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## MORPHOLOGICAL DIVERSITY OF THREE CULTIVARS OF TARO (*Colocasia esculenta* L.) AS INFLUENCED BY TRAINING METHODS AND PLANT SPACING IN IBADAN METROPOLIS, NIGERIA.

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### ABSTRACT

Cutting down all the established stems of taro is a common practice in Nigeria among the cocoyam farmers. Morphological descriptors were used to characterize three cultivars of taro grown under this training methods and density. It is a 4x3x2 factorial experiment laid out in a Randomized Completely Block Design (RCBD) with three replications. Results of Analysis of Variance showed that plant height, leaf surface position, leaf area index and leaf colour, interacted significantly to the maximum production of increased number of corms, corm length, corm weight, cormel weight and corm width. Result of principal component analysis explained morphological characters like plant height, leaf surface position, leaf colour, leaf area index, cormel weight, number of suckers or corms, flesh cormels colour and side shoot length or suckers, corm length and width and other yield component to be associated with the significant variations among the cultivars and can be used as a minimum descriptor for characterizing the taro cultivars. Correlation result showed that the plant height and leaf surface position are the principal traits that were significantly and positively correlated with the plant height type, shapes of cormels, corm shape and flesh corm colour, number of corms, corms weight and number of suckers. It was found out that cutting down of all the established stems of taro cultivar did not kill the plant mostly Ghana taro and Nkashi but rather improve their quantitative and qualitative yield/plant and should be practice for those going into commercial production as well as for breeding activities.

**Key words:** Influence, agro-morphology, diversity, cultivars, training methods, spacing

### INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schot) is a monocotyledon herbaceous aroids or root and tuber crop of the family Araceae and is commonly grown in the humid tropics of Asia, Africa and Latin America (Quero-Garcia *et al.*, 2010). It is one of the edible aroids (Shange, 2004; Lebot, 2009). Globally, it ranked fifth among the starchy root and tuber crops after cassava, potato, sweet potato and yam, has diverse traditional roles, and are prepared for eating in many different ways (Bamidele *et al.*, 2014; Igbabul *et al.*, 2014). Some varieties are used for the preparation of pounded fufu, a traditional dish often eaten in West Africa (Owuamanam *et al.*, 2010). Excellent varieties are known through propagation and yield performance. Propagation of taro is by the use of corms, cormels and cut corm tops of healthy plants, while the young leaves of taro (petioles and blades) are widely consumed (Matthews, 2014). There is a general problem of poor performance of Taro in Nigeria soils due to non-adoption of improved husbandry practices in taro production even when the crop are known to have strong resistant to ecological

challenges. This cultural practice can enhance performance of inherent traits of the crop. Among other improved methods of cultivating taro, including selection of improved varieties, spacing, to reheaping, raising moderate mounds, pruning and frequent weeding. Number of training methods existed and have been utilized for maximum yield of crops. Rajalingam *et al.*, (2017) noted that drape system of training in cucumber produced significantly maximum number of harvests (41.57), fruit yield per plant (13.15 kg), fruit yield per m<sup>2</sup> (19.94 kg) and estimated fruit yield (199.4 t/ha), while control registered lowest values for all these characters. Oga and Umekwe (2016) also noted that pruned plants of watermelon produced the longest vine (90.14cm), number of leaves (15.78), number of flowers (10.31) and number of fruits (2.63). Conversely, Tumuhimbise *et al.* (2009) asserted that plant population has been reported to impact taro growth, high plant population being associated with higher leaf area index corm yield due to high number of shoots per unit area.

In selection of improved varieties, collection, introduction and characterization are the preliminary steps in breeding program of any crop of research interest. Morphological assessment of crops including taro are the strongest tools used in taxonomic classification of plants, and this makes it application crucial (Ezeabara *et al.*, 2015). Morphological analysis can also help to identify clones and reduce duplication in cultivar collections maintained for conservation and breeding purposes (Khatemenlal *et al.*, 2019). Cultivar characterization and evolutionary process in viable populations are important links between the conservation and utilization of plant genetic resources (Mandal *et al.*, 2013). 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. Mwenye (2009) and Boampong *et al.*, (2018) noted that dendrogram indicated existence of diversity and similarities among the taro cultivars, cultivars were clustered mainly by plant height, petiole colour and corm weight. Manner and Taylor (2010) revealed that yield fluctuates because of difference in cultivar, planting density, fertilizer application levels, natural factors and cultivar. Training is a good cultural practice, the staked and pruned stem (shoots) can be used for various purpose. Taro's primary use is the consumption of its edible corm and leaves, since they are a good source of carotene, potassium, calcium, phosphorus, and iron (Deo *et al.*, 2009). Paul and Bari, (2011) also revealed that taro has a number of medicinal uses including, corms are used as an abortifacient, and to treat tuberculous ulcers, pulmonary congestion, crippled extremities, fungal abscesses in animals, and as an anthelmintic. Training methods like shielding, pruning both double or single pruned can harm or kill or revival a dying plant. According to Tumuhimbise *et al.*, (2009), plant population has been reported to impact taro growth, high plant population being associated with higher leaf area index, corm yield due to high number of shoots per unit area. Wider spacing tends to produce bigger, uniform corm shape and more suckers, whereas close spacing produces small corms (Joubert and Allemann, 1998, Tsedal, *et al.*, 2014). Taro is one of the underutilized crops grown in Nigeria and is grown mostly where crops can hardly survive. The essence of the study is to evaluate the relevance of training methods and plant spacing on morphological diversity of taro cultivars. Specific objective include: (i) To assess agro-morphological diversity among the three cultivars of taro (ii) To ascertain training methods best suited for growth and yield of taro (iii) To evaluate the effects of different husbandry practices on quality of taro (iv) To ascertain principal traits that characterized the grown taro cultivars.

#### Materials and methods

The field experiment was carried out at Owode extension research farm of Federal College of

Agriculture moor plantation, Apata, Ibadan Oyo state. The area lies along latitude 7° 50' North and longitude 3° 23' East. The annual rainfall and temperature range between 1500mm to 2000mm and 17.2 °C to 29.1 °C, respectively. The relative humidity is 67%. It is a clay soil, slightly acidic with pH value of 4.95 with moderate organic matter content. Three cultivars of taro were used in the experiment. Two of the taro cultivars (Nkashi and Nweduvu) was collected from Ebonyi State while one named Ghana taro was collected from International institute of tropical Agriculture (IITA) as improved variety. The taro was planted out on a field measuring 10.5m by 24.5m (257.25m<sup>2</sup>) which was prepared by ploughing and harrowing, and laid out into 8 plots of 3m by 2.5 m. Each plot contains 12 stands of three rows of Taro. It is a 4x3x2 factorial experiment laid out in a Randomized Complete Block Design (RCBD) with three replications. A plant spacing of 60x60cm and 50x50cm was used, the cultural training of the taro include Po-No stolon or shoots removed, P1- 2 shoots removed, P2-3 shoots removed before removal of the inner growing shoots, P3 - 4 shoots removed first before removal of the inner growing shoots. Data collected include plant height, stem girth, number of leaf, leaf area index, leaf colour surface position, leaf colour, leaf area index, number of suckers or corms, side shoot length or suckers, leaf sheath colour cormel weight, number of corms, number of cormels, flesh cormels colour, cormel length

Shape of cormels, cormel weight and shape of cormel. Data collected was subjected to analysis of variance (ANOVA) using SAS version 10.2 (2008) statistical computer packages and significant means compared using the least significant difference (LSD), while Principal component analysis and correlation analysis were done using a statistical software package of ade4: tools for multivariate data analysis as described by Martin-Bautista. and Larsen (1999).

#### Result and Discussion

The result indicate that the taro cultivar use was collected in three locations, each of which were identified with wide variabilities in traits (Table 1). The values number one to number three indicate the number of cultivars and the traits they exhibit in each case. The result indicate that a cultivar can produce a dwarf type of sucker as well as intermediate or long suckers. This indicate the high level of variabilities among the grown cultivar (Table 1)

#### Effect of training methods and spacing on morphological diversity of taro cultivars

None removal of stems of the suckers retarded the growth of the shoot and stems of the taro cultivars. Removal of fours stems allowed the tagged stems to grow vigorously. Ghana taro cultivar produced the longest stem (117.13cm) followed by Nkashi (115.87) and the least was cultivar Nweduvu (Table 2). None pruning increased significantly the stem girth, number

of leaf but reduced leaf area index. There was significant interaction at spacing and variety, variety and prune type significantly interacted only for leaf area index. This implies that wider spacing and pruning types mostly removal of 2 to 4 stems at interval enhances morphological variability among grown cultivars of taro. This result is in line with Joubert and Allemann (1998).

#### **Effect of training methods and spacing on morphological diversity on the yield taro cultivars.**

Ghana taro produced the highest number of corms (22.50), longest, widest corms (17.11cm and 6.25cm) and weightiest corm (7.9 t/ha). This was followed by cultivar Nkashi which had statistical similar with the yield of Ghana taro/IITA cultivar. Spacing and pruning types significantly interacted on the yield of taro cultivars (Table 3). There was significant interactive effect on spacing and cultivar on the number of corms, corm length, corm weight, while interaction on spacing, variety and prune types were obtained on the corm width and weight in tons per hectare. The vegetative yield was converted to yield on corm as Ghana taro produced the highest number of corms or suckers, corm length, corm width and corm weight. However, yield difference could be attributed to individual performance of the cultivars, wide spacing, and pruning types among other factors. This result agreed with Manner and Taylor, (2010) who asserted that yield fluctuates because of difference in cultivar, planting density, fertilizer application levels, natural factors and cultivar.

Pruning stems up to 4 stems per plant ensures maximum productions of cormel (subsidiary suckers) than corms (main suckers). The cormel of Ghana Taro obtained in IITA is an improve cultivars and produced the highest number of corms (26.15), longest cormel (5.87cm), widest cormel (3.19cm) as well as the weightiest (2.54 t/ha), which differed significantly among the cultivars. There was significant interactive effect on pruning type, spacing and cultivar on the number of cormels, cormel width, cormel length, and cormel weight, while interaction on prune types, spacing and cultivar was obtained except on cormel yield ton/ha. The interaction effect between the cultivars and training methods was significant as removal of some stems reduces the competition of spaces of the leaf, reduces nutrient stress and allows for healthy growth

#### **Principal component analysis result.**

The eight principal component selected among cultivars revealed that the first six components had Eigen values more than one and explained a total of 78.35% of the total variation. The first component "PC1" indicated 23.3 % of the total variation and was associated with characters like leaf surface position, leaf colour, leaf area index, cormel weight, plant height, number of suckers or corms, flesh cormels colour and side shoot length or suckers (Table 5). The

second principal component PC2 showed 20.7% of the total variation and this associated with characters like shape of cormels, number of cormels, flesh cormel colour, plant height, and leaf sheath colour. The third principal component is associated with leaf surface position, corm weight, plant height, cormel weight and shape of cormel, together accounted for 14.6%. About 7.5 percent of the total variation was explained by the fourth principal component and was related to characters like leaf vein colour, leaf surface position, shape of cormels and vein pattern. The fifth principal component accounted for 6.6% and is associated with characters like leaf area index, number of cormel, leaf sheath colour, leaf sheath edge colour and number of suckers. The sixth principal component is selected for having Eigen value greater than one and accounted for 5.7% and it is connected to characters like number of cormel and cormel length.

#### **Correlation result among the taro cultivars**

The correlation matrices between quantitative and qualitative traits (Table 6) established indicated that the plant height (PH) is the principal trait that is significantly and positively correlated with the plant height type, shapes of cormels, leaf surface position, corm shape and flesh corm colour. Number of corms is correlated with corms weight and number of suckers. While number of cormel is correlated with cormel weight and number of suckers but negatively correlated with flesh corm colour. The shape of cormels is correlated with leaf surface position, flesh cormels colour and the shapes of corm (sucker). The evaluated traits positively and significantly correlated with one axis to the other. This implies that the descriptor used contributed to maximum variability among the taro cultivars. The significant correlation of evaluated traits indicate that these traits can also be used for characterizing the morphological diversity of taro cultivars. This is in agreement with Khatemenla *et al.*, (2019). This findings is also synonymous Boampong *et al.*, (2018) asserted that there were high variability on the plant yield, veins colouration, leaf area index, broad leaves emanating from many suckers which correlated to high number of corms and cormels produced and this can be utilize as basis for genetic study.

#### **Conclusion**

Morphological characterization of taro cultivars indicated wide variation and cultural practice of pruning and population density would help to maintain traits that of genetic importance for the conservation and utilization of the crop in a breeding program. The morphological characters like plant height, leaf surface position, leaf area index, number of suckers, 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 Ibadan Southwest in Oyo State as well as Ebonyi Central zones in Ebonyi State Nigeria.

**Table 1. Collection, classifying qualitative traits according IPGR/IITA (1999) descriptors for taro**

No	Cultivar	Collection site
1	Nkashi	Onueke, Ebonyi State Southeastern Nigeria
2	Nweduvu	Idembia Ezza South, Ebonyi State Southeastern Nigeria
3	Ghana taro	International institute of tropical Agriculture (IITA)
	Growing attributes	Traits
i.	Number of sucker	2= 6 –10 = 2 (2, 3) , 3= 11 – 24 (1)
ii.	Side shoot length	1 = short (2) , 2= long (1, 3)
iii.	Plant height type	1=Dwarf (<50 cm) (2); 2=medium (50-100 cm) (1, 3); 3=tall (>100 cm) (1,3)
iv	Leaf vein colour	1=whitish; 2=yellow (1,2, 3); 3=orange; 4=green (2, 3); 5=pink; 6=red; 7=brownish (2); 8=purple (1, 2, 3)
v.	Vein pattern	1=V pattern ('V' space) (3); 2=I pattern ('I' space); 3=Y pattern ('Y' space) (2); 4=Y pattern and extending to secondary veins) (2)
vi.	Leaf sheath colour	1=whitish (3); 2=yellow (3, 2); 3=light green (1,2); 4=red purple (1,2,3); 5=brownish
vii.	Leaf sheath edge colour	1=dark brown (continuous) (1,2); 2=dark brown (not continuous) (3,2)
ix.	Corm shape	1=conical (1); 2=round (2,3); 3=cylindrical (1,3); 4=elliptical; 5=dumb-bell; 6=elongated (3,2); 7=flat and multi-faced; 8=clustered (1,2); 9=hammer shaped
x.	Cormel shape	1=conical (2); 2=round (2); 3=cylindrical (2,3); 4=elliptical; 5=elongated (1,3); 6=elongated and curved (1)
xi.	Leaf surface position	1=drooping (1, 3); 2=horizontal; 3=cup-shaped (2,3); 4=erect - apex up (1,2); 5=erect - apex down (3)
xii.	Flesh colour of cormels	1=white; 2=yellow; 3=orange; 4=pink; 5=red; 6=red-purple; 7=purple; 8=colour not uniform (lighter blotches or darker pigmentation))
xiv	Corm length	1- short 5-10cm (1,3), 2-intermediate 11- 15cm (1,2,3), 3- long- 16- 20cm (1,3)
Xv	Corm weight	Low (0.05-0.5kg) (2,3), medium (0.5 -1kg) (1,2,3), large(1.5 – 2kg) (1,3)

**Table 2. Influence of training methods and spacing on agro-morphology diversity and growth of taro cultivars**

Training methods	Plant h (cm)	Stem gt (cm)	No of leaf	Leaf Area Index
No Stems pruned	89.16	6.68a	7.20	891.44
2	93.68	10.43	6.99	966.23
3	102.33	10.98	6.86	999.12
4	133.12	8.77	4.78	899.59
LSD (0.005)	30.98	1.77	2.11	ns
Density (cm)				
60 x 50	119.76	11.58	7.44	986.69
50 x 50	99.89	9.13	6.72	887.32
LSD (0.005)	16.87	1.23	ns	ns
Cultivars				
C1- Nkashi/onueke	103.97	9.98	6.46	1012.56
C2-Nweduvu/onueke	115.87	10.05	6.29	986.74
C3-GhanaTaro/IITA	117.13	11.11	5.88	1289.26
LSD (0.005)	8.54	1.40	ns	149.09
Interactions				
Spacing*prunetype	Ns	Ns	Ns	Ns
Spacing*Variety	*	**	*	**
Spacing*variety* prunetype	Ns	Ns	Ns	*

Ns = not significant, \*, \*\* indicate significance effect of the treatment at 5% and 1% probability levels. h – Height, gt-girth, ci – cultivars

**Table 3. Influence of training methods and spacing on agro-morphology diversity and yield of corms taro cultivars**

Training methods	No of corms	Corm length (cm)	Corm width (cm)	Weight Kg/plant	Weight t/ha
No Stems pruned	16.24	9.44	4.68	1.76	5.76
2	18.48	7.56	6.89	3.67	9.67
3	20.14	10.29	5.78	2.45	7.85
4	23.11	9.98	6.38	3.77	10.12
LSD (0.005)	5.67	2.57	1.75	0.78	2.85
Density (cm)					
60 x 50	14.33	10.43	5.95	1.59	7.82
50 x 50	22.92	8.56	5.73	2.66	9.89
LSD (0.005)	6.03	1.8	Ns	0.52	2.21
Cultivars					
C1- Nkashi/onueke	18.77	11.34	6.31	2.14	6.92
C2-Nweduvu/onueke	20.87	9.56	4.78	2.11	8.56
C3-GhanaTaro/IITA	22.50	13.11	6.25	2.05	9.88
LSD (0.005)	2.45	3.76	1.10	Ns	2.55
Interactions					
Spacing*prunetype	n**	**	Ns	Ns	**
Spacing*Variety	*	**	*	**	**
Spacing*variety* prunetype	Ns	Ns	Ns	*	**

Ns = not significant, \*, \*\* indicate significance effect of the treatment at 5% and 1% probability levels. h – Height, gt-girth, ci – cultivars

**Table 4. Influence of training methods and spacing on agro-morphology diversity and yield of comel**

Training methods	No of comel	Cormel length (cm)	Cormel width (cm)	Weight Kg/plant	Weight t/ha
No stems pruned	17.22	7.22	3.40	1.46	1.57
2	20.06	6.62	3.20	1.75	1.64
3	19.33	5.68	2.78	2.35	2.22
4	23.78	7.09	3.59	2.98	2.52
LSD (0.005)	5.55	1.69	0.68	0.79	0.85
Density (cm)					
60 x 50	18.27	5.98	2.79	1.17	1.13
50 x 50	25.07	8.36a	4.50	1.97	2.46
LSD (0.005)	4.13	2.67	1.09	0.78	0.65
Cultivars					
C1- Nkashi/onueke	17.35	3.13	1.89	1.75	1.87
C2-Nweduvu/onueke	23.04	4.21	2.99	2.09	1.95
C3-GhanaTaro/IITA	26.15	5.87	3.19	2.44	2.54
LSD (0.005)	5.78	1.29	0.47	0.35	0.65
Interactions					
Spacing*prunetype	**	**	*	*	**
Spacing*Variety	*	**	Ns	**	**
Spacing*variety* prunetype	*	**	*	*	ns

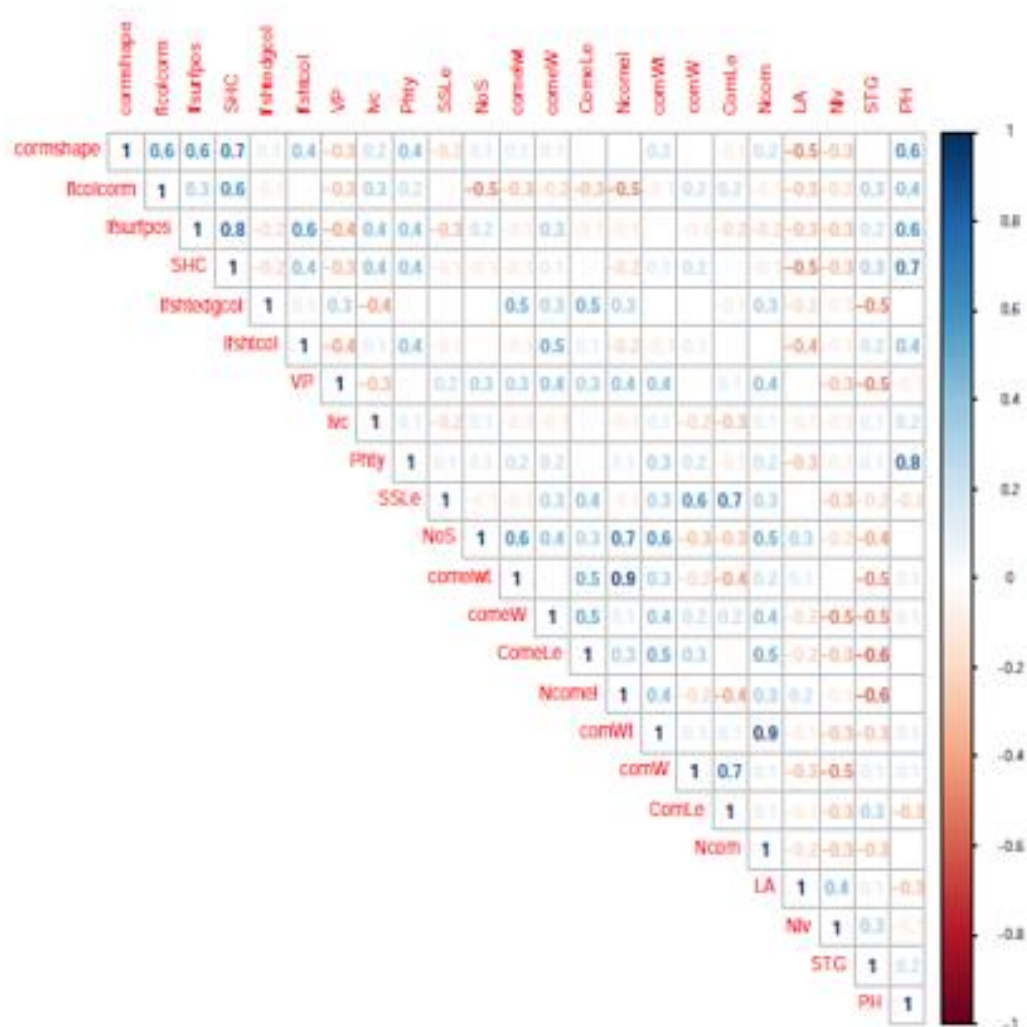
**Table V. Principal component analysis**

Variables	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
Eigen value	5.36	4.76	3.36	1.72	1.52	1.31	0.99	0.86
Proportion	23.29	20.69	14.61	7.47	6.62	5.68	4.33	3.72
Cumulative	23.29	43.98	58.59	66.06	72.68	78.36	82.69	86.41
PH	0.66	0.42	0.36	0.72	-0.53	-0.26	-0.61	0.86
STG	0.37	0.21	-0.31	-0.14	-0.57	-0.41	-0.65	-0.36
Nlv	-0.36	-0.29	-0.45	-0.04	0.01	0.54	0.36	0.43
Leaf Area	-0.56	-0.34	-0.53	-0.50	0.40	-0.32	-0.20	-0.13
Ncorm	0.29	0.02	-0.15	0.32	0.20	0.32	0.43	0.92
Cormle	0.72	0.34	-0.21	0.78	0.10	-0.59	0.11	0.14
CormW	0.22	-0.23	-0.49	0.61	-0.31	-0.72	-0.02	-0.01
CormWt	0.20	0.02	0.48	0.12	-0.03	-0.11	-0.32	0.52
Ncormel	0.58	0.52	-0.38	0.15	0.93	0.76	-0.01	-0.03
CormeLe	-0.38	-0.41	0.34	-0.27	0.18	0.55	0.14	-0.52
Cormelw	-0.36	0.64	-0.23	-0.23	0.50	0.07	-0.34	-0.21
cormelwt	0.62	-0.56	0.54	0.33	0.43	-0.23	-0.33	0.19
NoS	0.33	-0.23	-0.15	0.21	0.05	0.34	-0.29	-0.46
Ssle	0.46	-0.34	0.43	0.17	0.21	-0.12	0.28	-0.42
PHty	0.12	0.21	0.10	-0.08	-0.27	-0.41	0.39	-0.40
Ivc	-0.25	-0.12	-0.13	0.53	0.17	-0.25	0.10	0.85
Vp	-0.35	0.26	0.37	0.35	0.41	0.41	0.47	-0.10
Ifshtcol	0.13	0.46	0.16	0.58	0.16	0.01	-0.31	0.42
Ifshedgecol	0.25	0.35	-0.45	0.50	0.31	0.51	-0.12	-0.51
SHC	-0.24	0.46	0.04	0.47	0.32	-0.21	-0.57	0.76
Isurfpos	0.82	-0.13	0.65	0.45	-0.31	-0.12	0.35	0.74
Ficolcorm	0.33	0.67	-0.12	-0.35	0.25	-0.58	0.33	0.46
Cormshape	0.69	0.65	0.78	-0.31	0.12	0.22	-0.67	0.68

PC1— principal component 1, PH— plant height, STG – stem girth, Nlv – Number of leaf, Ncorm— Number of corm, cormle- corm length, cormW – corm width, CormWt– corm weight, Ncormel- number of cormel, cornele- cormel-length, CormelW – corm width, cormelWt-cormel weight, Nos – number of suckers, ssle- side shoot length or suckers, PHty – plant height type, Lvc – leaf vein colour, VP- vein pattern, Ifshtcol – leaf sheath colour, Ifshedgecol – leaf sheath edge colour, SHC – shape of cormels, Isurfpos- leaf surface position, ficolcorm - flesh colour cormels



**Table 6: correlation matrix for taro cultivars**



## References

- Akwee, P.E., Netondo, G. and Palapala, V.A. (2015). Comparative analysis of phenotypic characterization of Kenya and Pacific Islands tarogen germplasm collections *Colocasia esculenta* L. (Schott). *Scientia Agriculturae*. 9(2): 113-119
- Bamidele, O. P, Ogundele, F. G., Ojubanire, B. A., Fasogbon, M.B., Bello, O. W. (2014). Nutritional composition of "gari" analog produced from cassava (*Manihot esculenta*) and yautia (*Colocasia esculenta*) tuber. *Food Sci. Nutri*. 2(6):706-711. DOI: 10.1002/fsn3.165.
- Boampong, R., Aboagye, L.M., Nyadanu, D. and Esilfie, M. (2018). Agro morphological characterization of some taro (*Colocasia esculenta* (L.) Schott.) Germplasms in Ghana. *Journal of Plant Breeding and Crop Science*. 10(8):191-202.
- Deo, P.C., Tyagi, A.P., Taylor, M., Becker, D.K., and Harding, R.M., (2009). Improving taro (*Colocasia esculenta* var. *esculenta*) production using biotechnological approaches. *South Pacific Journal of Natural Science* 27: 6-13.
- Ezeabara, C.A., Okeke, C.U., Amadi, J.E., Izundu, A.I., Aziagba, B.O., Egboka, P.T., and Udechukwu, C. D. (2015). Morphological Comparison of Five Varieties of *Colocasia esculenta* (L.) Schott in Anambra State, Southeastern Nigeria. *American Journal of Plant Sciences*. 6:2819-2825.
- Igbabul, B. D., Amove, J., Twadue, I. (2014). Effect of fermentation on the proximate composition, anti-nutritional factors and functional properties of yautia (*Colocasia esculenta*) flour. *Afr. J. Food Sci. Technol*. 5:67-74.



- IPGRI. (1999). Descriptors for Taro (*Colocasia esculenta*). International Plant Genetic Resources Institute, Rome, Italy
- Joubert, F. J. (1998). Review of Taro (*Colocasia esculenta* (L.) Schott). pp. 1-42. University of Pretoria.
- Khatemenla1, S. Alam, Deepa, B, Phookan, Prakash Kalita , Madhumita Barooah and Madhumita C. Talukdar (2019). Morphological characterization of some upland taro (*Colocasia esculenta* L. Schott) cultivars of North-East India. International journal of current microbiology and applied sciences 8(6):1944-1946.
- Lebot, V. (2009). Tropical root and tuber crops: Cassava, sweet potato, yams and aroids, CABI, Cambridge, UK.
- Lewu, M.N., Mulidzi, A.R., Gerrano, A.S. and Adebola, P.O. (2017). Comparative growth and yield of taro (*Colocasia esculenta*) accessions cultivated in the Western cape, South Africa. *International Journal of Agriculture and Biology*. 19: 589–594.
- Matthews, P. J. (2014). On the Trail of Taro: An Exploration of Natural and Cultural History. National Museum of Ethnology, Osaka, Japan.
- Mandal, R., Mukherjee, A., Mandal, N., Tarafdar, J. and Mukharjee, A. (2013). Assessment of genetic diversity in taro using morphometrics. *Current Agriculture Research Journal*. 1(2):79-85
- Martin-Bautista, M. J., Vila, M. A. and Larsen, H. I. (1999). A genetic algorithm approach to an adaptive information retrieval. *Journal of the American Society for information science* 50(9), 760-771.
- Muenye, O. J. (2009). Genetic diversity analysis and nutritional assessment of cocoyam genotypes in Malawi. M. Sc. thesis submitted to university of the Free State Bloemfontein, South Africa.
- Oga, I. O. and Umekwe, P. N. (2016). Effects of Pruning and Plant Spacing on the Growth and Yield of Watermelon (*Citrullus lanatus* L.) in Unwana-Afikpo. *International Journal of Science and Research (IJSR)*. Volume 5 (4): 2319-7064
- Owuamanam, C. I., Ihediohanma, N. C, Nwanekezi, E. C. (2010). Sorption isotherm, particle size, chemical and physical properties of yautia corm flours. *Researcher* 2(8):11-19.
- Paul, K. K., and Bari, M. A. (2011). Studies on direct and indirect effects of different plant characteristics on yield of taro (*Colocasia esculenta*) var. Antiquorum. *The Agriculturists* 9(1&2): 89-98.
- Paul, K.K. and Bari, M.A. (2012). Estimates of genetics components for yield and related traits in cocoyam. *A scientific Journal of Krishi Foundation, the Agriculturists*. 10(2):127-132.
- Quero-Garcia. J., Noyer, J. L., Perrier, X., Marchand, J. L., Lebot, V. (2004). A germplasm stratification of taro (*Colocasia esculenta*) based on agromorphological descriptors, validation by AFLP markers. *Euphytica*. 137:387-395.
- Shange, L.P. (2004). Taro (*Colocasia esculenta* (L.) Schott) production by small-scale farmers in KwaZulu-Natal: Farmer practices and performance of propagule types under wetland and dry land conditions. MSc. Thesis. University of KwaZulu-Natal, Pietermaritzburg
- Tsedalu, M., Tesfaye, B. and Goa, Y. (2014). Effect of type of planting material and population density on corm yield and yield components of taro (*Colocasia esculenta* L.). *Journal of Biological and Agriculture Healthcare*. 4: 124– 137.
- Tumuhimbise, R., Talwana, H.L., Osiru, D.S.O., Serem, A.K., Ndabikunze, B.K., Nandi, H. and Palapala, V. (2007). Growth and development of wetland-grown taro under different plant populations and seedbed types in Uganda. *African Crop Science Journal* 17: 49 – 60.
- Udechukwu, P.T. (2015). Morphological Comparison of Five Varieties of *Colocasia esculenta* (L.) Schott in Anambra State, Southeastern Nigeria. *American Journal of Plant Sciences*. 6:2819-2825
- Wayne Vandredre (1990). Greenhouse cucumber production. University of Alaska. Fair Banks Cooperative Extension Service 1990.
- SAS (2008). SAS Institute User's guide. version 10.2, SAS Institute, Cary, NC, USA.