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Assessment of Morphological Diversity In (*Cucuma longa* L) Landraces Using DUS Descriptor

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Abstract
Twelve genotypes of turmeric were characterized for 19 characters in the form of multistate scores given by DUS guidelines. The twelve genotypes were laid out in RCBD using three replications. The list of genotypes used was; Ajo (Igbaraodo), Turmeric Uromi, Atale (Yakooyo), kadi – Odo, Atale (Temidire), Red ginger Atale Kabba Market, Atale (Igbara odo), Uloko (Okobo), Atale pupa (Omifon), Red ginger (Yenegua)and Ege Apana The morphological characterization of genotypes helped in linking a character to a specific trait, with potential in utilization for trait-specific selection. Data were analyzed using the Generalized Linear Model (GLM) of the analysis of variance (ANOVA). The mean value, standard deviation (SD), coefficient of variation (CV) and maximum and minimum values (summary statistics) for each character were determined. Principal component analysis (PCA) of the mean data was performed using SPSS statistical software (SPSS version 16.6 for Windows, SPSS Inc. Chicago, USA). Results show that out of the nineteen descriptor traits used for this experiment, venation pattern, no of leaves on the main shoot, rhizome habit, lamina length, leaf colour on the dorsal side, no of mother rhizome and status of tertiary rhizome are good descriptor traits for characterizing turmeric landraces.

Keywords: Turmeric, Morphological, Characterization, Distinctiveness uniformity and stability (DUS)

Introduction

Turmeric (*Curcuma longa* L.) is a monocotyledonous, herbaceous, rhizomatous spice belonging to the ginger family Zingiberaceae (Amadi, *et a*l.2013) The genus *Curcuma* L. contains many taxa of economic, medicinal, ornamental and cultural importance, turmeric (*C. longa* L.) being the best known. The highest diversity is in India and Thailand, with at least 40 species in each area (Sasikumar 2005). It is mainly cultivated in South East Asia with India being the largest producer and exporter. In India, turmeric is one of the important spice crops and plays a vital role in the national economy (Deb, and Chakrobarty, 2017). Turmeric spice is obtained from the underground rhizomes which after drying and processing, results in a bright yellow powder used as a natural food dye. In addition, the presence of various compounds like cucumin, the yellow-coloured pigment, with pharmacological activities has broadened the commercial value of this crop (Ravindran *et al*. 2007). There is a long tradition of using turmeric in the Chinese and Ayurveda systems of medicine. Modern biomedical research also attests to the medicinal value of turmeric in a variety of ailments and it is thought to be indigenous to the Indian subcontinent due to its potent and popular uses, its cultivation spread from India to Southeast Asia, China, Northern Australia, the West Indies, and South and Central America (Jiang, 2005). In Nigeria, it is grown mainly in small plots around homes (Olojede, *et al*., 2005) and can be found in the wild (Olife *et al*., 2013). In the last few years as awareness of its many uses continues to increase, many farmers have begun to grow it as a cash crop, especially in the ginger-growing areas of the southern part of Kaduna State (Olojede, *et al*., 2005. Turmeric is a cross-pollinated, triploid species, which can be vegetatively propagated using its underground rhizomes (Sasikumar 2005). Since hybridization is ineffective in most cases, genetic improvement is often limited to germplasm selection and mutation breeding (Ravindran *et al.,* 2007). Using its underground rhizomes (Sasikumar 2005). It is mainly cultivated in South East Asia with India being the largest producer and exporter In Nigeria, it can be found growing from low altitude (5m above sea level) in the Southern coastal plains of the rainforest to the mid-altitude (823m above sea level) in the Derived Savanna within Longitude 03o 02'E - 09o30'E and latitude 4o37'N – 10o04'N (Olojede and Nwokocha, 2011). In addition to their role in the colourants of curries, these compounds have been reported to be anti-inflammatory (Lukita- Atmadja *et al*., 2002), anti-arthritic, anti-oxidant (Masuda *et al*., 1999), anti-allergic, anti-

bacterial (Fagbemi *et al*., 2009), anti-cancer (Shao *et al*., 2002; Duvoix *et al*., 2005), anti-coagulant, antispasmodic, anti-parasitic, anti-mutagenic (Shukla *et al*., 2002) and anti-viral (HIV) properties (Ammon and Wahl, 1991). The major essential oils in turmeric are bisabolane sesquiterpenes that include ar-turmerone, curlone, α-turmerone, β-turmerone as well as some other sesquiterpenes like zingiberene, curcumenone, curcumenol, procurcumenol, dehydrocurdione, and germacrone-13-al (He *et al*., 1998; Chattopadhyay *et al*., 2004). For these and many other reasons, turmeric has been widely used as a food additive, condiment, and medicine. Plant rhizome has also been used as a carminative, digestive stimulant and for treatments of colds and infections Chattopadhyay *et a*l., 2004). In addition, the rhizome has also been intensively used as a traditional medicine in China for the treatment of cancer (He *et al*., 1998). In the last few years as awareness of its many uses continues to increase, many farmers have begun to grow it as a cash crop, especially in the ginger-growing areas of the southern part of Kaduna State (Olojede and Nwokocha, 2011). Protection of Plant Varieties and Farmers Rights Act (2001) of Nigeria recommended the use of a distinctness, uniformity and stability (DUS) manual for characterizing turmeric genotypes. Morphological characterization is an important tool even in the era of molecular characterization because of its reliability and easy identification with fewer resources for certain stable characters unaltered with environmental interactions (Hildago, 2003). This study was to characterize twelve turmeric genotypes for different morphological and rhizome characters based on DUS guidelines. Therefore the objectives of this study are to:

1. To determine the morphological diversity among the genotypes
2. To determine high-yielding turmeric genotypes
3. To determine duplication of cultivars within the turmeric genotypes

Materials and Methods

The turmeric genotypes used for this study were collected from the Genetic Resources Unit of the National Root Crops Research Institute, Umudike, Abia State. The twelve genotypes were laid out in RCBD using three replications. The list of genotypes used was; Ajo (Igbaraodo), Turmeric Uromi, Atale (Yakooyo), kadi – Odo, Atale (Temidire), Red ginger Atale Kabba Market, Atale (Igbara odo), Uloko (Okobo), Atale pupa (Omifon), Red ginger (Yenegua)and Ege Apana. The plot size was $4m^2$ (2m x 2m) using raised beds, while the seedling rate was one rhizome/stand. The plants were spaced 50cm x 30cm apart between and within rows, respectively. Fertilizer application was at the rate of 400kg per hectare of NPK (15:15:15). First weeding was carried out between 4 weeks after planting, and roguing was carried out 10 weeks after planting. Three plants of uniform size and vigour were selected for recording observations. Genotypes were evaluated for 19 DUS traits viz., Plant: pseudostem habit, plant height (cm), number of shoots, number of leaves on the main stem, Plant leaves: leaf disposition, petiole length (cm), leaf lamina length (cm), leaf lamina width (cm), dorsal leaf colour, ventral leaf colour, leaf venation pattern, leaf margin, vigour. Rhizome: Rhizome habit, rhizome shape, rhizome internode pattern, status of tertiary rhizome, primary rhizome length, and number of mother rhizomes were recorded at harvest. The assessment of characters was done at 5 months when the plant growth and its morphological characters were optimal. Harvesting was done when the leaves were dried.

Data Analysis

Data were analyzed using analysis of variance (ANOA), and Principal component analysis (PCA) of the mean data was performed using SPSS statistical software (SPSS version 16.6 for Windows, SPSS Inc. Chicago, USA). The goal of principal components analysis is to explain the maximum amount of variance with the fewest number of principal components) which was used in identifying the few characters that significantly influenced the observed variation among the genotypes (Abdi and Williams, 2010).

Results and Discussion

Morphological characters are predominantly used as markers for easy differentiation of genotypes because the characters are expressed genetically involving one or more genes. Among the 12 turmeric genotypes studied, considerable variation was recorded for all the important characters Table 1. Out of 20 characters assessed based on DUS descriptors, characters such as rhizome habit of turmeric is characterized as intermediate and compact, among the genotypes studied ,5 genotypes of turmeric are Intermediate while 7 genotypes are compact (Fig 2), for plant height (cm) 8 turmeric genotypes are short(<5cm) in height,4 genotypes are medium in height (5 to 10 cm), number of shoots, turmeric genotypes with few number of shoot is 6, turmeric genotypes with many number of shoot is 2 while turmeric genotypes with medium number of shoot is 3, leaf lamina length (cm), 8 turmeric genotypes are short in lamina length (<30cm),while 4 turmeric genotypes is medium in lamina length (30-40cm) ,leaf lamina width (cm), 6 turmeric genotypes have medium length (10-15cm) while 6 genotypes are narrow in lenght (<10cm) ,dorsal leaf colour; 5 genotypes are light green on the dorsal side while 7 turmeric genotypes are green colour on the dorsal side of the leaf, leaf venation pattern; 8 turmeric genotypes are distance in venation pattern, while 4 turmeric genotypes is close in venation pattern, status of tertiary rhizome is present in 6 turmeric genotypes and absent in 6 turmeric genotypes, number of mother rhizome (Fig 1); 3 genotypes has one mother rhizome, 4 genotype has more than three mother rhizome while 5 genotype has two to three mother rhizome, all the 12 turmeric genotypes exhibit the same pseudo stem habit, leaf disposition, leaf petiole length (cm), ventral leaf colour, leaf margin, rhizome shape, rhizome internode pattern , primary rhizome length and vigor. Morphological variation among the turmeric genotypes using the DUS descriptor is represented in Table 1.

Coded List of Genotype Status

Explanation of the status of each character expressed by the genotypes

1. Plant height (cm): Short (<85) = 3, Medium (85-100) = 5
2. Number of shoots: Few (>5) =1, Medium (3-5) =3, Many (>5) = 3
3. Number of leaves on main shoot: Intermediate (5-10) = 5, Many (>10) = 7
4. Number of tillers: 2=2, 3-5=, more than 5=4
5. Plant petiole length (cm): Short (<15) = 3, Intermediate (15-25) =5, Long (>25) = 7
6. Leaf lamina length (cm): Short (<30) =3, Medium (30-40) =5, Long (>40) =7
7. Leaf lamina width (cm): Narrow (<10) = 3, Medium (10-15) =5, Broad (>15) =7
8. Leaf colour on the dorsal side: Light green =3, Green =5
9. Leaf colour on the ventral side: Dark green= 7, Green =5
10. Leaf venation pattern: Close =3, Distance= 5
11. Vigor: Highly vigorous = 1, moderately vigorous= 2
12. Leaf margin; Compact = 1, Open = 9
13. .Rhizome habit: Compact= 3, Intermediate=5, Loose= 7
14. Rhizome shape: Straight= 3, Curved=5
15. Rhizome internode pattern: Close (<1) = 3, Distant (>1) =5
16. Status of tertiary rhizome: Absent= 1, Present= 9
17. Primary rhizome length: Short (<5 cm) =3, Medium (5-10 cm) =5, Long (>10 cm) =7
18. Number of mother rhizome: One= 1, Two =3, More than 3=5
19. Internode pattern: Close (<1) = 3, Distance= (>1)

Among the 12 turmeric genotypes used, the mean yield performance showed that Ajo Igbara-odo has the highest yield (5.27 t/ha), followed by Atale papa omifon (4.70 t/ha), Red ginger (4.43 t/ha), Ege Apana (4.20t/ha), Atale Temidire (4.07t/ha) and Atale Yakoyo(4.03t/ha) respectively. There is a significant difference in yield performance in Ajo igbara odo and Ataale pupa omifon, but there is no significant difference between Atale papa omifon (4.70 t/ha), Red ginger (4.43 t/ha), Ege Apana (4.20t/ha), Atale Temidire (4.07t/ha) and Atale Yakoyo(4.03t/ha).

PCAn analysis of morphological trait

The PCA variable loading percentage explained and the cumulative variance for the first three components axes are given in Table 3. Out of the fifteen traits studied, three principal components exhibited more than one eigenvalue and showed 76.64% variability among the characters under investigation (Table 3) PC1 showed 39.56%, PC 2 showed 23.96% and PC 3 showed 13.08% variability among turmeric landraces used. Principal component one (PC 1), principal component two (PC 2) and principal component three (PC 3) had eigenvalues of 3.955, 2.396 and 1.308 respectively (Table 3). Furthermore, the first principal component (PC 1) accounted for 39.56% of the total variation and had factors with high contributions as the number of tillers, number of mother rhizome, rhizome weight and vigour. The second principal component (PC 2) accounts for an additional 23.96% of the total variation depicted in lamina width, lamina length, and plant height and lastly the principal component here (PC 3), accounts for an additional 13.08% of the total variation and had factors with high contribution as number of leaves on a main shoot, number of shorts and stationary rhizome status.

Conclusion

Findings show that out of fifteen descriptor traits used for this experiment, the number of mother rhizome, number of tillers, plant height, lamina length, lamina width, number of leaves on a main shoot, number of the shoots and stationary rhizome status are good descriptor trait for characterizing turmeric genotypes. The nine related characters showed that they are from the same family, but different in eleven traits which indicated they are different and distinct turmeric genotypes. However, since none of the genotypes are uniform in all the characters ranked, it showed that there was no duplication among the genotypes. The variations analyzed using DUS characters offer a bright scope for selections based on desirable morphological traits which can be used in future breeding programmes. Turmeric genotypes such as Ajo Igbaraodo (5.27 t/ha), Ataala pupa Omifon (4.70 t/ha) red ginger (4.43 t/ha), Ege Apana (4.20 t/ha), Atale Temidire (4.07t/ha) and Atale Yakoyo(4.03t/ha) will offer an Agronomic (yield) background for breeding high yield turmeric landraces.

References

Abdi, H. and Williams, L. J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics*, 2 (4): 433–459.

Amadi, C. O., Olojede, O.A., Eleazu, C., Obasi, C. P. and Nwokocha, C. C. (2013) Multi-location Evaluation of Turmeric Genotypes in Nigeria. *Journal of Agricultural Science and Technology*, 3: 842-846

Ammon, H. P. and Wahl, M. A. (1991). Pharmacology of Curcuma longa. Planta Med. 57:1–7. doi: 10.1055/s-200960004.

Chattopadhyay, J., Biswas, K., Bandyopadhyay, U. and Banerjee, R. K. (2004) Turmeric and curcumin: biological actions and medicinal applications. *Curr Sci*. 87:44–53.

Deb, B.C. and Chakrobarty, S. (2017). Evaluation of genetic variability and characterization of some elite turmeric genotypes in the Terai Region in India. *International Journal of Current Microbiology and Applied Science*, 6(5): 2357-2366.

Duvoix, A., Blasius, R., Delhalle, S., Schnekenburger, M., Morceau, F., Henry, E., Dicato, M. and Diederich, M. (2005). Chemopreventive and therapeutic effects of curcumin. *Cancer Lett.* 223:181–190. doi: 10.1016/j.canlet.2004.09.041.

Fagbemi, J. F., Ugoji, E., Adenipekun, T. and Adelowotan, O. (2009) Evaluation of the antimicrobial properties of unripe banana (Musa sapientum L.), lemon grass (Cymbopogon citratus

S.) and turmeric (Curcuma longa L.) on pathogens. *African Journal of Biotechnology*. 8 (7) 1176-1182

Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on turmeric (Curcuma longa L.). India. http://plantauthority.gov.in/pdf/Turmeric.pdf.

He X-G, Lin L-Z, Lian L-Z, and Lindenmaier, M. (1998) Liquid chromatography-electrospray mass spectrometric analysis of curcuminoids and sesquiterpenoids in turmeric (Curcuma longa). *J. Chromatogr*. A. 818 (1): 127-132. doi: 10.1016/S0021-9673(98)00540-8..

Hidalgo, R. (2003). Variabilidad genetic characterization the species vegetables. In: Franco TL Hidalgo, R (eds).Anarsi estadistico de characterization morfologigal de recursos fitogenteticos. Boletin Tecnico No 8 IPGRI, Cali, Colombia pp2-26 available at http/www.1pgri.cigar.org/Publications/pelf/894pdf(Accessed 10 June, 2016).

Jiang, H. (2005) Modern Tools to Study Traditional Medicinal Plants: Ginger and Turmeric. A Dissertation Submitted to the Faculty of the Department of Pharmaceutical Sciences, In Partial Fulfillment of the Requirements For the Degree of Doctor of Philosophy In the Graduate College The University of Arizona 2005. Pp. 262

Lukita-Atmadja, W., Ito, Y., Baker, G. L., and McCuskey, R. S. (2002) Effect of curcuminoids as anti-inflammatory agents on the hepatic microvascular response to endotoxin. *Shock*. 17:399–403. doi: 10.1097/00024382-200205000-00010.

Masuda, T., Hidaka, K., Shimohara, A., Maekawa, T., Takeda, Y., and Yamaguchi H. (1999) Chemical studies on antioxidant mechanism of curcuminoid: analysis of radical reaction products from curcumin. *J Agric Food Chem.* 47:71–77. doi: 10.1021/jf9805348.

Olife, I. C., Onwualu, A. P., Uchegbu, K. I. and Jolaoso, M. A. (2013) Status Assessment of Spice Resources in Nigeria. *J Biol, Agric and Healthcare*, 3(9):12-18.

Olojede, A. O. and Nwokocha, C.C. (2011). A decade of research on minor root and tuber crops at NRCRI: The contribution towards food sufficiency and economic empowerment in Nigeria, In Root and Tuber Crops Research for Food Security and Empowerment. C. O. Amadi, K. C. Ekwe, G. O. Chukwu, A. O. Olojede, C. N. Egesi (Eds). 2011.387-396.

Olojede, A. O., Iluebbey, P. and Dixon, A.G.O. (2005) IITA/NRCRI Collaborative Germplasm and data collection on minor Root and Tuber Crops in Nigeria. In: Annual report 2005 National Root Crops Research Institute, Umudike: Pp. 77-8.

Ravindran, P. N., Babu, K. N. and Sivaranan, K. (2007). Turmeric: the genus Curcuma: medicinal and aromatic plants – industrial profiles. CRC press, Boca Raton, 484p

Sasikumar B (2005). Genetic resources of curcuma: diversity, characterization and utilization. *Plant Genet Res* , 3: 230-251.

Table 1: Morphological variation among turmeric genotypes (Using DUS descriptor)

Names	Pseudo stem habit	Plant height(cm)	No of shoots	No of leaves on the main shoot	Leaf disposition	leaf petiole length(cm)	Lamina length	Lamina width(cm)	Venation pattern	Leaf margin	Leaf colour on the ventral side	Leaf colour on the dorsal side	Vigor	Rhizome habit	Rhizome shape	Primary rhizome length(cm)	No mother rhizome	Internode pattern (cm)	Status of stationary rhizome	Number of Tillers	Rhizome weight (kg/plot)
Ajo (Igbaraodo)	9	3	6	5	5	3	3	3	5	5	5	3	1	5	5	5	1	3	9	6	6
Turmeric Uromi	9	3	3	5	5	3	5	3	5	5	5	5	1	3	5	5	3	3	9	4	4
Atale (Yakooyo)	9	5	5	5	5	3	3	5	5	5	5	3	1	3	5	5	1	3	1	3	5
kadi – Odo	9	3	3	5	5	3	5	5	5	5	5	3	1	5	5	5	3	3	9	3	5
Atale (Temidire)	9	3	5	5	5	3	5	3	3	5	5	5	1	3	5	5	1	3	9	4	6
Red ginger	9	3	4	5	5	3	3	5	5	5	5	3	1	5	5	5	1	3	9	5	6
Ege Apana	9	5	5	7	5	3	3	5	5	5	5	3	1	3	5	5	1	3	9	5	6
Atale (Kabba market)	9	3	5	5	5	3	3	3	3	5	5	5	1	5	5	5	3	3	1	2	2
Atale(Igbara-Odo)	9	5	4	5	5	3	3	5	5	5	5	5	1	5	5	5	5	3	1	3	5
Utoko (Okobo)	9	3	3	6	5	3	3	3	3	5	5	5	1	3	5	5	5	3	1	3	3
Atale pupa (Omifon)	9	5	6	5	5	3	5	5	5	5	5	5	1	3	5	5	3	3	1	3	5
Red ginger Yenegoua	9	3	4	5	5	3	3	3	3	5	5	5	1	3	5	5	5	3	1	3	2

Note: Each column is a character and rows respective state or genotype

Table 2: Mean Yield Performance (t/ha) of 12 turmeric genotypes evaluated

Turmeric landraces	Mean t/ha
Ajo Igbara odo	5.27
Ataale pupa omifon	4.70
Red ginger	4.43
Ege Apana	4.20
Atale Temidire	4.07
Atale Yakoyo	4.03
Atale Igbaraodo	4.03
Kadi Odo	3.93
Turmeric Uromi	3.47
Utoko (Okobo)	2.1
Atale Kabba market	1.76
Red ginger yenegoa	1.70
FLSD (P <0.05)	0.85

Table 3: Factor loading on 15 morphological traits of three principal components and percentage of variance accounted for each component

Character (Traits)	PCA 1	PCA 2	PCA 3
Plant height	0.085	0.418	-0.327
No of leaves in the main shot	0.287	-0.230	-0.588
No of shoots	-0.135	-0.195	0.542
Leaf petiole length	0.000	0.000	0.000
Lamina length	0.161	0.490	0.172
Lamina width	0.156	0.567	0.080
Vigor	0.403	-0.221	-0.163
Primary rhizome length	0.000	0.000	0.000
No mother rhizome	-0.413	0.066	-0.156
Rhizome shape	0.000	0.000	0.000
Internode pattern	0.000	0.000	0.000
Stationary rhizome status	0.382	-0.165	0.332
No of tillers	0.442	-0.182	0.037
Pseudo stem habit	0.000	0.000	0.000
Rhizome weight	0.407	0.239	0.244
Eigenvalue	3.955	2.396	1.308
% variance contribution	39.56	23.96	13.08
% cumulative contribution	39.56	63.55	76.64

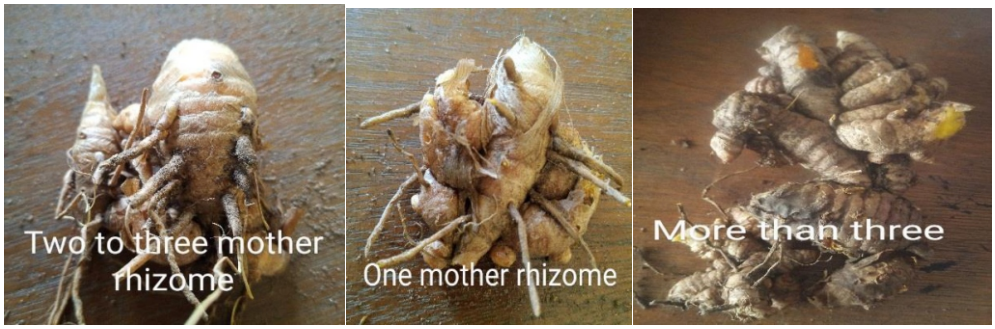

Fig.1: Morphological variations in the number of mother rhizomes among the genotypes

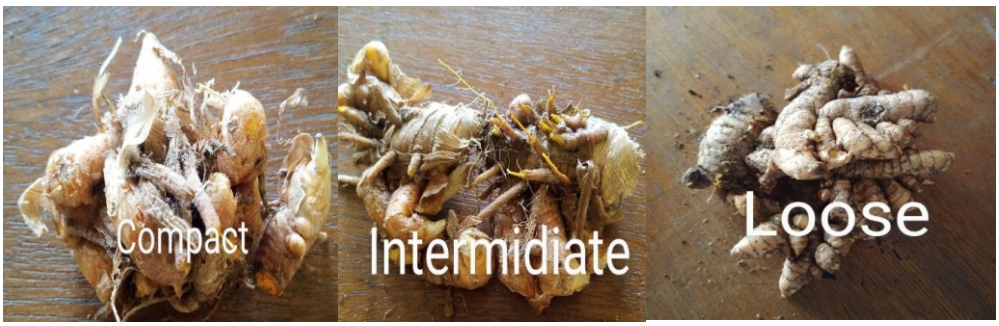

Fig. 2: Morphological variations in Rhizome habit among the genotypes