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A Comparative Assessment Of Taro{Colocasia Esculenta L. (Schott)} Phenotypic Corms/Cormels Characteristics Among Kenya And Tarogen Core Taro Collections For Taro Crop Improvement And Breeding

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***Abstract:** Determination of qualitative phenotypic taro cormels characters were scored based on the key International Plant Genetic Resources Institute (IPGRI) descriptors for taro (IPGRI, 1999). Twenty five taro germplasm each from Kenya and Tarogen core taro collections from Pacific Island Communities were used for this research study. These characteristics were as follows: Corm shape, Corm cortex color; Corm flesh color; Number of sprouting suckers; Corm sucker length; Corm weight; Corm length; Corm diameter; Number of cormels; Corm branching and cormel root colour. Shannon's Diversity Index was used to calculate the diversity for the qualitative characters that showed polymorphism in various traits. A two-way analysis of variance (ANOVA) was used to analyze cormels genotypic agronomic performance among Kenyan and the Pacific Islands tarogen collections. The analyses of variance were tested at 0.05 level of significance. In Kenya, the corm characters with highest diversity value were corm shape (1.399), corm cortex color (1.204) and corm flesh color (0.973) while Tarogen core taro collections from Pacific Islands community showed similar variations with the corm shape leading with diversity value of 1.357. The application of analysis of variance test at (p>0.00) revealed a significant difference between corms/cormels and yields of taro accessions with reference to taro genotype performance characters and yields. These findings have shown that there exists a high significant difference between taro genotype agronomic cormels characters and yields between Kenya and PITCs taro collections. The application of analysis of variance test at (p>0.00) revealed a significant difference between taro cormels characters with reference to yield performances.*

***Keywords:** Taro (Colocasia esculenta), Phenotypic, corms/cormels, germplasm, accessions*

ABBREVIATION

ANOVA-Analysis of Variance
GPS-Geographical Positioning System
FAO-Food and Agricultural Organization
IPGRI-International Plant Genetic Resources Institute for taro descriptors
SDI-Shannon's Diversity Index

I. INTRODUCTION

Colocasia esculenta (L.) *Schott* var. *esculenta* belongs to the genus *Colocasia*, and monocotyledonous family Araceae (Deo *et al.*, 2009; Purseglove, 1972). There are two botanical varieties of taro – *C. esculenta* var. *esculenta*, commonly known as dasheen, and *C. esculenta* var. *antiquorum*, commonly known as eddoe (Purseglove, 1972; FAO, 2012). Dasheen varieties have large central corms, with suckers and/or stolons, whereas eddoes have a relatively small central

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corm and a large number of smaller cormels (Mace, Marthur & Izquierdo, 2006). In the dasheen types of taro, the corm is cylindrical and large (Deo *et al.*, 2009). It is up to 30cm long and 15cm in diameter, and constitutes the main edible part of the plant. In eddoe types, the corm is small, globoid, and surrounded by several cormels (stem tubers) and daughter corms. The cormels and the daughter corms together constitute a significant proportion of the edible harvest in eddoe taro (Deo *et al.*, 2009; IPGRI, 1999). The eddoe types have side tubers (cormels) that may be 5 – 20 in number and become as big as the mother corm. The cormels are usually absent in the dasheen types and it is the mother corm which is the main storage organ (IPGRI, 1999). Cultivated taro is a herbaceous plant which grows to a height of 1-2m (Deo *et al.*, 2009; Mace *et al.*, 2006). The plant consists of a central corm from which leaves grow upwards, roots grown downwards, while cormels, daughter corms and runners (stolons) grow laterally (Deo *et al.*, 2009). The root system is fibrous and lies mainly in the top one meter of soil. The surface of each corm is marked with rings showing the points of attachment of scale leaves or senesced leaves. Axillary buds are present at the nodal positions on the corm. The apex of the corm represents the plant's growing point, and is usually located close to the ground level. The actively growing leaves arise in a whorl from the corm apex.

Taro germplasm characterization under different ecological zones, assessment of its genotype agronomic performances and the selection of desirable genotypes for breeding crops has received very little attention. Pacific Island communities such as Thailand, Hawaii, Malaysian, Papua New Guinea, and Samoa amongst others are bulk producers of taro production and greater exporters of taro which offer competitive prices and quality (McGregor *et al.*, 2011) compared to Kenyan taro. Taro yields in Kenya are unknown compared to West Africa countries. In West Africa, the yields are lower than those of the Pacific and Asian Countries (FAO, 2012; FAO, 2008; FAO, 1999; FAO, 2006). This gives a clear indication of Kenyan taro genotype agronomic performances is extremely low that could not be even counted among taro producers in Africa. This has had undesirable impacts on food production systems and security among rural farmers who have neglected a great number of these underutilized crops including taro.

Phenotypic characters are vital diagnostic features for distinguishing taro genotypes (Tafadzwanashe and Modi, 2013; Garcia *et al.*, 2006). They may serve as genetic bench markers that could facilitate selection of suitable taro germplasm variety for crop improvement (Saidia *et al.*, 2012; Elibariki *et al.*, 2013). In terms of taro cultivation by Kenyan small holder farmers, there was a clear indication of lack of phenotypic variability assessment towards identifying heritable desirable traits that are important for crop productivity and breeding. The phenotypic characters such as plant height, petiole length and number of suckers amongst others could have a direct effect on genotype yield per plant at the genotypic level (Paul and Bari, 2011; Trujillo *et. al.*, 2002). In Kenya, taro agronomic performances have never been documented and this could attest to the fact there is no concerted efforts to improve taro production systems. Researchers have also showed that significant correlations exist between yields and several vegetative traits. This reinforces the suitability of agronomic characters in selecting genotypes (Garcia *et al.*, 2006; Dwevedi and Sen, 1999). The improved taro germplasm accessions can ensure food security and opportunities for income generation (Verma and Cho, 2004). There is limited documented information on the development of taro cultivation and consumption in Eastern Africa in general (Cheema, 2007) and in Kenya in particular. Small scale growing of taro is what has been reported in many areas. Taros in these areas particularly in flood prone areas in Kenya are intercropped with bananas and other crops (Chepchumba, 2007).

In Kenya, few studies have been done on taro phenotypic characterization of cormels and it agronomic performances yet its agricultural production is very low. The agronomic potential and its importance remain unknown because it has remained unexploited and underutilized yet it's an economically viable crop. Such underutilized crop has great untapped potential to support smallholder rural farmers by improving their food and nutritional security, and income while sustaining its genetic resources to cope with environmental challenges (Padulosi *et al.*, 2013). On the other hand, this root tuber crop has received very little attention attached to it in Kenya compared to Pacific Island countries who are the largest commercial producers of taro as cash crop and foreign exchange earner (McGregor *et al.*, 2011; FAO, 2008).

Despite the strides undertaken by various stakeholders and constraints limiting sustainable taro production are unknown, it leads to an unrealized agronomic potential of taro in addressing perennial food security. This could be attributed to a lack of understanding and awareness of farmers, about the magnitude of the food security problem which underlies the very concept of sustainable development. For example, the potential for the development of value added taro crop products have not been investigated (Palapala, *et al.*, 2005). There is limited information on its phenotypic cormel/cormels characteristics towards identifying heritable desirable traits that are important for taro productivity and breeding. Its agronomic potential production and contribution to food sustainability and security has not been adequately explored (Palapala *et al., 2009;* Watanabe, 2002*).* There is an urgent need to preserve the taro indigenous germplasm of native food crops for future crop development and posterity. Comparative analysis of phenotypic corms/cormels characteristics of taro from different regions could form a benchmark towards improving food security in terms of taro productivity and germplasm diversification. This study was therefore conceived to assess taro cormes/cormels phenotypic characteristics with reference to taro genotypes yield performances.

II. MATERIALS AND METHODS

Fifty taro germplasm accessions of Kenya and Tarogen core taro collections from Pacific Islands community were collected and used for this research study. The study was conducted in a farm field station at Masinde Muliro University of Science and Technology (MMUST) Main campus, located 00^{O} 17.30' North and $34^{o}45$' East (GPS receiver) at Kakamega county. Descriptors of taro *(Colocasia esculenta)* developed by IPGRI (1996) were followed for data collections. Determination of qualitative phenotypic cormels characters was scored based on the key International Plant Genetic Resources Institute (IPGRI) descriptors for taro (IPGRI, 1999). These characteristics were as follows: Corm shape, Corm cortex color; Corm flesh color; Number of sprouting suckers; Corm sucker length; Corm weight; Corm length; Corm diameter; Number of cormels; Corm branching and root color. A two-way analysis of variance (ANOVA) was used to analyze genotypes agronomic performances among Kenyan and the Pacific Islands tarogen collections. The analyses of variance were tested at 0.05 level of significance. Shannon's Diversity Index was used to calculate the diversity for the qualitative characters that showed polymorphism in various traits using a formula by Shannon and Weaver, (1963), Galwey (1995) and Bish *et al.*, (1998).

Shannon Diversity Index (H) formula:

$$SDI_i = -\sum_{J=1}^{d_i} P_{ij} \log P_{ij}$$

Where

SDI= Shannon's Diversity Index for the I^{th} qualitative character; d_i being the character state for ith character, and the proportion of accessions for j^{th} character state of ith character. P_i = the proportion of the character state of accessions i.

S/NO.	Kenya Accession Number	Taro germplasm	S/No.	Tarogen core taro from Pacific Islands Communities	Taro germplasm
1.	KCT/GHT/31	Kigoi	1.	BL/WH/08	PEXPH15-6
2.	KCT/KGI/32	Kigirigasha	2.	BL/HW/26	BC99-11
3.	KCT/NGC/33	Ngirigacha	3.	BL/HW/37	Pa'akala
4.	KWK/LKW/13	Lukuywa	4.	BL/SM/43	Sama043
5.	KWK/ISW/14	Ishwa	5.	BL/SM/80	Alafua
6.	KWK/SHT/12	Shitao	6.	BL/SM/92	Silipisa
7.	KWK/KAK/15	Kakamega T15	7.	BL/SM/111	Pauli
8.	KWK/KAK/16	Kakamega T16	8.	BL/SM/116	Manu
9.	KWK/KAK/17	Kakamega T17	9.	BL/SM/120	Manono
10.	KWK/BSA/42	Amagoro Teso	10.	BL/SM/128	Nu'utele2
11.	KMM/ELU/73	Eluhya	11.	BL/SM/132	Fanuatupu
12.	KMM/ENG/75	MumiasEN75	12.	BL/SM/143	Vaimuga
13.	KMM/END/74	Enduma	13.	BL/SM/149	Lepa
14.	KMM/MMU/78	Mumias T78	14.	BL/SM/151	Letoga
15.	KMM/MMU/79	Mumias T79	15.	BL/SM/152	Saleapaga
16.	KRT/KTL/61	Kiminini	16.	BL/SM/158	Lalomanu
17.	KNY/SYA/51	Siaya	17.	CA/JP/03	Mayako
18.	KNY/KIS/81	Kisii T81	18.	CE/IND/01	Kudo
19.	KNY/KIS/82	Kisii T 82	19.	CE/IND/06	IND155
20.	KNY/NYA/52	Kisumu	20.	CE/MAL/14	Klauang
21.	KNY/LVT/21	Lake VictoriaT21	21.	CE/MAL/12	Klang
22.	KNY/LVT/22	Lake Victoria T22	22.	CE/THA/07	Srisamrong
23.	KWK/BSA/41	Amagoro Busia	23.	CE/THA/09	Tadeang
24.	KWK/KAK/12	Kakamega T12	24.	CE/THA/24	Boklua
25.	KWK/LVT/23	Lake Victoria	25.	BL/PNG/10	C3-12

Table 1: Taro genotypes identification (Colocasia esculenta L. (Schott)

III. RESULTS AND DISCUSSIONS

The corms/cormels shapes were morphologically variable from both regions. Four of the corm qualitative characters assessed showed higher polymorphism rate among the taro accessions. The corm characters with highest diversity value were corm shape (1.399), corm cortex color (1.204) and corm flesh color (0.973) for Kenyan taro accessions (Table 2). Tarogen core taro collections from Pacific Islands taro showed similar polymorphism variations with corm shape leading with diversity value of 1.357 (Table 3). It was followed by corm length, corm root color and corm flesh color as shown on table 3. Most of the tarogen core taro collections corm shapes ranged from elliptical, conical and round while Kenyan genotypes showed conical, cylindrical and dumb-bell shapes (Table 2 and Table 3). In contrast, Kenya taro genotype accessions showed whitish purple and grayish white corms flesh color while a greater percentage of tarogen core taro collections from Pacific Islands showed whitish color (Table 3). However, majority of the Kenyan taro accessions corms length were longer while their counterparts from Pacific Islands were showing intermediate corm length. On the other hand, there were greater similarities in corms root color and corm branching for Kenya and Pacific Islands tarogen core collections which had the lowest diversity indices (Table 2 and Table 3).

Character	IPGRI descriptors	% frequency	*SDI(H´)*	Total *(H´)*
Corm shape	Conical	28	0.356	
	Elliptical	32	0.365	1.357
	Round	24	0.343	
	Cylindrical	16	0.293	
Corm cortex color	Purple	20	0.180	
	ND	80	0.179	0.359
Corm flesh color	White	80	0.179	
	Yellow	16	0.293	0.601
	Purple	4	0.129	
Corm branching	Branched	84	0.146	
	Unbranched	16	0.293	0.439
Corm root color	White	56	0.325	
	Others	44	0.361	0.686
Corm length	Intermediate	56	0.325	
	Long	24	0.343	0.848
	Short	20	0.180	

Table 2: Frequency distribution (%) and Shannon's Diversity indices (SDI) on qualitative phenotypic characters based on IPGRI descriptors of taro accessions for Tarogen core taro germplasm collections from Pacific Islands Communities

Character	IPGRI descriptors	% Frequency	*SDI(H´)*	Total *(H´)*
Corm shape	Conical	40	0.367	
	Elliptical	4	0.129	1.399
	Round	12	0.254	
	Cylindrical	28	0.356	
	Dumb-bell shaped	16	0.293	
Corm cortex color	Light Brown	32	0.365	
	Brown	40	0.367	1.204
	Dark Brown	24	0.343	
	Blackish	4	0.129	
Corm flesh color	White	12	0.254	
	Whitish purple	48	0.352	0.973
	Grayish white	40	0.367	
Corm branching	Branched	76	0.209	
	Unbranched	24	0.343	0.552
Corm root color	White	16	0.293	
	Brown	84	0.147	0.44
Corm length	Intermediate	8	0.202	
	Long	88	0.112	0.516
	Short	4	0.202	

Table 3: Frequency distribution and Shannon's Diversity indices (SDI) on qualitative phenotypic characters based on IPGRI descriptors of taro accessions from Kenya collections

Based on analysis of variance tests, there exists a high significant difference between taro genotype agronomic characters and yields between Kenya and Tarogen core taro collections from Pacific Islands communities. The application of analysis of variance tests at (p>0.00) revealed a significant difference between the corms/cormels with reference to genotypes yield performances as depicted by results on tables 4, 5, 6 and 7. At 95% confidence level interval, the hypothesis test results in a P-value, statistically, there is a significant difference between genotype performance characters and yields. Taro genotypes performance characters exhibited direct effect on yield per plant at the genotypic level. This could means that the selection of taro genotypes could be based on these genotype characters as a benchmark for selecting key characters to efficiently maximize taro productivity.

A COMPARATIVE ANALYSIS OF VARIANCE (ANOVA) OF GENOTYPE AGRONOMIC PERFORMANCES FOR KENYA AND PACIFIC ISLANDS TAROGEN COLLECTIONS

Corms and yields						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Characters	189.749	24	7.906	1.059	0.45	1.984
corms and yields	2219.379	1	2219.379	297.126	**0.05	4.260
Error	179.268	24	7.469			
Total	2588.395	49				

***Significant at 0.05 level of significance*

Table 4: Corms and yields among Kenya taro accessions

Corms and yields						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Accessions	145.518	24	6.063	1.774	0.084	1.984
Corms and Yields	925.704	1	925.704	270.851	** 0.05	4.260
Error	82.026	24	3.418			
Total	1153.249	49				

***Significant at 0.05 level of significance*

Table 5: Corms and yields among Tarogen core taro accessions from Pacific Islands Community

Cormels and yields						
Source of Variation	SS	Df	MS	F	P-value	*F crit*
Characters	507.865	24	21.161	2.351	0.021	1.984
Cormels and yields	139.980	1	139.980	15.549	*0.001	4.260
Error	216.060	24	9.003			
Total	863.9053	49				

**Significant at 0.001 level of significance*

Table 6: Cormels and yields among Kenya taro accessions

Cormels and yields						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Characters	144.185	24	6.008	2.518	0.014	1.983
Cormels and Yields	236.879	1	236.879	99.273	**0.05	4.260
Error	57.267	24	2.386			
Total	438.3317	49				

***Significant at 0.05 level of significance*

Table 7: Cormels and yields among Tarogen core taro accessions from Pacific Islands Community

This result shows a clear indication of very good genotypes performances in terms of yields potential. Singh *et al.* (2012) found out that taro could produce an average of 6 ton/ ha^{-1}. The higher yielding great potential of Kenyan taro genotypes were reflected in the findings compared to Pacific Island taro collections. This is in agreement with what Goenaga and Chardon (1993) and (1995) who reported that taro crop could yields 34000 and 20000 kgha-1. This analysis of taro genotypic agronomic characters performance has revealed suitable characters determining yields among taro accessions. In order to maximize taro genotypes yields performance, the selection of accessions could be based on such characters including the weight of cormels, number of cormels, cormel breadth among others. These results are in agreement with Cheema *et al.* (2007) who observed a clear correlation between the numbers of cormel per plant. They observed that the corm weight and length or circumference had direct positive effects on total yields per plant accession. Similarly, Paul and Bari (2011) also reported that in order to efficiently maximize the cormels yield in taro; the selection can be based on corm weight and higher girth of main sucker. This could mean the selection of taro genotypes be based on such characters to efficiently maximize the cormels yields in taro.

Findings by Bertan *et al.* (2007), Cheema *et al.* (2006), Dwivedi and Sen (1999), Paul and Bari (2011) have also reported that phenotypic and genotypic characters such as petiole, leaf and corm characteristics holds higher merits to be selected for taro breeding programme towards improving its production. They reported that these characters exhibited direct effects on yield per plant at the genotypic level. Bertan *et al.* (2007) also found that the phenotypic performance for specific traits, adaptability to certain agrozones and yield stability are some of different methods employed by breeders towards classification of germplasm into heterotic groups. This concurs with Baig *et al.*, 2009 who reported that knowledge of genetic variation and genetic relationship among genotypes is an important consideration for classification, utilization of germplasm resources and breeding. Therefore, the selection of taro genotype accessions could be pegged on key desirable heritable characters with high genetic diversity, its adaptability to agrozones and yield potential towards improving taro productivity.

IV. CONCLUSIONS

The corms/cormels phenotypic characters showed distinct polymorphic variations among Kenya and Tarogen core taro genotypes from Pacific Islands. Corms/cormels shapes phenotypic characters displayed high polymorphic rate among all taro genotypes hence holds higher criteria for selection by taro breeders. Corms/cormels phenotypic characterization of taro genotypes could be used as a benchmark for selection and identifying heritable desirable traits towards improving food security in terms of taro productivity, germplasm diversification and breeding. Taro genotype performance characters that exhibited direct effect on yield per plant at the genotypic level holds higher merits to be selected for taro breeding programs. The findings have shown that significant correlations exist between genotype performance characters and corm yields. The characters hold high merits to be selected for taro breeding program because they have direct and indirect effects on taro production potential.

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