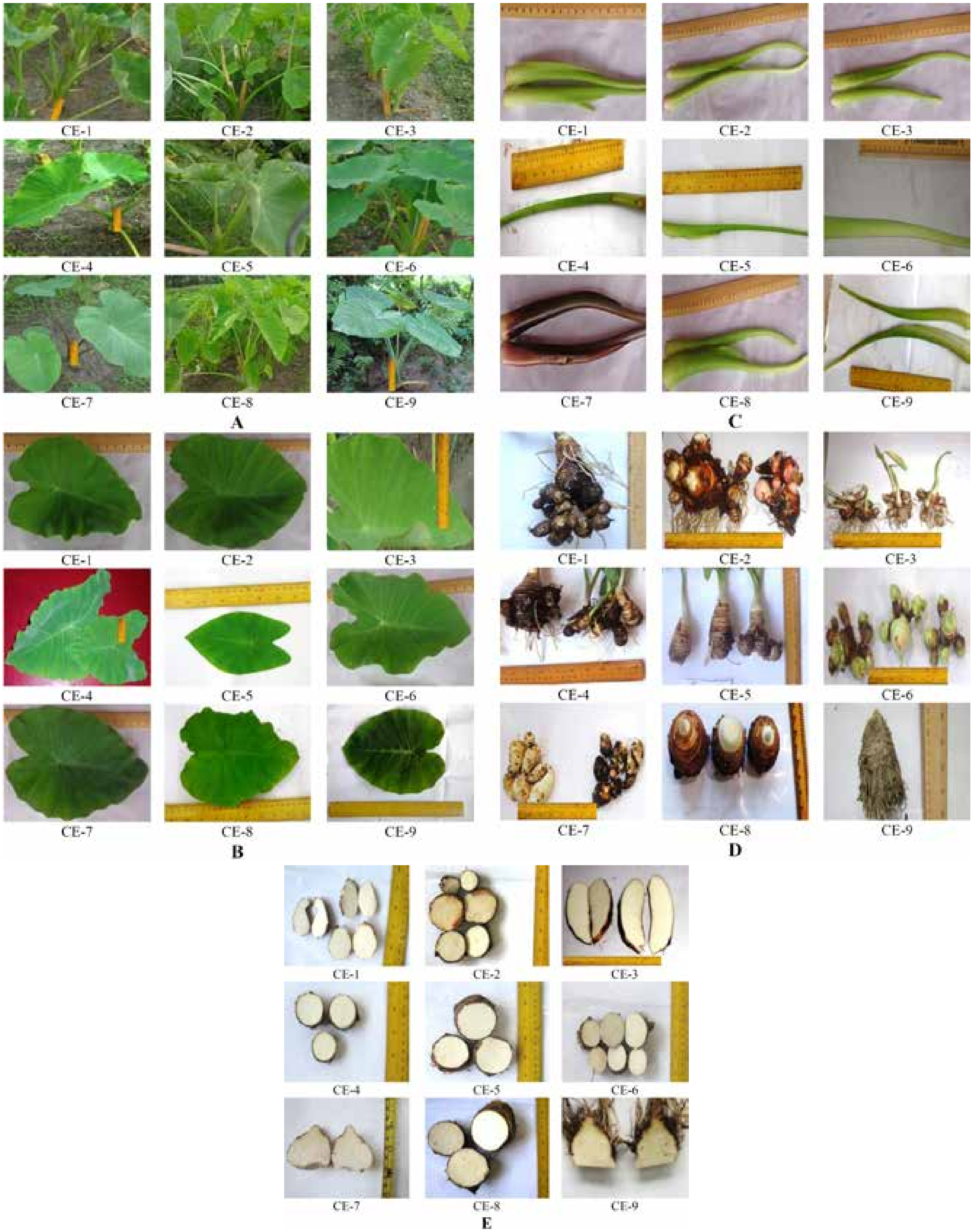

Fig. 1. Variation showing plant parts of *Mukhikachu/ Salad Kachu* (A = Whole plant, B = Leaf, C = Petiole, D = Corm and cormels, E = Pulp colour).

Table 3. Estimation of genetic variability among different traits of *Colocasia* germplasm.

Traits	Plant height (cm)	Petiole length (cm)	Leaf No.	Leaf length (cm)	Leaf breadth (cm)	Corm length (cm)	Corm breadth (cm)	Corm weight (g)	Cormel No.	Cormel length (cm)	Cormel weight (g)	Yield plant^{-1} (g)
GV	234.57	555.79	1.70	16.57	38.66	9.10	4.64	7060.25	8.84	5.36	3218.54	7596.91
PV	273.94	558.83	1.75	17.33	40.15	9.38	4.95	7083.34	9.09	5.60	3300.45	7685.96
GCV	14.81	37.05	29.67	14.15	24.17	37.27	34.36	56.65	57.60	48.04	62.36	36.42
PCV	16.00	37.15	30.08	14.47	24.63	37.84	35.50	56.74	58.42	49.11	63.15	36.63
h^2	85.63	99.46	97.25	95.57	96.29	97.00	93.66	99.67	97.21	95.71	97.52	98.84
GA	29.20	48.43	2.65	8.20	12.57	6.12	4.29	172.81	6.04	4.66	115.41	178.51
GA%	28.23	76.12	60.26	28.49	48.85	75.62	68.50	116.50	116.99	96.82	126.85	74.59

GV =Genotypic variance, PV = Phenotypic variance, GCV= Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, h^2 (bs)= Heritability (broad sense), GA = Genetic advance, GA (%) = Per cent genetic advance

considered high, values less than 10% are considered low, and values between 10 and 20% are considered medium. The maximum GCV and PCV among the nine genotypes of *Mukhikachu* / *salad kachu* was recorded for inflorescence number (97.19 and 97.42, respectively), while the lowest was recorded for leaf length (14.15 and 14.47, respectively) (Table 3). Since the GCV values were lower than the PCV values, there may be a lot of scope for selection. This shows that the environment had a significant influence on how these traits expressed themselves. Previous reports by Poddar *et al*. (17) and Mukherjee *et al*. (14), indicated high GCV and PCV in *Colocasia* for number of cormels and weight of corms plant^{-1}.

In all studied the traits on nine genotypes of *Colocasia*, high heritability was recorded, with the highest in petiole length (99.46), indicating that selection was effective. The GCV estimates the degree of variability for a genotype and assists in comparing the variability among different traits. Maniee *et al*. (12) stated that high heritability implies that the selection of these characteristics would be less affected by environmental factors. Heritability, which measures the proportion of phenotypic variance due to genetic factors, is useful in crop breeding as a forecasting tool, according to Songsri *et al*. (18).

Based on Johnson *et al*. (10) classification, the range for Genetic Advance (GA) % was from 28.23% for plant height to 199.75% for inflorescence number, indicating that all studied characters had very high genetic advance, hence variability exists among the traits. An important element in predicting which genotype selection is optimal is considering both high heritability estimates and large genetic advance values, which suggest the potential for significant advances in phenotypic selection. The study of *mukhikachu* accessions reveals a broad range of variability due to significant variation in most cultivars (Padmakshi *et al*., 16).

Taro is one of the most important commercial food crops because it meets the demands of rural populations. The selection of high-yielding, high-quality germplasm will determine its future. The main goals of the current study were to provide important details about *Colocasia* sp. by examining the morphological variation in the germplasm, and discover potential variants such as CE-2, CE-1 (*C. esculenta* var. *antiquorum*), and CE-9 (*C. gigantea*). The high variability observed in the collected germplasm indicates that they can be exploited for varietal improvement and used as a source of genetic material in breeding programs.

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AUTHORS' CONTRIBUTIONS

Execution of field/lab experiments and data collection and preparation of the original manuscript (SB); Conceptualization & designing of the experiments (MAR); Analysis of data and interpretation (MAZAM); Editing of the manuscript (MHR).

DECLARATION

The authors declare that they have no conflict of interest.

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