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Agro-morphological characterization of some taro (*Colocasia esculenta* (L.) Schott.) germplasms in Ghana

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Taro (*Colocasia esculenta* (L) Schott.) is one of the underutilized crops in Ghana which has great potential in terms of food and nutritional value. Eighteen (18) accessions collected from Samoa (8), Malaysia (2), Indonesia (2) and Ghana (6) were studied under field conditions to collect data on their agro-morphological characteristics and yield potential for the development of the crop. The study was conducted at Nobewam in the Ejisu-Juaben Municipality in Ashanti Region. Randomized complete block design (RCBD) was used with three replications. Data were collected for 16 qualitative and 13 quantitative traits. Variations were observed in the vegetative and yield components. Plant height of the accessions ranged from 66.1 to 110.4 cm; corm length ranged from 12.5 to 18.5 cm; the maturity period ranged from 7 to 9 months and the corm weight ranged from 0.26 to 0.79 kg. Significant differences ($p<0.05$) were observed, indicating higher degree of variability in the accessions. Significant ($p<0.001$) and positive correlations were observed between corm length and corm diameter; economic (corm) yield and biological (stover) yield, corm diameter, corm length and corm weight. Leaf length correlated positively with corm diameter and corm weight. The principal component analysis (PCA) showed that the first component (PC1) accounted for 53.98% of the morphological traits. Nine accessions: CE/MAL/32, BL/SM/158, BL/SM/10, BL/SM/116, CE/IND/16, BL/SM/132, BL/SM/16, CE/MAL/14 and SAO/006 possess desirable characters such as earliness and yield which could be exploited for varietal development of taro in Ghana.

Key words: Agro-morphological traits, characterization, *Colocasia esculenta*, principal component analysis.

INTRODUCTION

Taro, Colocasia esculenta (L) Schott is a member of the monocotyledonous family, Araceae and sub-family, Aroideae (Lebot, 2009; Van Wyk, 2005). Taro is the most widely cultivated species in the Colocasia genus (Vinning, 2003) and it is the fourth most consumed tuber crop in the world (Revill et al., 2005).

Taro is important for food security since many tropical areas often experience unfavorable environmental

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conditions (Singh et al., 2012). The crop is widely cultivated in Africa, especially in Ghana (Darkwa and Darkwa, 2013) where it represents the third most important root crop after yam and cassava (Nwanekezi et al., 2010) and in more than 65 countries worldwide (USDA, 2001). Globally, about 12 million tons of taro are produced from 2 million hectares of land with an average of 6 tons per hectare (FAOSTAT, 2010).

The corm of taro is an excellent source of carbohydrate and its digestibility is estimated to be 98% (Deo et al., 2009). Due to its ease of assimilation, it is suitable for persons with digestive problems. Taro is useful to people allergic to cereals and can be consumed by children who are sensitive to milk and as such its flour is used in infant food formulae (Opara, 2001). The leaves of taro have higher levels of protein, potassium, calcium, phosphorous, iron, vitamin A, thiamine, niacin, riboflavin and dietary fibre (Xu et al., 2001; Yared, 2007).

Taro has enormous health benefits which include building strong immune system, lowering blood pressure, reducing weight gain and fatigue, preventing cell damage, building strong bone and also supports thyroid function (Misram and Sriram, 2002).

In Ghana, taro has been cultivated mainly in extensively dense populated high rainfall areas of the country (Ofori, 2003). Taro is cultivated mainly in developing countries using low input production systems. It is generally considered as an easy crop to grow provided there is adequate rainfall (Matthews, 2010). It has been used as a potential crop in Ghana since the 1983 famine and used as gap filling seasonal food crop when other crops are not available (Chaïr et al., 2016). In spite of taro's value as food source and other enormous benefits and uses, it is still considered as an 'orphan' crop in Ghana.

The taro industry in West Africa provides very useful source of livelihood; however, the crop is getting extinct especially in Ghana due to several biophysical and socio-economic factors (Darkwa and Darkwa, 2013). Considering the socio-economic importance of taro in the Pacific countries and in West Africa, a concerted effort that will be beneficial to both regions especially in Ghana should be sought. This would go a long way to improve the role of taro in providing staple food and income for taro socio-economic groups in Ghana. For any effective work to be done on taro, it is important to know its characteristics (both qualitative and quantitative) in local and exotic accessions found in Ghana. The characteristics of these accessions will serve as the basis for selection of accessions that are high yielding, nutritious and tolerant to the taro leaf blight disease in Ghana. This will help identify their characteristics and their qualities for further improvement and will be very important in both germplasm conservation and the root and tuber improvement program of the country.

The objective of the study was therefore, to determine the qualitative and quantitative characteristics of taro germplasm using agro-morphological traits.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Nobewam in the Ejisu-Juaben Municipal. The site is situated at latitude 06° 41'N and longitude 01° 23'W with an altitude of 228.7 m above sea level. The area has a bimodal rainfall pattern and receives mean annual rainfall of 2000 mm with maximum and minimum temperatures of 32.1 and 21.8°C, respectively (Meteorological Department, Ejisu Ashanti, 2014). The soil of the area has a pH of 5.3 to 6.5 (MOFA Ejisu-Juaben District, 2012). The environmental conditions are conducive for the production of *Colocasia esculenta* (L.) Schott.

Accessions evaluated

Eighteen *C. esculenta* (L.) Schott accessions were used in the study. The accessions used consisted of 12 exotic accessions from South-East Asia and 6 locals obtained from the Crops Research Institute (CRI) in Fumesua, Kumasi, Ghana.

The exotic ones were obtained from Malaysia, Indonesia, Samoa, while the local ones were obtained from different parts of Ghana which included Ejisu in the Ashanti Region, Magrivi and Gambia No. 2 in the Brong Ahafo Region, Ankokrom in the Central Region, Akrofo-Agove in the Volta Region and Bunso in the Eastern Region.

Experimental design

The experiment was laid out in a randomized complete block design (RCBD) using 20 m × 12 m plots with three replications. A single row plot, with each row 10 m long was used. Ten plants were spaced 1 m between rows and 1 m between plants. The planting materials were raised from tissue culture materials at Crop Research Institute and planted in November, 2014.

Data collection

Descriptors of taro (*C. esculenta* (L.) Scott.) developed by International Plant Genetic Resource Institute (IPGRI)/International Institute for Tropical Agriculture (IITA) (1999) were used for data collection.

Among the descriptors developed by IPGRI/IITA (1999) to characterize taro cultivars, 16 qualitative and 13 quantitative traits were measured. Both foliar and subterranean data were considered. Foliar traits were measured at five months after planting, while, subterranean traits were evaluated at harvest (at nine months). Quantitative traits were recorded on individual plant basis using sample average of five plants selected at random from the row. While for the qualitative traits, only the first replications of the experiment were considered, whereas for quantitative characters, the entire replications were considered.

A total of 29 plant characteristics, split into vegetative and corm characteristics were used to characterize the accessions as described by IPGR/IITA (1999). Qualitative traits were stolon and sucker formation, shape of lamina, orientation of lamina, leaf lamina margin, lamina colour, variegation of lamina, sinus, colour of leaf petiole, variation on petiole, flowering, maturity, leaf lamina margin colour, leaf vein pattern, corm shape and corm flesh colour. The quantitative traits measured were corm weight, corm length, corm diameter, plant height, number of leaves, leaf length, leaf width, number of stolons, number of suckers, economic yield, biological yield, dry matter and harvest index.

Table 1. Frequency distribution of leaf characteristics of the taro accessions

Qualitative trait	Description Adopted	No. of accessions	Frequency (%)
Shape of lamina	Flat	18	100
Orientation of lamina	Tip pointing downwards	7	38.9
	Semi-horizontal	11	61.1
Leaf lamina margin	Undulated narrow waves	18	100
Lamina colour	Green	9	50
	Light green	3	16.7
	Dark green	3	16.7
	Yellow green	3	16.7
Variegation of lamina	Absent	14	77.8
	Present	4	22.2
Leaf lamina margin colour	Purple	13	72.2
	Green	5	27.8
Leaf vein pattern	Y-pattern	18	100
Sinus	Wide	18	100

Table 2. Frequency distribution of petiole characteristics of the taro accessions.

Qualitative trait	Description adopted	No. of accessions	Frequency (%)
Colour of leaf petiole	Green	4	22.2
	Light green	4	22.2
	Yellow green	3	16.7
	Dark green	2	11.1
	Light purple	1	5.6
	Dark purple	2	11.1
	Blackish	2	11.1
Variegation on petiole	Absent	15	83.3
	Present	3	16.7

Statistical data analysis

Data for quantitative characters were subjected to analysis of variance (ANOVA) using Genstat Release 12.1. Least significant difference (LSD) was used to separate the means at 5% probability level (P<0.05). Pearson correlation, principal component and clustering of genotypes were carried out to assess the diversity between genotypes for the traits measured.

RESULTS

Frequency distribution of major qualitative traits

Vegetative characters

Tables 1 to 4 show variation in qualitative traits. A wide range of variations were observed among the 18 taro accessions that were studied with regards to agro-morphological characters that were assessed. Variation was shown in major phenotypic characters in foliar and subterranean plant parts. However, no variation was seen in some characters such as shape of lamina, leaf lamina margin, leaf vein pattern and sinus as they appeared similar for all accessions.

Leaf characteristics

Out of the eight phenotypic classes of this character, four showed variation among the accessions while four were

Table 3. Frequency distribution of corm characteristics of 18 the taro accessions.

Qualitative trait	Description adopted	No. of accessions	Frequency (%)
Corm shape	Elliptical	9	50.0
	Dump-bell	1	5.6
	Cylindrical	3	16.7
	Conical	5	27.8
Corm flesh colour	Pink	3	16.7
	Purple	1	5.6
	White	5	27.8
	Brown	1	5.6
	Light yellow	6	33.3
	Yellowish	2	11.1
Corm eating quality	Poor	0	0.0
	Ok	6	33.3
	Good	12	66.7

Table 4. Frequency distribution of other qualitative characteristics of the 18 taro accessions

Qualitative trait	Description adopted	No. of accessions	Frequency (%)
Sucker formation	Absent	3	16.7
	Present	15	83.3
Stolon formation	Absent	7	38.9
	Present	11	61.1
Flower formation	Flowering	9	50
	Rarely flowering	2	11.1
	Absent	7	38.9
Maturity	Early	3	16.7
	Medium	9	50
	Late	6	33.3

similar. The cultivars studied showed that 61.1% (representing 11 accessions) had semi-horizontal leaf orientation and 38.9% that represents seven accessions had the tip of the leaf pointing downwards (Table 1 and Figure 1). Four predominant leaf lamina colours were observed among the accessions. These were 50 (green), 16.7 (light green), 16.7 (yellow green) and 16.7% (dark green).

With respect to leaf lamina margin colour, the accessions fell into two categories as purple (72.2%) and green (28.8%). A little over 22% of the accessions exhibited variegation of the lamina with the rest of the accessions (77.8%) showing no variegation of the lamina.

In this study, all the taro accessions had Y-shaped leaf vein pattern, undulated leaf lamina margin, flat lamina shape and wide (>45°) sinus.

Petiole characteristics

Table 2 and Figure 2 show variation among the taro accessions based on petiole characteristics.In this study, seven distinct petiole colours were exhibited by the accessions. Over 22% of the accessions exhibited green and light green colours each, 16.7% of the accessions exhibited yellow green petiole colour. Dark green, light purple and blackish petiole colours which represents 11.1% each for dark green, light purple and blackish clours respectively was seen for some of the accessions. Light purple colour was exhibited by only accession

A B

Figure 1. Photograph showing leaf vein pattern and variability in petiole colour of the accessions of taro

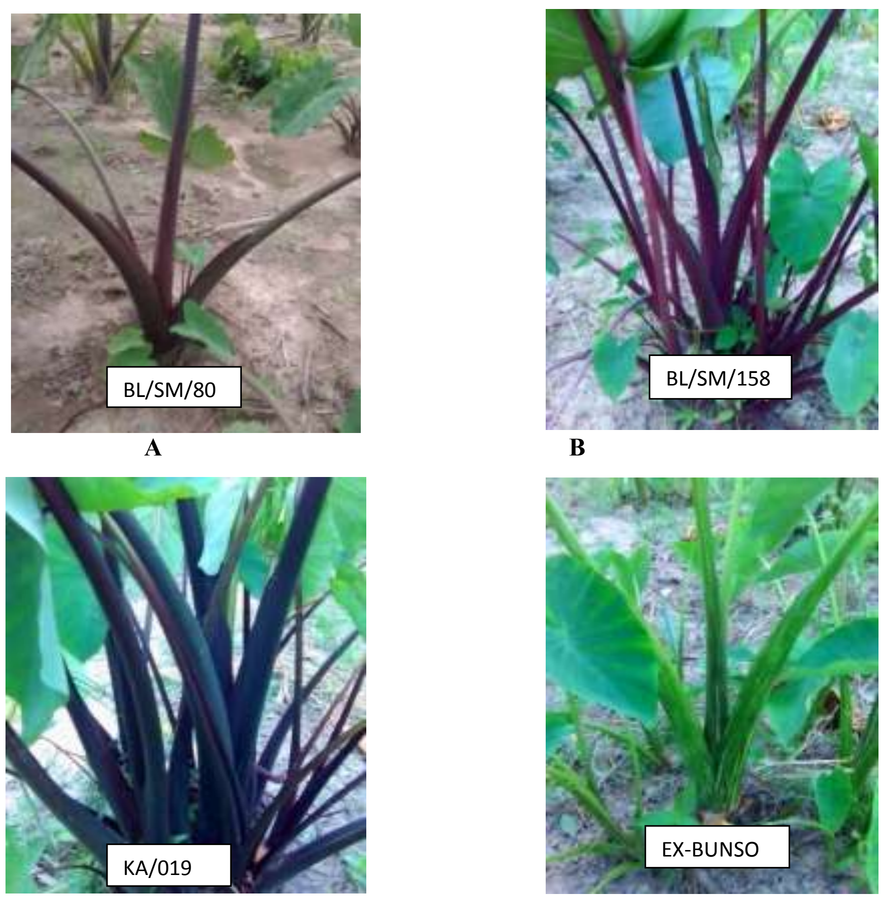

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Figure 2. Variation in Petiole Colour of the Accessions

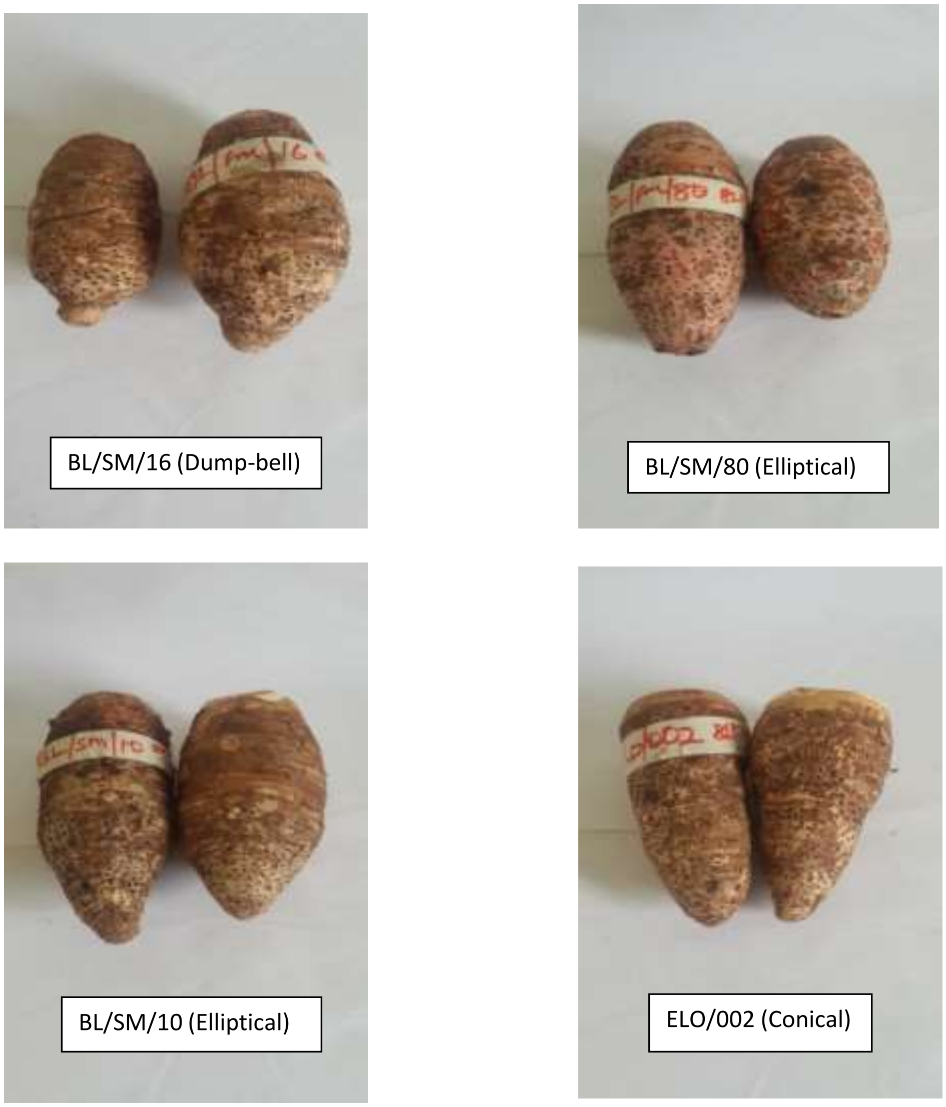


Figure 3. Variation in Corm Shape of the Accessions

(5.6%).

Variegation on the petiole were present in three accessions (16.7%) while the rest of the accessions (83.3%) did not show any variegation on the petiole.

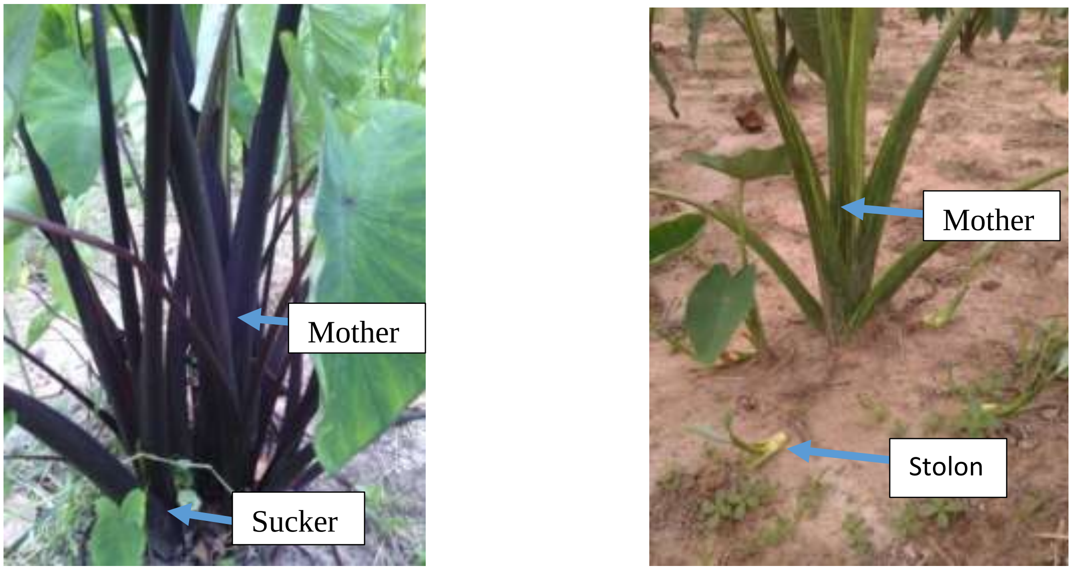
Corm characteristics

Table 3 and Figure 3 show the variation in corm characteristics of the accessions. Corm flesh colour of the accessions ranged from pinkish white (16.7%), purple (5.6%), white (27.8%), brown (5.6%), light yellow (33.3%) and yellowish (11.1%). The corm shape of *C. esculenta* varied from elliptical (50%), dump-bell (5.6), cylindrical (16.7%) to conical (27.8%).

The maturity of the accessions were classified as early (16.7%), medium (50%) and late (33.3%). Assessement based on corm eating quality was put into three groups as poor (Corm Quality Score (CQS) =1-<1.50), ok (1.50-<2.25) and good (2.25-<3.00). Twelve out of the 18 accessions (66.7%) were classified as good, 6 accessions (33.3%) were on the other hand ok with none of the accessions having a poor eating quality of the corm.

Stolon/sucker formation and flowering

Table 4 and Figure 4 show variation in stolon and sucker formation and Figure 5 shows variation in flower formation among the accessions. Sixty-one percent of the accessions had stolons, while 38.1% had no stolon. For sucker formation, 16.7% of the accessions did not show any formation of suckers while 83.3% had suckers. Forthy-four percent of the accessions exhibited the



(a) Mother plant and sucker (b) Mother plant and stolons

Figure 4. Variability in suckering and stolon formation of the accessions of taro

(a) Introduced accession with flowers (b) Local accession without flowers

Figure 5. Flowering ability of local and introduced accessions of taro (The arrow shows the flower).

formation of both stolons and suckers. Flowering was observed in 61.1% of the accessions and 38.9% did not flower.

Variation in quantitative traits

The analysis of variance for quantitative traits showed significant difference ($p<0.05$) among the 18 taro accessions for all the characters examined (Table 5). Among the accessions, plant height ranged from 66.09 to 110.40 cm. Plant height was highest in accession CE/MAL/32 (110.40 cm) with accession BL/SM/115 recording lowest plant height (66.09 cm). Leaf length ranged from 29.3 to 46.9cm. Accession BL/SM/116 recorded the highest leaf length (46.9 cm) and accession BL/SM/115 however showed the lowest leaf length (29.3 cm). Leaf width ranged from 20.1 to 34.4 cm with

Table 5. Variation in quantitative traits of the 18 taro accessions

Accession	PH (cm)	LL (cm)	LW (cm)	NLP	NStP	NSuP	CL (cm)	CD (cm)	CW (kg)	EY (kg)	BY (kg)	HI (%)	DM (%)
CE/MAL/32	110.4	44.8	34.4	5.6	6.2	3.1	17.8	31	0.79	0.20	0.22	90.9	32.7
BL/SM/10	101.6	39.8	26.5	5.6	3.9	0.0	18.5	27.6	0.77	0.19	0.27	70.4	27.7
BL/SM/16	90.6	43.1	28	5	3.7	1.6	14.9	26.4	0.47	0.13	0.16	81.3	28.0
BL/SM/116	99.1	46.9	32.4	5.1	4.3	2.0	17.3	28.7	0.68	0.21	0.22	95.5	35.3
BL/SM/80	84.8	34.5	23.7	4.8	0.0	5.0	16.3	24.7	0.52	0.19	0.20	95.0	35.3
CE/IND/12	79.1	37.4	26.1	4.8	0.0	2.3	15.4	26.8	0.56	0.18	0.21	85.7	32.0
BL/SM/115	66.1	29.3	20.1	4.4	0.0	3.2	12.5	20.5	0.28	0.11	0.12	91.7	32.0
BL/SM/151	91.9	42.6	29.6	5.3	3.4	1.6	12.7	22.2	0.36	0.13	0.18	72.2	30.0
CE/MAL/14	84.2	34.4	25.1	4.8	5.0	2.0	13.9	22.6	0.34	0.11	0.12	91.7	36.3
SAO/006	76.2	33.6	25.3	4.2	0.0	6.3	16.9	25.0	0.50	0.088	0.09	97.8	17.7
CE/IND/16	103.9	41.4	29.8	6	6.8	0.0	16.7	25.6	0.55	0.16	0.21	76.2	27.3
BL/SM/132	82.7	32.8	22	4.4	0.0	3.7	12.5	21.0	0.26	0.1	0.12	83.3	40.3
BL/SM/158	82.5	33.9	24.5	4.7	0.0	5.3	13.6	24.7	0.39	0.12	0.13	92.3	32.7
EX-BUNSO	104.5	42.4	28.5	4.9	8.7	0.0	14.4	25.1	0.42	0.13	0.14	92.9	35.3
SAO/020	89.3	41.5	29.2	4.9	3.0	0.7	13.2	23.1	0.39	0.17	0.25	68.0	28.0
ELO/002	68	32.9	22.1	4.7	1.4	0.4	15.5	23.8	0.44	0.19	0.29	65.5	26.0
KA/019	89.5	36	24.7	4.6	0.0	4.1	13.3	22.8	0.37	0.17	0.19	89.5	32.0
KA/035	98.8	45.2	30.1	4.9	4.0	0.9	15.3	22.9	0.41	0.14	0.18	77.8	25.7
LSD (<0.05)	21.95	9.99	6.63	0.72	1.93	1.58	2.72	4.2	0.21	0.06	0.08	0.26	0.09

PH: Plant height, LL: Leaf length, LW: Leaf width, NLP: number of leaves/plant, NStP: number of stolons/plant, NSuP: number of sucker/plant, CL: corm length, CD: corm diameter, CW: corm weight, EY: economic yield, BY: biological yield, HI: harvest index, DM: dry matter.

accession CE/MAL/32 recording the highest leaf width (34.4 cm) and accession BL/SM/115 had the lowest leaf width (20.1 cm). The range for number of leaves per plant was between 4.2 and 6.0. Accession CE/IND/16 had the highest number of leaves per plant (6.0) and accession SAO/006 had the lowest number of leaves per plant (4.2). Number of stolons ranged from 0 to 8.7 and the highest number of stolons per plant among the accessions was seen in accession EX-BUNSO (8.7). Seven of the accessions did not show the presence of stolons and these were KA/019, BL/SM/158, BL/SM/132, SAO/006, BL/SM/115, CE/IND/12 and BL/SM/80. Among the accessions studied, number of suckers per plant ranged from 0 to 6.3. Accession SAO/006 recorded the highest number of suckers per plant (6.3), while accessions BL/SM/10, CE/IND/16 and EX-BUNSO had no suckers. From the studies conducted, the corm diameter of the accessions ranged from 20.5 to 31.0 cm. Accession CE/MAL/32 had the highest corm diameter (31.0 cm) and the lowest corm diameter was recorded for accession BL/SM/115 (20.5 cm). The corm length was between 12.5 and 18.5 cm among the accessions. The highest corm length was seen in accession BL/SM/10 (18.5) and accessions BL/SM/132 and BL/SM/115 however, recorded the lowest corm length (12.5 cm). Corm weight of the accessions ranged between 0.26 to 0.79 kg. Accession CE/MAL/32 had the highest corm weight (0.79 kg) among the accessions studied and accession BL/SM/132 however, recorded the lowest corm weight (0.26 kg). For economic yield, the range was between 0.09 and 0.21 kg, and accession BL/SM/16 recorded the best economic yield (0.21 kg) with accession SAO/006 recording the worst economic yield (0.09 kg) among the accessions studied. The biological yield of the accessions ranged from 0.09 to 0.29 kg. With this, accession ELO/002 recorded the best biological yield (0.29 kg) and the worst biological yield was recorded for accession SAO/006 (0.09 kg). Table 5 shows that, harvest index among the accession ranged from 65.5 to 97.8% with accession SAO/006 recording the highest of 97.8% and accession ELO/002 recorded the least harvest index of 65.5%. For dry matter among the accessions, the range was between 17.7 to 40.3%. Accession BL/SM/132 had the best dry matter of 40.3% and accession SAO/006 recorded the least dry matter of 17.7%.

Diversity among the accessions

Figure 6 shows a dendrogram for the existing diversity and similarity among the taro accessions based on agro-morphological traits At similarity index of 0.94 (94.0%), five major clusters were identified and the number of accessions belonging to each cluster varied from 1 to 12. Cluster I consisted of two accessions (CE/MAL/32 and BL/SM/116). Cluster II was also made up of two accessions (BL/SM/10 and CE/IND/16). Cluster III had the highest number of accessions including KA/035,

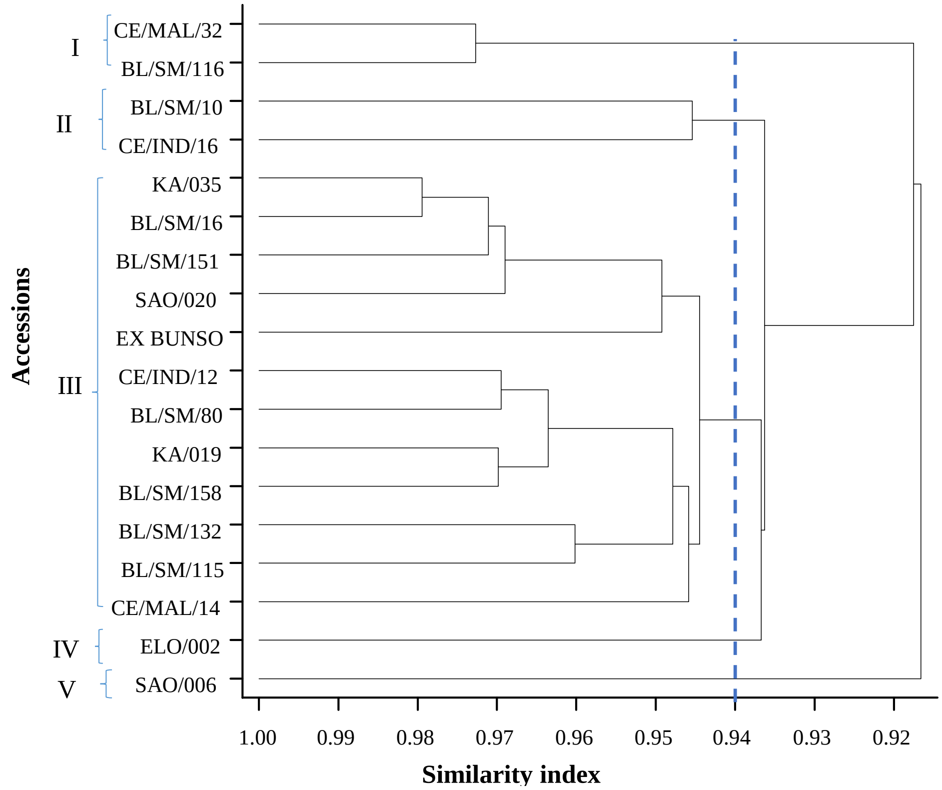


Figure 6. Cluster analysis of 18 accessions of taro using morphological characters

Table 6. Principal component analysis of the morphological traits of the taro accessions.

Character	PC1	PC2	PC3
BY	0.00191	0.00276	-0.00134
CD	0.09790	-0.09745	-0.11907
CL	0.05346	-0.04685	-0.15807
CW	0.00561	-0.00369	-0.00840
DM	0.01577	-0.06010	0.94245
EY	0.00120	0.00048	-0.00029
HI	-0.35871	-0.92099	-0.04659
LL	0.32065	-0.06970	-0.1819
LW	0.21951	-0.10108	-0.16424
NLP	0.02596	0.00292	-0.00563
NStP	0.15214	-0.03985	0.00373
NSuP	-0.08532	-0.09117	0.00728
PH	0.82249	-0.33388	0.10111
Variation (%)	53.98	33.61	7.54

BL/SM/16, BL/SM/151, SAO/020, EX-BUNSO, CE/IND/12, BL/SM/80, KA/019, BL/SM/158, BL/SM/132, BL/SM/115 and CE/MAL/14. Clusters IV and V consisted of only one accession each: ELO/002 and SAO/006 respectively. At similarity index of 1.00 (100%), all the accessions were totally distinct from each other.

Principal component analysis

The first five principal components (PCs) cumulatively accounted for over 98% of variation (Table 6). The first component (PC1) alone explained 53.98% of total variation and was mainly associated with characters such as plant height, leaf length and leaf width. The second principal component (PC2) explained 33.61% of variation.

Association among traits

Table 7 shows the character associations among the 18 taro accessions studied. The results show strong significant ($p<0.001$) and positive correlation between biological yield and corm weight (0.55*), economic yield (0.88***) and number of leaves per plant (0.55*). There was significant ($p<0.001$) but negative correlation between biological yield and harvest index (-0.70***) as well as number of suckers per plant (0.55*). Corm diameter showed significant ($p<0.001$) and positive correlation with corm length (0.83***), corm weight (0.94***), economic yield (0.62**), leaf length (0.57**), leaf width (0.66**), number of leaves per plant (0.56**)

Table 7. Correlation matrix among morphological characters of the taro accessions.

Characters	BY	CD	CL	CW	DM	EY	HI	LL	LW	NLP	NStP	NSuP	PH
BY	1												
CD	0.42	1											
CL	0.45	0.83***	1										
CW	0.55*	0.94***	0.92***	1									
DM	-0.15	-0.09	-0.34	-0.18	1								
EY	0.88***	0.62**	0.57**	0.70***	0.07	1							
HI	-0.70***	0.13	0.08	0.01	0.08	-0.35	1						
LL	0.38	0.57**	0.38	0.51*	-0.07	0.43	-0.25	1					
LW	0.32	0.66**	0.45	0.59**	-0.1	0.41	-0.09	0.94***	1				
NLP	0.55*	0.56**	0.51*	0.63**	-0.04	0.52*	-0.43	0.66**	0.69***	1			
NStP	0.18	0.4	0.31	0.35	0.06	0.17	-0.2	0.70***	0.71***	0.69***	1		
NSuP	-0.55*	-0.1	-0.12	-0.16	0.05	-0.32	0.75***	0.52*	-0.36	-0.59**	-0.69**	1	
PH	0.27	0.57**	0.45	0.56**	0.11	0.37	-0.15	0.84***	0.84***	0.76***	0.79***	-0.42	1

*=Significant at P<0.05, **=Significant at P<0.01, ***=Significant at P<0.001, CD=corm diameter, CL=corm length, BY=biological yield, CW=corm weight, DM=dry matter, EY=economic yield, HI=Harvest Index, LL=leaf length, NLP=number of plant, NStP=number of stolons/plant, NSuP=number of suckers/plant, PH=plant height.

and plant height (0.57**). The results also showed that corm length had strong significant (p<0.001) and positive correlation with corm weight (0.92***) and significant (p<0.01) and positive correlation with economic yield (0.57**) as well as number leaves per plant (0.51**). Corm weight correlated significantly (p<0.01) and positively with economic yield (0.70***), leaf width (0.59**), number of leaves per plant (0.63**), plant height (0.56**) and leaf length (0.51*). Economic yield correlated significantly (p<0.05) and positively with number of leaves per plant (0.52*). The correlation between harvest index and number of suckers per plant was also significant (p<0.001) and positive (0.75***). Leaf length showed significant (p<0.001) and positive correlation with leaf width (0.94***) and plant height (0.84***). Leaf length again was significant (p<0.01) and positive with number of leaves per plant (0.66**). There was also significant (p<0.001) and positive correlation between leaf width and number of leaves per plant (0.69***), number of stolons per plant (0.71***) and plant height (0.84***). Number of leaves per plant also showed significant (p<0.001) and positive correlation with number of stolons per plant (0.69***) and plant height (0.76***); however, it showed significant (p<0.01) and negative correlation with number of suckers per plant (-0.59**). Number of stolons per plant correlated significantly (p<0.001) and positively with plant height (0.79***) and significantly (p<0.01) but negative with number of suckers per plant (-0.69**).

DISCUSSION

Variation in qualitative traits

There was a wide range of variability in most of the qualitative traits studied except for shape of lamina, leaf lamina margin, leaf vein pattern and sinus. The green petiole colour of some of the accessions suggests that they might have made contribution to the production of assimilates which were channeled to the economic part of the plant which resulted in some accessions (CE/MAL/32, BL/SM/10 and BL/SM/116) with green petioles having the greatest corm weight, while those with non-green petiole colour particularly BL/SM/132 had low corm weight. The presence of many stolons and suckers probably had little or no effect on the accession's ability to produce reasonable corm weight as some of the accessions such as SAO/006 and CE/MAL 32 had greater number of suckers and stolons, respectively, and still recorded a significant corm weight (0.5 and 0.79 kg, respectively). This suggests that stolons and suckers are independent structures from the 'mother corm' in assimilate production and thus do not affect the mother corm.

The diversity in eating quality among the accessions collaborates with the findings of Opoku-Agyemang et al. (2004). It was seen that most of the accessions that were classified as good had high dry matter content. This also supports the findings of Markwei et al. (2000) in an ethno-botanical study on cocoyam and taro. It was observed that eating quality is one of the major characters that local farmers use to distinguish between cocoyam varieties, especially when all other visible characters fail to distinguish them. The variation in the vegetative and corm characteristics are in agreement with the works of Yared (2007) and Tewodros (2013) who identified variations in qualitative characters in taro.

Variability in quantitative traits

The analysis of variance of quantitative traits showed significant difference among the accessions for all the characters examined. Plant height among the accessions indicates that, the accessions were all tall as plants with heights greater than 50 cm are considered as tall plants (IPGRI/IITA, 1999) (Table 5). Accession CE/MAL/32 was highest in terms of corm weight and this could be attributed to the significant values for the growth parameters (plant height, leaf length, leaf width and number of leaves per plant). The low biological yield and high harvest indices for accessions SAO/006 and BL/SM/115 indicates that these accessions are early mature types and may have lost most of the vegetative parts at the time of harvesting. The studies show that there is a great potential of the accessions in future breeding programs of taro through selection for the improvement of the crop in Ghana. The significant difference in the traits among the accessions also gives enough room to select superior ones. Also, other workers including Asfaw (2006), Tewodros (2013) and Yared (2007) have reported a wide range of variation among taro (*C. esculenta*) species in Ethiopia. Furthermore, Muluneh (2006) and Tewodros (2008), reported similar results in yam and Amsalu (2003) in cassava.

Diversity among the accessions

The cluster analysis indicates the extent of diversity that is practical for use to breeders (Sultana et al., 2006). The range in similarity index for both morphological and biochemical traits among the accessions are large enough to suggest sufficient variability among the accessions. The dendrogram summarizing the existence of diversity and similarities among the accessions based on quantitative agro-morphological characters revealed that the accessions were clustered mainly by origin and by plant height (tall or dwarf plant). Accessions BL/SM/132 and BL/SM/115, which were clustered, are from Samoa and accessions SAO/006 and ELO/002 which were also clustered and very distinct are landraces. Accessions CE/IND12, BL/SM/80, KA/019 and BL/SM/158 were clustered and are tall plant (plant height >50 cm).

Principal component analysis (PCA)

PCA was used to obtain a simplified view of the relationship between variables, and the PCA loading are presented in Table 6 for morphological traits. The first principal component (PC1 = 53.98%) contributed more to the total variation in morphological traits and plant height, leaf length and leaf width had a high contributions towards the variability among the accessions. This suggests that for any improvement in the yield of taro, attention should be on plant height, and traits that correlated positively and significantly such as leaf length, leaf width and number of leaves per plant as they contributed to the plant height and yield. This means that higher plant height could restrict high harvest index and number of suckers per plant. This study is in line with earlier reports on taro germplasm by Tewodros (2013) in Ethiopia on the contribution of PC1 to variation in taro on morphological traits.

Association among the traits

The results show significant ($p<0.001$) correlation among some of the accessions. Traits with significant ($p<0.001$) and positive correlation suggest that these traits could be improved together. The significant ($p<0.001$) but negative correlation between some of the traits signifies that an increase in one trait could result in a decrease in the other. The strong significant ($P<0.001$) and positive correlation of the growth parameters and yield parameters agrees with the findings of Rubaihayo et al. (2001) and Pandey et al. (2005) in cassava and potato, respectively. Therefore, selection based on these traits will be efficient to maximize the fresh corn yield as well as future improvement program of taro.

Conclusion

From this study, it can be concluded that agro-morphological characterization was useful in identifying variations among the accessions. The positive correlation between yield components and leaf length, leaf width, number of leaf per plant and plant height indicates that the yield of taro can be improved by concentrating on these characters. The study also indicates that there is a wide range of variation in different traits of *C. esculenta* in the country (Ghana). Nine accessions: CE/MAL/32, BL/SM/158, BL/SM/10, BL/SM/116, CE/IND/16, BL/SM/132, BL/SM/16, CE/MAL/14 and SAO/006 possess desirable characters such as earliness and yield which could be exploited for varietal development of taro in Ghana. Therefore, there is need to consider effort in conservation and research into taro.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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