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Assessment of Character Association in Relation to Growth, Yield and Studies on Various Quality Parameters [Calcium Oxalate Crystals (Raphides), Shelf Life and Starch] in Different Colocasia (*Colocasia esculenta* L.) Genotypes

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ABSTRACT

Colocasia (*Colocasia esculenta* L.) is an important root crop especially in the humid tropics and sub-tropics. The study was carried out at the "All India Co-ordinated Research Project on Improvement of Tuber Crops", Central Experiment Station, Wakawali during kharif season of the year, 2016 to studied the phenotypic and genotypic associations of herbage yield were significantly positive with all plant height, number of leaves per plant and leaf length. The inter relationship between plant height and petiole length, number of leaves and leaf area were positive and significant at both phenotypic and genotypic levels. And also studies on different colocasia genotypes for calcium oxalate crystals, shelf life and starch content under konkan condition. The presence or absence of micro-character in plant system like calcium oxalate crystals has been used for understanding the palatability of the genotype. The number in calcium oxalate crystals (COCs) and starch content can differ from genotype to genotypes and it might be genetically controlled. We have studied the calcium oxalate crystals in the different plant parts (leaves and petiole), shelf life (leaves) and starch (corm and cormels) among all the colocasia genotypes. The calcium oxalate content in terms of raphide counts per 200 microscopic field was varied from 58.47 to 251.00.The genotype BCC-11 contained less amount of calcium oxalate (40.40 r 200^{-1} mf). The starch content was varied from 13.57 % and 24.13 % and significant difference was observed for shelf life of leaves (10.42 to 13.95 hrs) among different colocasia genotypes.

Keywords

Colocasia, Phenotypic correlation, Genotypic correlation Calcium oxalate, Shelf life, Starch and raphides count per 200 microscopic fields

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Introduction

Colocasia (*Colocasia esculenta* L. Schott) also known as '*edode'* or '*arvi' is* a tropical tuber crop belongs to the monocotyledonous family 'Araceae' of the order Arales whose members are known as 'aroids' (Henry, 2001 and Van Wyk, 2005). Colocasia is believed to have originated in South Central Asia, perhaps in Eastern India or Malaysia (Sturlevant, 1919; Onwueme, 1978 and Watt, 1989). Globally colocasia is cultivated in an area of around 2.0 million ha with an annual production of 12.0 mt and average yield of 6.5 t ha^{-1} (FAO STAT, 2010). In the last 5 years (2008-2012), 88 per cent of the area and 78 per cent of the production is in Africa. The annual global per capita consumption of colocasia is 1 kg.

Colocasia is importantbecause subsistence food crops are declining gradually leading to wide spread genetic erosion. In the world, it attains a commercial crop status in few countries notably Hawaii, Egypt, Philippines and Caribbean Islands (Alexander, 1969). Despite of limited commercial development, it is important in diet of many people of the world, especially in under developed countries and has a potential as commercial crop for specialty foods. Colocasia is well adapted to shade and can withstand drought to a great extent. The crop is found to thrive well in acidic as well as alkaline soils. Colocasia is one of the tuber crops mainly grown for leafy vegetable under Konkan during *kharif* season. Colocasia is a rich source of starch and reasonably good source of major components of the diet *viz*., proteins, minerals and vitamins. All parts of the plant including corm, cormels, rhizome, stalk, leaves and flowers are edible and contain abundant starch (Bose *et al.,* 2003). Among the essential amino acids (those cannot be synthesized in the human body), phenylalanine and leucine are relatively abundant in colocasia. The acridity of tubers and leaves is due to presence of caclium oxalate. Caclium oxalate content in tubers and the leaves varies from variety to variety (Asokan *et al.,* 1980). The oxalic acid content in tubers and leaves plays an important role in consumer's acceptability as tuber and leafy vegetable. The consumer's preference is for the varieties having less acridity.

However, so far not much work towards development of high yielding sutiable types with less calcium oxalate and high starch content has been done in this crop except few attempts of germplasm collection and their evaluation (Plucknett *et al.,* 1970). Hence, it was felt necessary to undertake well planned research work to evaluate suitable genotypes for growth performance and herbage yieldof colocasia as consumer acceptability under hot and humid climate of Konkan region.

Growth parameters

Sibyala (2013) studied the performance of sixteen different taro (*Colocasia esculenta* L.) cultivars for growth, yield and quality parameters and reported that the plant height was maximum in IG Collection-8 (96.23 cm) and minimum was recorded in IG Collection-4 (58.03 cm). While maximum number leaves (15.47) plant^{-1} were observed in IG Collection-6. Maximum leaf lamina length (42.97 cm), width (33.93 cm), petiole length (75.97 cm) and petiole width (6.30 cm) was recorded by cultivar CA-21, while minimum in cv. Kasibugga.

Angami *et al.,* (2015) carried out varietal evaluation in taro and reported that 'Panchamuki' recorded significantly highest plant height (179.33 cm), petiole length (153.15cm), petiole breadth (13.87), leaf size (3095.67 cm^2) and LAI (1.14).

Surjit and Tarafdar (2015) evaluated taro germplasm at Horticultural research station, BCKV, West Bengal under AICRP on tuber crops and observed variations in all the plant growth characters. They recorded the range of leaf lamina length from 24.34 cm to 39.41 cm, leaf lamina breadth from 16.17 cm to 28.57 cm and length of petiole varied from 44.25 cm to 76.11 cm.

Bassey *et al.,* (2016) evaluated taro germplasm in AkwaIbom state Nigeria and concluded that there was significant difference among the taro accessions for plant height, no of leaves, leaf area and corm characters. The genotypes 'Oku Abak' exhibited superior performance in plant height, no of leaves, leaf area. While 'Ikot Ada Idem' recorded the lowest value for height and no of leaves.

Herbage yield

With concerned to leafy vegetable colocasia gained less importance over its tuber characters. Most of the studies was carried out with respect to tuber characters even though the leaves of colocasia was economically important as like tuber. So, with this, present study was focused on herbage yield as one objective and base for the feature work.

Quality parameters

Chadha *et al.,* (2007) recorded that the dry matter percentage of tubers (cormels) was maximum in BCC-10 (29.18%) and minimum in Telia (23.23%). Starch (dry weight basis) content was also maximum in the same cultivar BCC- 10 (65.7%) and minimum in the cultivar, Telia. Maximum protein (fresh weight basis) content of fresh tuber was recorded in cultivar, BCC-32 (0.90%) and minimum in BCC-24 (0.70%).

Hung *et al.,* (2007) reported that starch content of taro corms ranged from 21.1% to 26.2% and oxalates from 234 mg to 411 mg 100^{-1} g dry matter.

Chattopadhyay *et al.,* (2010) studied the nutrient composition of corms of elephant foot yam. Maximum dry matter and starch (fresh weight basis) content was observed by NDA-9 (32.50 % and 28.70 %), minimum in Midnapur (17.50 % and11.75 %). They also noticed that the highest crude protein content was in cultivar Singur (2.60 %) and the lowest in cultivars Midnapur (0.84%), Ranchi (1.01%), and Bidhan Kusum (1.08%).

Angami *et al.,* (2015) estimated bio chemical constituent of different taro cultivars and reported that ‘Nadia Local’ showed highest level of oxalic acid (1.05 mg 100 g^{-1}), highest dry matter content (27.50 %) was recorded in cultivars KCA-1 and Panchamukhi, while the highest moisture (82.83 %) was recorded in IG collection-5.

Saadi and Mondal (2012) studied the calcium oxalate crystals (Raphides and Idioblast) of some selected members of Araceae in Eastern India and reported that two types of calcium oxalate crystal (Type-I and Type-IV). In *Amrophophallus campanulatus* (Type-IV) having longer crystals and *Colocasia esculenta* (Type-IV) having shorter crystals.

Surjit and Tarafdar (2015) evaluated taro germplasm at Horticultural research station, BCKV, West Bengal under AICRP on tuber crops and observed variations in starch content (13.71 % to 18.36 %) and dry matter content of cormels varied from (22.77 % to 25.46 %).

Materials and Methods

The experiment was carried out during the period of June to November, 2016 (Kharif season crop) at “All India Co-ordinated Research Project on Improvement of Tuber Crops”, Central Experiment Station, Wakawali falls under tropical humid zone with an average rainfall of 3000 mm is situated at an altitude of 242 m above MSL. The geographical situation is 17^0 48’ N latitude and 73^0 78’ E longitude. The experiment was laid out in Randomized Block Design with 16 treatments (genotypes) in 3 replications.

Each plot was measured in 1.35 × 1.8 m consisted of three rows with 3 plants per row. Accordingly, 9 plants spaced at 60 × 45 cm apart, were accommodated per plot. Observations on morphological characters were recorded at 15, 30, 45, 60 and 75 DAP except days to 1^{st} leaf emergence and herbage yield was recorded at 45, 60 and 75DAP and the procedure for calcium oxalate, shelf life and starch content as follows;

Calcium oxalate crystals

Crystals were isolated from both fresh and dry plant specimens. However, dry material was preferred to increase crystal recovery. With the purpose of avoiding potential contamination of crystalline samples by soil particles, plant stems, leaf, petiole, root, corm or storage organ were carefully washed with abundant distilled water. After removal of needles epidermis, thin sections of plant stems, leaf, petiole, root, and corm or storage organ were excised and washed several times. The raphides could be easily separated manually. Clearing technique is used to specifically locate the calcium oxalate crystals in the plant tissue.

Tissue sections were macerated in water and crystals were mechanically freed with the help of dissection knives, segments were fixed in glycerine and water. After that we prepared a slide for observation. The slides were observed under light microscope (10X x 40X) as well as phase contrast microscope (Leica DM-1000) and polarized microscopy for detailed analysis and obtaining better picture as well as measuring the length and breadth of raphide crystal (Saadi and Mondal, 2012).

Starch (%)

To a known quantity (10 g) of fresh ground sample, little water was added and heated up to 60 ^{0}C temperature. After some time, 100 ml of 95 per cent alcohol was added and centrifuged till the precipitate settled at the bottom. The residue was filtered and washed with 50 per cent alcohol and transferred to a 500 ml stoppered conical flask with 100 ml of distilled water and 20 ml concentrated HCL.

Then the conical flask was kept on boiling water bath for 2½ hours, cooled and neutralized with 1 N NaOH using phenolphthalein indicator and the volume made up with distilled water. This test solution was used for determination of starch (Ranganna, 1977).

% Starch = % Reducing sugars × 0.90

Shelf life of leaves

The harvested leaves of each treatment were kept at ambient temperature (28.4-31.3^{o}C, 80-85.7% RH) and shelf life was estimated based on their shrivelling and shrinkage.

Statistical Analysis

The experimental data were statistically analyzed by following the standard procedures of Panse and Sukhatme (1985).

Results and Discussion

The results obtained from the present study as well as discussions have been summarized under following heads:

Assessment of character association in relation to growth and herbage yield in different colocasia genotypes

The intensity and direction of the association among the characters may be measured by genotypic (G) and phenotypic (P) correlation depending on the types of material under study.

The estimates of phenotypic and genotypic correlation coefficient (Table 1) depicted that the genotypic correlation were higher than the corresponding phenotypes ones for all the character combinations establishing predominant role of heritable factors.

The phenotypic and genotypic associations of herbage yield were significantly positive with all plant height, number of leaves per plant and leaf length.

Table.1 Genotypic and phenotypic correlations in herbage yield and related leaves characters

Character		Plant height	Petiole length	Petiole girth	Leaf thickness	No. of leaves	Leaf length	Leaf Breadth	Leaf Area	Herbage yield
Plant height	G	1.000	0.835	0.169	-0.192	0.506	0.364	0.072	-0.663	0.450
	P	1.000	0.791**	0.148	-0.166	0.430**	0.299*	0.059	-0.654**	0.428**
Petiole length	G		1.000	0.284	0.239	0.261	0.367	0.065	-0.400	0.191
	P		1.000	0.268	0.227	0.221	0.334*	0.057	-0.371**	0.160
Petiole girth	G			1.000	-0.026	0.125	0.489	0.460	0.270	0.293
	P			1.000	-0.003	0.047	0.321*	0.380**	0.239	0.226
Leaf thickness	G				1.000	0.329	-0.078	0.272	0.221	0.307
	P				1.000	0.224	-0.056	0.256	0.202	0.298
No. of leaves	G					1.000	0.437	0.087	0.484	0.980
	P					1.000	0.318**	0.004	0.411**	0.822**
Leaf length	G						1.000	0.227	-0.027	0.495
	P						1.000	0.205	-0.007	0.433**
Leaf breadth	G							1.000	0.455	0.039
	P							1.000	0.365*	0.037
Leaf area	G								1.000	0.324
	P								1.000	0.037
Herbage yield	G									1.000
	P									1.000

P: Phenotypic correlation; G: Genotypic correlation
*, **: Significance at 5% and 1 % probability, respectively

Table.2 Starch and calcium oxalate content of different colocasia genotypes

Genotypes		Starch (%)	Ca Oxalate (Raphide counts per 200 microscopic field)	Shelf life (hr)
G_1	Sanjivini	18.10	239.60	11.30
G_2	NDB- 9	16.70	240.13	12.18
G_3	M-12-429	20.07	223.73	11.77
G_4	Mahim	19.37	82.73	11.38
G_5	DevkibaiWalanga	17.13	113.67	11.97
G_6	Sawantwadi	16.87	64.67	12.67
G_7	Muktakeshi	17.57	64.73	10.92
G_8	Kelva	13.57	104.13	11.90
G_9	BCC-11	16.93	40.40	10.42
G_{10}	M-9-111	21.80	136.87	13.95
G_{11}	SreePallavi	17.73	229.87	12.32
G_{12}	KhedShiravali	15.60	233.60	11.60
G_{13}	Talsure	16.87	137.87	10.90
G_{14}	Ac-20	20.47	58.47	12.85
G_{15}	NDB-22	24.13	251.00	10.90
G_{16}	Khopoli	14.10	87.13	11.23
	Mean	**17.94**	**139.13**	11.77
	SEm (±)	0.77	22.97	0.41
	CD (P=0.05)	2.24	66.34	1.19

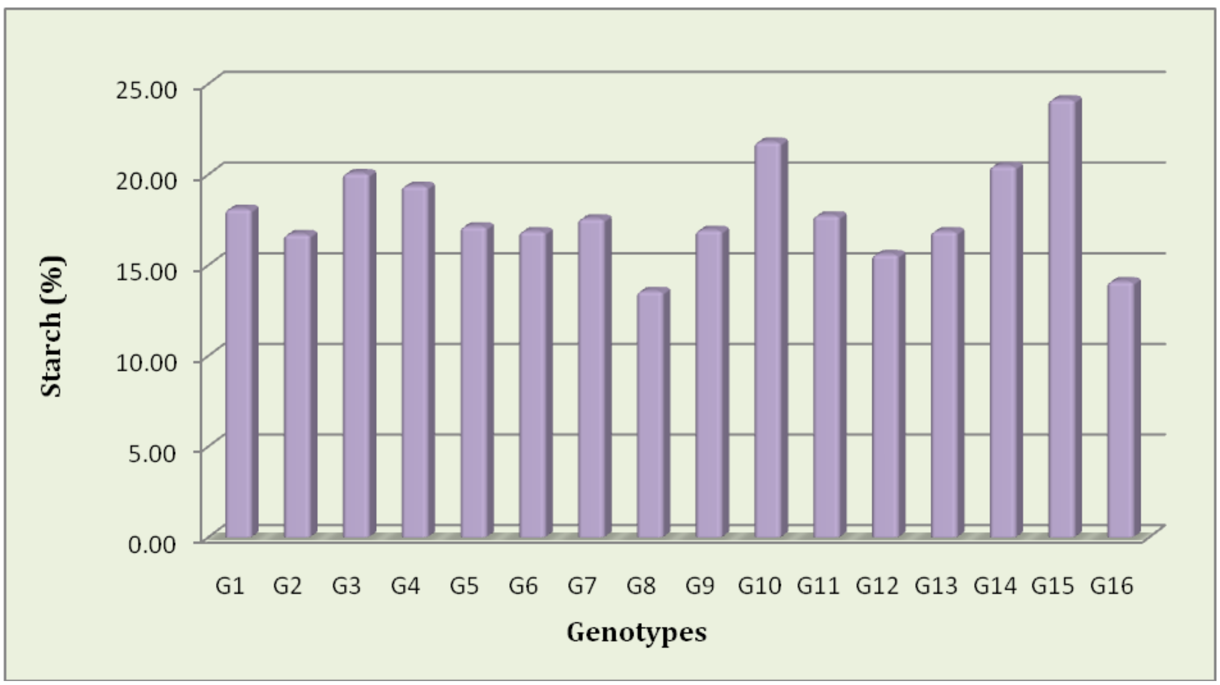

Fig.1 Starch content in different colocasia genotypes

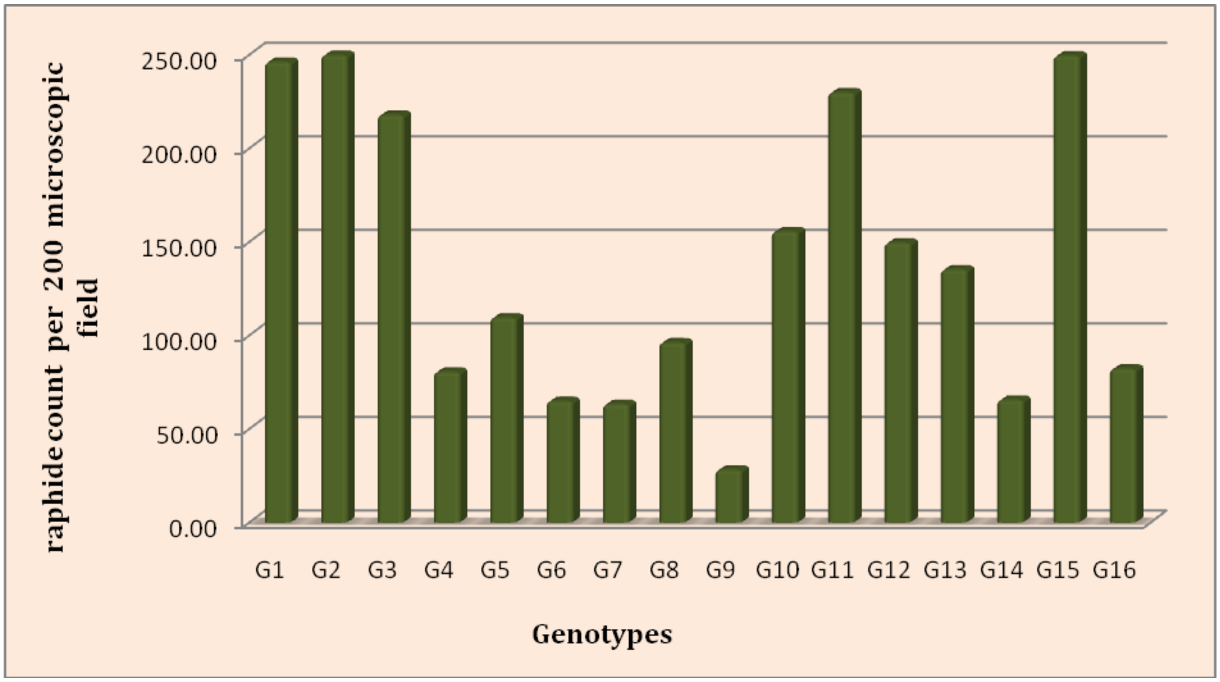

Fig.2 Calcium oxalate content in different colocasia genotypes

The inter relationship between plant height and petiole length, number of leaves and leaf area were positive and significant at both phenotypic and genotypic levels. Similarly, petiole length, number of leaves per plant and leaf breadth conferred positive and significant correlation with leaf area at both the levels. These findings were consonance with Mohankumar *et al.*, (1990), Thankamma *et al.*, (1995) and Mukherjee *et al.*, (2016). Highly significant positive correlation between herbage yield and number of leaves per plant might be assigned to more vegetative growth from the cormel of the colocasia genotypes.

Studies on various quality parameters

Calcium Oxalate (Raphide counts per 200-microscopic field)

Significant differences were noticed with respect to calcium oxalate content in different colocasia leaves and petiole among all the colocasia genotypes (Table 2 and Figure 1). The calcium oxalate content in terms of raphide counts per 200 microscopic field was varied from 58.47 to 251.00. Higher amount of calcium oxalate content (251.00 r 200^{-1} mf) was found in the NDB-22 genotype and it was at par with NDB-9 (240.13 r 200^{-1} mf), Sanjivini (239.60 r 200^{-1} mf), KhedShiravali (233.60 r 200^{-1} mf), SreePallavi (229.87 r 200^{-1} mf) and M-12-429 (22.373 r 200^{-1} mf). While, less amount of calcium oxalate (40.40 r 200^{-1} mf) was found in the genotype BCC-11.Libert and franceschi (1987), Ejoh *et al.*, (2006) and Temesgen *et al.*, (2016) also observed similar variation in ca oxalate content. The concentrations of oxalate in plants are influenced by environmental and biological factors, fertilizer application, light intensity, plant variety and genotype. The oxalate content in taro leaves is a major factor to consider when different Genotypes of taro are recommended for human or animal consumption (Hang *et al.,* 2017). The acridity of colocasia is related to calcium oxalate content and less acridity is preferred for consumption.

Starch (%)

Significant differences were noticed with respect to starch content in different colocasia corm and cormels among all the colocasia genotypes (Table 2 and Figure 2). The starch content was varied from 13.57 % and 24.13 %. Higher amount of starch content (24.13 %) was recorded in NDB-22 followed by M-9-111 (21.80 %). While, less amount of starch was found in the genotype Kelva (13.57 %) followed by Khopoli (14.10 %). Awasthi (2000), Santosa *et al.,* (2002), Sen *et al.,* (2006) and Chattopadhyay *et al.,* (2010) observed similar range of variations in starch content among different taro genotypes. Surjit and Tarafdar (2015) observed variations in starch content (13.71 % to 18.36 %).

Shelf life of leaves (hr)

The data on the shelf life of the leaves of different colocasia genotypes are presented in Table 2. It is seen that there was a significant difference among the colocasia genotypes and in the range of 10.42 to 13.95 hrs. The maximum shelf life (13.95 hr) was observed in M-9-111 and it was at par with AC-20 (12.85 hr). While, the lowest shelf life (10.42 hr) was recorded in BCC-11 genotype. Chauhan (2016) also observed the variations in shelf life content in indigenous genotypes of water spinach. The shelf life and keeping quality of different colocasia genotypes is related to the moisture content in leaves and respiration rate.

Thus, it indicated the variation in moisture, starch and Calcium oxalate content which is the most important qualitative character for the crop improvement in colocasia.

From the correlation study, it is evident that if the plant height, leaf length and number of leaves are increased, the herbage yield per plant will be increased as well. Other characters were shown nullified effect through direct and indirect effect. This helps to reduce undesirable direct indirect effects in order to make use of only concerned characters for selection.

With respect to quality parameters, BCC-11, NDB-22 were found to be superior for quality parameters based on the palatability. All these parameters of genotypes should be tested for two to three seasons for valid conclusion. These genotypes can be recommended for commercial cultivation as a leafy vegetable during *kharif* in the Konkan region.

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