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Morphological Characterization, Variability and Traits Association among Accessions of Three Species of *Crassocephalum* (Moench.) S. Moore from Nigeria

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Abstract
Crassocephalum species have served as vegetables for decades, yet they remain undomesticated and uncultivated. The knowledge of the variability and traits association of these species could enhance the improvement and thus facilitate their domestication and cultivation. Twenty-one accessions of *Crassocephalum* species were characterized in a Randomized Complete Block Design to determine intra and inter-specifies variability and traits association for their improvement with a view to facilitate their domestication and cultivation. One way Analysis of Variance (ANOVA), Principal Component Analysis (PCA), and correlation coefficients were used to analyze the data. The results revealed significant intra and inter-specifies variability among the accessions characterized. The first three axes of PCA accounted for over 60% of total variation with leaf length, leaf width, days to 50% flowering, days to maturity, number of achenes/head and number of filled achenes/head as discriminants. Positive and significant phenotypic correlations were observed between leaf length and leaf width with petiole length, internode length, peduncle length, and number of days to maturity. High positive correlation was observed for number of capitula/plant with capitulum diameter and number of filled achenes per head. Hence, the principal contributors to total variation which are leaf length, leaf width, days to 50% flowering, days to maturity, number of achenes/head and number of filled achenes/head are hereby suggested to breeders in developing a suitable breeding programme for *Crassocephalum crepidioides*, *C. rubens* and *C. togoense*.

Keywords: Crassocephalum, Characterization, Crop improvement, Breeding, Cultivation

Introduction

The consumption of vegetables is important to most Nigerians and the entire world due to their nutritional and medicinal benefits. They are generally grown by both peasant and commercial farmers in Nigeria to serve as source of income. Major vegetables that are commonly cultivated are Okra, *Amaranthus*, and *Corchorus*, but there are others which people have consumed for decades or centuries but are neglected due to low research attention, non-domestication and non-cultivation (Gruber, 2017). The vegetables in this category are usually referred to as underutilized or orphan vegatables, but they can promote better nutrition, if given proper research attention (Pingali, 2012). One of these underutilized vegetables is *Crassocephalum* (Schramm *et al.*, 2021). *Crassocephalum* is a green leafy vegetable popular among numerous edible vegetables common to the Yoruba people in Nigeria (Olufolaji and Denton, 2000 and Bankole *et al.*, 2003). Schramm *et al.* (2021) described *Crassocephalum* as an African orphan leafy vegetable mainly collected from the wild. Oyelakin and Ayodele (2013) reported that *Crassocephalum* is mainly collected from abandoned farmlands, roadside and waste dumping sites. *Crassocephalum* species are highly nutritious and medicinal with appreciable minerals, protein and antioxidants (Adjatin *et al.*, 2013). The nutritional composition reported for *Crassocephalum* is similar to the values obtained for some other leafy vegetables, such as *Corchorus olitorus* (Oguntona *et al.*, 1989) and *Amaranthus cruentus* (Fasuyi, 2006). Therefore, they may serve as substitutes to animal protein in this present dispensation when animal proteins are becoming unaffordable. The leaves are useful in the treatment of indigestion, sleeping sickness, nose bleeding, stomach upset, fresh wounds and epilepsy (Tindall, 1983; Okeno *et al.*, 2003).

Crassocephalum (Moench.) S. Moore is a genus in the family Asteraceae and tribe Senecioneae (Pelser *et al.*, 2007). It is commonly found in Tropical Africa (Fowomola and Akindahunsi, 2005). The family

Asteraceae is cosmopolitan, comprising about 1,100 genera and up to 20,000 species (Olorode, 1984; Hickey and King, 1988; Pruski, 2007) and represented in West Africa by 82 genera (Olorode, 1984). Species in the genus are erect, branched with lyrate-pinnatifid coarsely serrated and thistle-like leaves (Hutchinson and Dalziel, 1963; Hyde and Wursten, 2007). One striking feature of *Crassocephalum* is the coincidence of their spontaneous appearance with yam maturation in yam plantation which remains an issue that is yet to be understood. The genus is represented by 24 species in tropical Africa and 15 species in West Africa, out of which 9 are reported in Nigeria (Herman *et al*., 2000). Species reported in Nigeria are; *C. crepidioides* (Benth.) S. Moore, *C. biafrae* (Oliv. & Hiern) S. Moore, *C. rubens* (Juss.ex Jacq.) S. Moore, *C. togoense* C.D. Adams, *C. manii* Hook. f., *C. vitellinum* (Benth.) S. Moore, *C. picridifolium* (DC.) S. Moore*, C. bauchiense* Hutch., and *C. sarcobasis* (Boj. ex DC.) S. Moore. Other species reported in West Africa but not in Nigeria are; *C. montuosum* S. Moore, *C. gracile* Hook.f., *C. guineense* C.D. Adams, *C. boughieaium* C.D. Adams, *C. liberium* S. Moore and *C. baoulense* (Hutchinson and Dalziel, 1963; Herman *et al.,* 2000). Of the nine species reported in Nigeria, Olorode and Okoli (1978) reported *C. crepidioides*, *C. biafrae*, *C. rubens* and *C. togoense* as the most commonly found species in Southwest, Nigeria. This was corroborated with the findings of Oyelakin and Ayodele (2013) who reported the same sets of species as available *Crassocephalum* species in Southwest, Nigeria. However, Pelser *et al.* (2010) had separated *C. biafrae* from the genus *Crassocephalum* and the species had since been moved to the genus *Senecio*.

Crassocephalum crepidioides is commonly known as 'ebolo' by Yoruba people in Nigeria. It is called thickhead, red flower ragleaf or fireweed in English language (Oyelakin and Ayodele, 2013). It is a stout erect herbaceous plant of up to 1.2m tall. It has lyrate-pinnatifid leaves, clustererd heads, numerous silky yellowish to white slender pappus, yellow corolla, purple anthers and brown achene (Hyde and Wursten, 2007). One of the striking features of this species is the strength of its odour that emanates when the leaves or stem are squeezed (Olorode and Okoli, 1978). It is much appreciated for this special odour and flavour, which is sharp but not bitter. Some people like this species because of the strength of the odour, while others hate it for the same reason (Tindall, 1983). *Crassocephalum rubens* is commonly known as 'ebure' by Yoruba people in Nigeria. Its an erect branched annual herb of up to 70cm tall. Leaf shape is ovate or obovate and lyrate pinnatifid with serrated margin. It has a solitary capitulum, purple florets, but sometimes white, pink or blue, drooping flower on long peduncles and erect fruits (Grubben and Denton, 2004; Hyde and Wursten, 2007). *Crassocephalum togoense* has erect habit, 60-90cm tall. The leaves are ovate to obovate with 4-5 pairs of segments cut down close to the midrib and larger towards the apex, with smaller paired linear lobes towards the base (Jeffrey, 1986). The colour of the floret is mauve with sparsely setulose involucral bracts (Hyde and Wursten, 2007). This species is widely distributed in Nigeria but commonly found in the savanna zones (Olorode, 1984).

Despite the nutritional and medicinal values, abundance and utility of *Crassocephalum* in Western and Central Africa, the species remain uncultivated, under-exploited, under-utilized and still mainly harvested from the wild due to various numbers of factors such as achene availability and lack of selection for uniformity of desired morphological traits to the breeders for its improvement (Okeno *et al.*, 2003). When cultivated, yields of *Crassocephalum* can reach 25–27 t/ha per year (Grubben, 2004). Yet, very little effort is invested in the cultivation and production of *Crassocephalum*. They are regarded as wild vegetables and sometimes mis-classified as weeds because they usually grow in abandoned farmlands, roadside, and waste dumping sites. Therefore, there is a need to safeguard their economic potentials, save them from extinction and promote their cultivation and domestication (Adjatin *et al*., 2013).

The study of morphological variability has proven to be the first step and most valuable tool in selecting desirable traits for crop improvement (Smith and Smith, 1989; Taia, 2005; Singh, 2006; Karaca, 2013 and Oyelakin *et al*., 2021); therefore the success of any breeding programme relies largely on the morphological variability within the crop species, which guarantees the continuous existence of the crop, and yield improvement (Govindaraj *et al*., 2015). Therefore, the starting point of improvement programme is to determine the amount of variation present in the available genetic materials (Govindaraj *et al*., 2015). Several workers had reported the improvement of some crops based on variation among morphological traits such as high fruit set, leaf and stem pubescence, as well as leaf length and width (Weerakoon *et al.*., 2010; Denton and Nwangburuka, 2011). They all reported that knowledge of the extent and magnitude of multivariate tools will provide information on traits that can be rapidly developed through selection.

The use of multivariate tools such as Principal Component Analysis (PCA) has proven to be useful for characterizing accessions with a view to selecting characters that are of agronomic and economic importance (Shiker, 2012). PCA is a powerful statistical methods widely applied to reduce the original variables into Principal Components (PCs). These PCs clarify the connections between traits and divide the total variance of the original traits into a small number of uncorrelated new variables (Wiley and Lieberman, 2011). Furthermore, knowledge of the relationship between traits will help in choosing traits that can be considered as selection index for crop improvement (Olayiwola and Ariyo, 2015).

Unlike other vegetables, information on morphological variability and triats association on *Crassocephalum* is scanty. Where efforts were made, reports of such efforts were inconclusive as they lacked detailed information on morphological variability (Olorode, 1974; Olorode and Okoli, 1978). Other scientific investigations carried out on *Crassocephalum* were focused on the medicinal values (Gbile and Adesina, 1986; Akah, 1996; Gullie *et al*., 2004; Okpara *et al*., 2006), biochemical composition and nutritional content (Tindall, 1983; Fowomola and Akindaunsi, 2005; Dairo and Adanlawo, 2007). Therefore, an understanding of variability of the *Crassocephalum* species would enhance its improvement and facilitate approaches for faster domestication and cultivation, since breeders are known for developing improved cultivars based on selection of desired morphological traits from wild collection (Oyelakin *et al*., 2021). Hence, this research was initiated to determine the intra-specific and inter-specific variability and traits association among accessions of *Crassocephalum* species collected from the wild in Southwest, Nigeria with a view to assisting breeders in developing a suitable breeding programme for *Crassocephalum* improvement, in order to facilitate their rapid domestication and cultivation.

Materials and Methods

Study area

The study covered Oyo, Ogun, Osun, Ekiti and Lagos States in Southwest, Nigeria. It is a tropical region with annual rainfall between 1500 and 3000 mm and temperature ranging from 21ºC to 34ºC. It is characterized by wet and dry seasons (Oyelakin *et al.*, 2021).

Collection of accessions

Capitula of accessions of species investigated were collected from abandoned farmlands, roadsides, dilapidated buildings and waste dumping sites and had their achenes extracted from the capitula. Specific numbers were assigned to the collected accessions at the point of collection. The species had their identities confirmed at the Federal University of Agriculture, Abeokuta Herbarium as shown in Table 1.

Experimental design

The experiment was laid out in Randomized Complete Block Design in fivee replicates (Steel *et al.*, 1996). This was conducted at the research and experimental field in the Department of Pure and Applied Botany at the Federal University of Agriculture, Abeokuta. Ten achenes of each accession were planted in each of 10 litres plastic buckets filled with topsoil and organic manure arranged in single row plots of 4.5m^2 with spacing of 75 cm x 50 cm bewteen rows and within rows, respectively at research and experimental field in the Department of Pure and Applied Botany at the Federal University of Agriculture, Abeokuta. The plants were later thinned to one plant per bucket. Regular watering as well as other planting and cultural practices were carried out to ensure healthy plant production.

Morphological data

Morphological data were collected by visual evaluation of qualitative traits while quantitative traits were measured using ruler, tape rule and thread where necessary. Ten measurements were taken and recorded for each of the quantitative traits on every accession.

Qualitative vegetative traits

The plant growth habit, leaf colour, leaf shape, leaf margin, anthocyanin and stem pubescence were visually observed when 50% of the plants had produced capitula while leaf pubescence was observed on young leaf of matured plants.

Qualitative reproductive traits

Types of capitula, position of capitula, receptacle reflexion, floret colour, intensity of odour and pappus colour were observed at plant flowering while achene colour, achene shape, achene texture, achene curvature and achene stripe were observed after the harvest.

Quantitative vegetative traits

The plant height (cm) was measured when 50% of the plants had opened capitula. The leaf length (cm) was measured from the base to the apex, while leaf width (cm) was measured at the widest part. The internode length (cm), peduncle length (cm), stipule length (cm) and stipule width (cm) were measured on healthy matured plants.

Quantitative reproductive traits

Numbers of days to 50% flowering, days to maturity, duration of pollination, number of capitula, capitulum diameter, number of heads/peduncle, number of florets/heads were counted when 50% of the plants had opened capitula, number of filled achenes/head and number of unfilled achenes/head were counted while achene length (cm) and pappus length (cm) were measured after the harvest.

Statistical analyses

Data were subjected to One-way Analysis of Variance (ANOVA) using SPSS software version 20 (IBM, 2011). Separation of means was carried out using Duncan's Multiple Range Test (DMRT) at 5% probability level. Principal Component Analysis (PCA) was computed to determine traits accounting for the variation among the accessions using the procedure of Jolliffe (2002) while Correlation coefficients were computed according to the procedure of Ziya *et al*. (2012).

Results and Discussion

Results

Variation in qualitative vegetative and reproductive traits among accessions

The most important observed qualitative vegetative and reproductive traits responsible for variation were stem colour, leaf margin, plant growth habit, leaf shape, and branching as well as type of capitula, floret colour, intensity of odour, achene colour and pappus colour (Tables 2 and 3).

Variation in quantitative vegetative traits among accessions

There was high variation in measured vegetative traits with plant height, internode length, leaf length, leaf width, and petiole length as the most important. Plant height ranged from 50.6±3.78 cm to 107.0±5.31cm while internode length ranged from 2.3±0.46cm to 7.4±1.64cm. Leaf length ranged from7.6±1.56cm to 18.5±1.42cm,while leaf width ranged from 4.1±0.57cm to 9.1±0.69cm. However, petiole length ranged from 0.7±0.13cm to 4.4±0.43cm (Table 4).

Variation in quantitative reproductive traits among accessions

The traits were highly variable and the most important among them were days to 50% flowering, days to maturity, number of capitulum/plant, number of florets/head, and number of filled achene/head. Accession AS/004 was first to reach 50% flowering at 65days among *C. rubens* while AS/010 was first to reach 50% flowering at 92 days among *C. crepidioides*. There was no variation in number of days to 50% flowering between 2 accessions of *C. togoense*. However, accession AS/014 was first to reach maturity at 139 days among *C. rubens* while AS/010 was first to reach maturity at 236 days after planting among *C. crepidioides*, but AS/021 mutured first at 247days between *C. togoense* accessions (Table 5). However, accession AS/003 had the highest number of capitula/plant with the mean value of 55 among *C. rubens* while highest number of capitula/plant with the mean value of 236 was recorded in AS/015 among *C. crepidioides*. For *C. togoense* accessions, AS/023 had the highest number of capitula/plant with the mean value of 152. AS/001 had the highest number of florets per plant with the mean value of 526 among *C. rubens* while AS/012 had the highest number of florets per plant with the mean value of 174 among *C. crepidioides*. There was no variation in number of florets per plant between 2 accessions of *C. togoense*.

Number of filled achene per head was highest in AS/020 with the value of 374 among *C. rubens* while AS/012 had highest number of filled achene per head with the mean value of 155 among *C. crepidioides*. AS/023 had highest number of filled achene per head with the mean value of 143 between *C. togoense* accessions (Table 5).

Principal Component Analysis of quantitative traits among accessions

Only the first three axes were considered informative in PCA with 66.79% of the total variation and Eigen value greater than 1.0. The percentage variances reduced progressively from PC1 to PC3, while Eigen values ranged from 1.51 in PC3 to 2.72 in PC1 (Table 6). The six most important traits with high eigen values that defined PC1 are leaf length, leaf width, days to 50% flowering, days to maturity, number of achene/head, and number of filled achene/head which accounted for highest percentage of (29.31%). PC2 was mostly influenced by plant heigth and number of floret per head with 22.47%, while PC3 was largely influenced by internode length which accounted for 10.01% of total variation (Table 6).

Correlation coefficients of the quantitative traits among accessions

A significant positive correlation ($p < 0.01$) exists between leaf length and leaf width (0.63), petiole length (0.52), internode length (0.89) and peduncle length (0.91). However, there was a negative significant correlation ($p < 0.01$) between leaf length and days to 50% flowering (-0.70). There was a significant positive ($p < 0.01$) correlation between leaf width and petiole length (0.91), internode length (0.57) peduncle length (0.53), days to 50% flowering (0.83) and days to maturity (0.67). In addition, there was a positive and significant ($p < 0.01$) correlation between internode length and peduncle length (0.99) but internode length was significant and negatively correlated ($p < 0.01$) with days to 50 % flowering (-0.76), capitulum diameter (-0.34) and number of florets per head (-0.32) ($p < 0.05$) (Table 7).

A significant and positive correlation ($p < 0.01$) exists between number of capitula/plant and capitulum diameter (0.80), number of head/peduncle (0.94), number of floret/head (0.84), number of filled achene/head (0.62), achene length (0.68) and pappus length (0.42) ($p < 0.05$). Number of achene/head showed significant positive correlation ($p < 0.01$) with number of filled achenes/head (0.95) and pappus length (0.88). Also, there was a significant positive correlation ($p < 0.01$) between number of filled achenes/head and achene length (0.64) (Table 7).

Discussion

Accessing intra and inter-specifies variability and traits association among plant species through characterization is not a new concept and its efficiency in crop improvement through breeding programme has been reported by many researchers (Smith and Smith, 1989; Taia, 2005; Singh, 2006; Karaca, 2013; Idehen *et al.*, 2020; Oyelakin *et al.*, 2021).

In this study 21 accessions of *Crassocephalum* species collected from Southwest Nigeria were characterized using 38 morphological traits. Intra and inter-specifies variability observed on stem colour, leaf margin, plant growth habit, leaf shape and branching as well as qualitative reproductive traits on capitula, floret colour, intensity of odour, achene colour and pappus colour could be genetic rather than environmental. This assertion is made due to the fact that all the accessions were raised in the same environment and subjected to similar cultural practice, which eliminated the influence of the environment on the phenotypic expressions of the accessions traits.

Furthermore, intra and inter-specifies variability observed on the quantitative vegetative traits on plant height, internode length, leaf length, leaf width and petiole length as well as quantitative reproductive traits on days to 50% flowering, days to maturity, number of capitulum/plant, number of florets/head and number of filled achenes/head could be due to differences at the genotypic level. This is because all accessions were grown under the same environmental condition and subjected to same cultural management, thus, reducing the influence of environment to a considerable level. The findings from this study corroborate the work of Weerakoon *et al.* (2010) and Govindaraj *et al*. (2015), on the use of desirable morphological traits for improvement of crops through breeding programmes. Therefore, the relatively wide intra and inter-specifies variability on both qualitative and quantitative morphological traits suggests the possibility of these traits to be used for improvement of *Crassocephalum* species in order to facilitate their domestication and cultivation if selected by Breeders.

From this study, PCA result showed that most important morphological traits which contributed significantly to total variation were mostly associated with the first principal axis. This observation confirmed the contribution of the six traits to variability among the twenty-one accessions thus implying that if selection is to be made between cluster group for breeding program, leaf length, leaf width, days to 50% flowering, days to maturity, number of achenes/head and number of filled achenes/head should be given high priorities. This result corroborates the reports of Idehen *et al.* (2020) and Nsabiyera *et al.* (2013) who selected morphological characters identified by the first principal component for crop improvement. Therefore, these traits could be selected by breeders for improvement of *Crassocephalum* species in order to facilitate their domestication and cultivation.

In this study, positive significant phenotypic correlation of leaf length with leaf width, petiole length, internode length and peduncle length suggests that these traits possessed greater practical values for selection than the other component traits. Significant positive correlation between leaf length and leaf width implied selection of long leaf may ultimately lead to broader leaf, which is the traits that most consumers prefer in vegetables. Also, from this study, petiole length had highest correlation with leaf width followed by number of days to maturity and association with internode length and peduncle length was significant, thus direct selection for these traits will be rewarding. Number of capitula/plant had high positive correlation with capitulum diameter and filled achenes per head, thus selection based on number of filled achenes per head through number of capitula/plant and capitulum diameter will be rewarding. This is because preservation of achenes (seeds) for long time without drying of the endosperm remains the major challenge to the cultivation of *Crassocephalum* species, hence achenes that could be preserved for long time should be developed to encourage farmers to adopt the cultivation of this vegetable bearing in mind their great potential and economic values. These important traits should be selected for their improvement by Breeders in order to facilitate their domestication and cultivation. The suggestion to select traits based on strong positive correlation among morphological variables in this study corrobotated the report of Dijack *et al.* (1999), Idehen *et al.* (2020) and Oyelakin *et al.* (2021). They all reported the suitability of selecting morphological characters for improvement of different crops bsed on their strong positive correlation.

Conclusion

The first three axes accounted for over 60% of total variation with leaf length, leaf width, days to 50% flowering, days to maturity, number of achenes/head and number of filled achenes per head as discriminants in the studied accessions. Positive and significant phenotypic correlation between leaf length and leaf width with petiole length, internode length and peduncle length, number of days to maturity makes them good traits for selection in improvement programmes. High positive correlation which number of capitula per plant had with capitulum diameter, and number of filled achene/head makes number of filled achene per head suitable for selection for improvement programme. Hence, the principal contributors to total variation which are leaf length, leaf width, days to 50% flowering, days to maturity, number of achene per head, and number of filled achene/head are hereby suggested to breeders in developing a suitable breeding programme for *Crassocephalum* species improvement in order to facilitating their domestication and cultivation. Therefore, the relatively wide intra-specific and inter-specific variability on both qualitative and quantitative morphological traits suggests the possibility of these traits to be used for improvement of *C. crepidioides*, *C. rubens*, and *C. togoense* in order to facilitate their domestication and cultivation if selected by breeders.

References

Adjatin, A., Dansi, A., Yevide, A. I. S., Agre, A. P., Dansi, M. and Akoegninou, A. (2013). Agromorphological Characterization of Gbolo (*Crassocephalum crepidioides* (Benth.) S. Moore and *C. rubens* (Juss.ex Jacq.) S. Moore, an Aromatic Herb consumed as Leafy Vegetable in Benin. *International Research Journal of Agricultural Soil Science,* 3: 208-218.

Akah, P. A. (1996). Antidiarhea Activity of *Kigelia africana* in Experimental Animals. *Journal of Herbs, Spices and Medicinal Plants,* 4(2): 31-38.

Bankole M. O., Ayodele M. S. and Adejumo, O. T. (2003). The Antimicrobial Effects of some Asteraceae commonly Eaten as Vegetables in Southwest Nigeria on some Enteric Pathogens. *Compositae Newsletter*, 40: 56-61.

Denton, O. A. and Nwangburuka, C. C. (2011). Heritability, Genetic Advance and Character Association in Six Yield related Character of *Solanum anguivi*. *Asian Journal Agricultural Resources*, 5: 201-207.

Dijack, M., Modarres, A. M., Hamilton, R. I., Dwyer, L. M., Stewart, D. W., Mather, D. E. and Smith, D. L. (1999). Leaf Reduced-stature Maize Hybrids for Short-season Environments. *Crop Science*, 39(4):

1106-1110.
Idehen, E. O., Labulo, A. and Oyelakin, A. S. (2020). Character Association and Contributions to Variability in *Corchorus* Accessions Evaluated at two Locations. *Nigerian Journal of Seed Science*, 4(1): 20-30.
Fasuyi, A. O. (2006). Nutritional Potentials of some Tropical Vegetable Leaf Meals: Chemical Characterization and Functional Properties. *African Journal of Biotechnology*, 5: 49-58.
Fowomola, M. A. and Akindahunsi, A. A. (2005). Protein Quality Indices of Sand box (*Hura crepitans*) seed. *Journal of Food, Agriculture and Environment*, 3: 16-19.
Gbile, Z. O. and Adesina, S. K. (1986). Nigerian Flora and its Pharmaceutical Potentials. *Journal of Ethnopharmacology*, 19: 1-16.
Grubben, G. J. H. (2004). *Plant Resources of Tropical Africa 2: Vegetables*. eds. G. J. H. Grubben and O. A. Denton (Wageningen: PROTA Foundation).
Grubben G. J. H and Denton, O. A. (2004). *Plant Resources of Tropical Africa 2*. Vegetables. PROTA Foundation, Wageningen, Netherlands/Backhuys Publishers, Leiden, Netherlands/ CTA, Wageningen, Netherlands. 668pp.
Gruber, K. (2017). Agrobiodiversity: The Living Library. *Nature*, 544: S8–S10.
Govindaraj, M., Vetriventhan M. and Srinivasan, M. (2015). Importance of Genetic Diversity Assessment in Crop Plants and its Recent Advances: An Overview of its Analytical Perspectives. *Genetics Research International*, 12: 23-31.
Gulliie, M. A., Ogiiteu, H., Segul, M., Karaman, I. and Sahin, F. (2004). Antimicrobial Effect of *Quercus ilex* L. Extract. *Phytotheraphy Research*, 18: 208-211.
Herman, P. P. J., Relief, E., Koekemoer, M. and Welman, W. G. (2000). Asteraceae (Compositae). In: *Seed Plants of Southern Africa* (O.A Leistner (Ed). Strelizia. National Botanical Institute. Pretoria.
Hickey, M. and King, C. (1988). *100 Families of Flowering Plant*. (2nd Ed.) Cambridge University Press, New York. Pp 461- 462.
Hutchinson, J. J. and Dalziel, J. M. (1963). *Flora of West Tropical Africa*. Avi Publishing. Westport (2nd ed.vol.11). Reviewed by Keay, R.W.J. Crown Agents, London. Pp 244-248.
Hyde, M. A. and Wursten, B. (2007). *Flora of Zimbabwe: Genus Crassocephalum* http://www Zimbabwe flora.co.zw/species data/genus.php.
IBM, CORP. (2011). IBM SPSS: Statistics for Windows, Version 20.0. Armonk, New York. IBM Corp.
Jeffrey, C. (1986). The Senecioneae in East Tropical Africa. *Kew Bulletin,* 41: 873-943.
Jolliffe, I. T. (2002). Principal Component Analysis. Springer series in Statistics 2nd Edition. Springer-Verlag New York.
Karaca, M. (2013). Isozymes as Biochemical Markers in Plant Genetics. *International Journal of Agricultural Science*, 3(11): 851-861.
Nsabiyera, V., Logose, M., Ochwo-Ssemakula, M., Sseruwagi, P., Gibson, P. and Ojiewo, C. O. (2013). Morphological Characterization of Local and Exotic Hot Pepper (*Capsicum annuum* L.) Collections in Uganda. *Bioremediation, Biodiversity and Bioassav*, 7(1): 22-32.
Oguntona, T., Oguntona, C. R. B. and Williams, L. (1989). Survey of Food and Nutrient Intake of Kanuri of Borno Nigeria. *Nigerian Journal of Science*, 10: 86-91.
Okeno, J. A., Chebet, D. K. and Mathenge, P. W. (2003). Status of Indigenous Vegetable in Kenya. *Acta Horticulturae*, 621: 95-100.
Okpara, J. O., Okpala, E. J., Ayo, J. O. and Mamman, M. (2006). Evaluation of the Anti-diarrhea Activity of *Adasonia digitata* (Baobab) Leaves Ethanol Extract. Proc.31st Conf. Nig. Soc. of Animal Production, held March 12th-15th, 2006 at Bayero University, Kano, Nigeria.
Olayiwola, M. O. and Ariyo, O. J. (2015). Inter-character Relationships of Okra Traits as affected by Environment. *International Journal of Vegetable Science*, 21(3): 249-263.
Olorode, O. (1974). Chromosome Numbers in Nigerian Compositae. *Botanical Journal of the Linnean Society*, 68: 329-335.
Olorode, O. (1984). *Taxonomy of West African Flowering Plants*. Longman Group Ltd., London & New York. 66-78Pp
Olorode, O. and Okoli, B. B. (1978). Cytogenetic Studies in some Nigerian species of *Crassocephalum.* (Senecioneae- Compositae). *Nigerian Journal of Genetics*, 2: 81-90.
Olufolaji, A. O. and Denton, O. A. (2000). Vegetable programme in National Horticultural Research Institute (NIHORT). *25years of Research into Horticultural Crops.*
Oyelakin, A. S. and Ayodele, M. S. (2013). Morphotaxonomic Evaluation of the Relationship between Four Species of *Crassocephalum* (Moench.) S. Moore (Asteraceae) in Southwestern Nigeria. *Scientific Research and Essay*, 8(33): 1629-1636.
Oyelakin, A. S., Olabiyi, D. O., Amaogu, C. C. and Olabisi, A. O. (2021). Morphological Characterization on Accessions of Pepper (*Capsicum annuum* L. and *Capsicum frutescens* L.) cultivated in Nigeria. *Feddes Repertorium*, 132(4): 346-363.
Pelser, P. B., Nordenstam, B., Kadereit, J. W. and Watson, L. E. (2007). An ITS phylogeny of Tribe Senecioneae (Asteraceae) and a new Delimitation of *Senecio* L. *Taxon*, 56:1077-1089.
Pelser, P. B., Kennedy, A. H., Tepe, E. J. and Shidler, J. B. (2010). Pattern of causes of Incongruence between Plastid and Nuclear Senecioneae (Asteraceae) Phylogenies. *Journal of Botany*, 97**:** 856-873.
Pingali, P. L. (2012). Green Revolution: Impacts, Limits, and the Path Ahead. Proceedings of National Academy of Science USA. 109, 12302–12308. doi: 10.1073/pnas.0912953109.

Pruski, J. F. (2007). Asteraceae. In: *Flora of the Vegezuelan Guayana*, (3). Aralianceae- Cactaceae. Missouri Botanical Garden, St. Louis. Pp. 177-393.

Schramm, S., Rozhon, W., Adedeji-Badmus, A. N., Liang, Y., Nayem, S., Winkelmann, T. and Poppenberger, B. (2021). The Orphan Crop *Crassocephalum crepidioides* Accumulates the Pyrrolizidine Alkaloid Jacobine in response to Nitrogen Starvation. *Plant Science*, 12: 1-13.

Schippers, R. R. (2000). *African Indigenous Vegetables. An Overview of the Cultivated Species*. Natural Resources Institute, Chatham, U.K., NRI, ACP-EU Technical Centre for Agricultural and Rural Corporation 214Pp

Singh, R. J. (2006). Genetic Resources, Chromosome Engineering and Crop Improvement: Vegetable Crops. CRC Press.

Shiker, M. (2012). Multivariate Statistical Analysis. *British Journal of Science*, 6 (1): 55-66.

Smith, J. S. C. and Smith, O. S. (1989). The Description and Assessment of Distances between Inbred Maize; the Utility of Morphological, Biochemical, and Genetic Descriptors and a Scheme of the Testing of Distinctiveness between Inbred Lines. *Maydica*, 34: 151-161.

Taia, W. K. (2005). Modern Trends in Plant Taxonomy. *Asian Journal of Plant Science*, 4: 184-206.

Tindall, H. D. (1983). *Vegetables in the Tropics*. Macmillan Education Ltd Houndmills, Basingstoke, Hampshire RG 212xs. Printed in Hong Kong. Pp 84-86.

Weerakoon, S. R. and Somaratne, S. (2020). Agromorphological Characterization and Relationships among Mustard Germplasm (*Brassica juncea* (L.) Czen and Coss) in Sri Lanka: A Classification Tree Approach. *Journal of Agricultural Science*, 5(2): 89-97.

Wiley, E. O. and Lieberman, B. S. (2011). *Phylogenetics: Theory and Practice of Phylogenetic Systematics,* 2nd ed.-Hoboken, N.J: Wiley- Blackwell.

Ziya, D., Rukiye, K., Tevrican, D. and Aydin, A. (2012). Correlation and Path Analysis of Grain Yield and Yield Components of some Turkish Oat Genotypes. *Pakistan Journal of Botany,* 44(1): 321-327.

Table 1: List and area of collection of *Crassocephalum* accessions used for this study

SN	Accession No	Local name	Taxonomy	Area of collection	Location	State
1	AS/001	Ebure	*C. rubens*	Guguru village via Ogbomoso	Yam farmland	Oyo
2	AS/002	Ebure	*C. rubens*	Telemu village via Iwo	Yam farmland	Osun
3	AS/003	Ebure	*C. rubens*	Igbeti-Ogbomoso road	Cleared land	Oyo
4	AS/004	Ebure	*C. rubens*	Adodo village near Ogbomoso	Yam/Maize farmland	Oyo
5	AS/005	Ebure	*C. rubens*	Asero, Osiele-Adatan road	Roadside	Ogun
6	AS/006	Ebure	*C. rubens*	Aramoko-Ikeji	Roadside	Ekiti
7	AS/007	Ebure	*C. rubens*	Joju village along Sango-Ota	Roadside	Ogun
8	AS/009	Ebure	*C. rubens*	Okuku, along Ikirun-Ilorin road	Yam/pepper farmland	Osun
9	AS/013	Ebure	*C. rubens*	Igbeti town	Yam farmland	Oyo
10	AS/014	Ebure	*C. rubens*	Guguru village via Ogbomoso	Yam farmland	Oyo
11	AS/016	Ebure	*C. rubens*	Awe, along Iwo road	Waste place	Oyo
12	AS/017	Ebure	*C. rubens*	Epe, beside local government secretariat	Waste place	Lagos
13	AS/019	Ebure	*C. rubens*	Oru-Ijebu road	Waste place	Ogun
14	AS/020	Ebure	*C. rubens*	Bakatatri, along Ibadan-Abeokuta road	Dilapidated building	Ogun
15	AS/010	Ebolo	*C. crepidioides*	Osiele, along Ibadan-Abeokuta road	Yam/Maize farmland	Ogun
16	AS/012	Ebolo	*C. crepidioides*	No 21, Salami street, Idimu, Egbeda	Vegetable garden	Lagos
17	AS/015	Ebolo	*C. crepidioides*	Adodo village near Ogbomoso	Yam/Maize farmland	Oyo
18	AS/018	Ebolo	*C. crepidioides*	Aguo village, along Oyo-Ibadan road	Roadside	Oyo
19	AS/022	Ebolo	*C. crepidioides*	Campus, Ekiti State University Ado-Ekiti	Waste place	Ekiti
20	AS/021	None	*C. togeoense*	Apomu town, Ibadan-Ife road	Abandoned farmland	Osun
21	AS/023	None	*C. togeoense*	Eleekara, along Oyo-Fiditi road	Dilapidated building	Oyo

Table 2: Qualitative Vegetative Traits of *Crassocephalum* Accessions

Accession No	SC	A-pig	LM	SP	GH¶	LC	LS	LP	Branching
AS/001	Green	Light purple	Serrated	Sparse	Erect	Light green	Ovate	Sparse	Sparse
AS/002	Green with purple stripes	Light purple	Serrated	Sparse	Erect	Green	Lanceolate	Sparse	Sparse
AS/003	Green	Purple	Serrated	Sparse	Erect	Light green	Lanceolate	Dense	Sparse
AS/004	Green with purple stripes	Purple	Serrated	Sparse	Suberect	Green	Lanceolate	Sparse	Sparse
AS/005	Green	Purple	Serrated	Sparse	Erect	Light green	Ovate	Sparse	Sparse
AS/006	Green with purple stripes	Purple	Serrated	Sparse	Erect	Green	Lanceolate	Sparse	Sparse
AS/007	Green	Light purple	Serrated	Sparse	Erect	Green	Lanceolate	Dense	Sparse
AS/009	Green	Purple	Serrated	Sparse	Erect	Green	Lanceolate	Dense	Sparse
AS/013	Green with purple stripes	Light purple	Serrated	Sparse	Erect	Light green	Deltoid	Sparse	Sparse
AS/014	Green	Light purple	Serrated	Sparse	Erect	Dark green	Ovate	Sparse	Sparse
AS/016	Green with purple stripes	Purple	Serrated	Sparse	Erect	Green	Ovate	Sparse	Sparse
AS/017	Green	Purple	Serrated	Sparse	Erect	Green	Ovate	Sparse	Sparse
AS/019	Green	Light purple	Serrated	Sparse	Erect	Dark green	Lanceolate	Sparse	Sparse
AS/020	Green	Purple	Serrated	Sparse	Erect	Dark green	Ovate	Sparse	Sparse
AS/010	Green	Dark purple	Deeply serrated	Dense	Stout erect	Light green	Ovate	Sparse	Intermediate
AS/012	Green	Dark purple	Deeply serrated	Dense	Stout erect	Light green	Ovate	Sparse	Intermediate
AS/015	Green	Purple	Deeply serrated	Dense	Stout erect	Green	Ovate	Sparse	Intermediate
AS/018	Green with purple stripes	Dark purple	Deeply serrated	Dense	Stout erect	Light green	Lanceolate	Sparse	Intermediate
AS/022	Green	Purple	Deeply serrated	Dense	Stout erect	Dark green	Ovate	Sparse	Intermediate
AS/021	Green with purple stripes	Purple	Deeply serrated	Dense	Erect	Greenpurple	Ovate	Sparse	Dense
AS/023	Green with purple stripes	Purple	Deeply serrated	Dense	Erect	Green	ovate	Sparse	Dense

SC = Stem colour, A-pig = Anthocyanin pigmentation, LM= Leaf margin SP = Stem pubescence, GH = Growth habit, LC= Leaf colour, LS = Leaf shape, LP = Leaf pubescence

Table 3: Qualitative Reproductive Traits of *Crassocephalum* Accessions

Accession No	TC	PC	RR	FC	IO¶	A-col	AS	AT	AC	A-stripe	PC
AS/001	Solitary	Terminal	Full	Purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/002	Solitary	Terminal	Full	White	Weak	Brown	pointed	Smooth	present	Present	White
AS/003	Solitary	Terminal	Full	White	Weak	Brown	pointed	Smooth	present	Present	White
AS/004	Solitary	Terminal	Full	Light purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/005	Solitary	Terminal	Full	Purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/006	Solitary	Terminal	Full	Purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/007	Solitary	Terminal	Full	Light purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/009	Solitary	Terminal	Full	Light purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/013	Solitary	Terminal	Full	White	Weak	Brown	pointed	Smooth	present	Present	White
AS/014	Solitary	Terminal	Full	Purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/016	Solitary	Terminal	Full	White	Weak	Brown	pointed	Smooth	present	Present	White
AS/017	Solitary	Terminal	Full	White	Weak	Brown	pointed	Smooth	present	Present	White
AS/019	Solitary	Terminal	Full	Light purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/020	Solitary	Terminal	Full	Purple	Weak	Brown	pointed	Smooth	present	Present	White
AS/010	Clustered/mutiple	Terminal & axillary	Full	Brick red	Strong	Dark brown	pointed	Rough	present	Present	White to yellowish
AS/012	Clustered/mutiple	Terminal & axillary	Full	Brick red	Strong	Dark brown	pointed	Rough	present	Present	White to yellowish
AS/015	Clustered/mutiple	Terminal & axillary	Full	Reddish brown	Strong	Dark brown	pointed	Rough	present	Present	White to yellowish
AS/018	Clustered/mutiple	Terminal & axillary	Full	Reddish brown	Strong	Dark brown	pointed	Rough	present	Present	White to yellowish
AS/022	Clustered/mutiple	Terminal & axillary	Full	Brick red	Strong	Dark brown	pointed	Rough	present	Present	White to yellowish
AS/021	Clustered/mutiple	Terminal & axillary	Full	Mauve	Weak	Dark brown	pointed	Rough	present	Present	White to tinged red
AS/023	Clustered/mutiple	Terminal & axillary	Full	Mauve	Weak	Dark brown	pointed	Rough	present	Present	White to tinged red

TC = Types of capitula, PC = Position of capitula, RR = Receptacle reflexion, FC = Floret colour, IO = Intensity of odour, A-col = Achene colour, AS = Achene shape, AT = Achene texture, AC = Achene curvature, A-stripe = Achene stripe, PC = Pappus colour

Table 4: Data on Quantitative Vegetative Traits of *Crassocephalum* Accessions (cm)

Accession No	Plant height	Internode length	Leaf length	Leaf width	Petiole length	Peduncle length	Stipule length	Stipule width
AS/001	75.7 ± 4.85^{f}	7.4 ± 1.64^{a}	9.8 ± 1.36^{g}	5.1 ± 0.77^{ef}	1.3 ± 0.29^{g}	27.7 ± 7.93^{e}	Absent	Absent
AS/002	65.9 ± 1.99^{i}	4.5 ± 0.81^{d}	10.5 ± 1.80^{f}	5.3 ± 1.53^{ef}	1.5 ± 0.31^{g}	22.7 ± 5.60^{f}	Absent	Absent
AS/003	66.5 ± 1.99^{i}	3.1 ± 0.61^{f}	10.6 ± 1.16^{f}	4.5 ± 0.57^{g}	1.0 ± 0.31^{i}	34.4 ± 4.42^{a}	Absent	Absent
AS/004	71.0 ± 4.78^{h}	4.9 ± 1.00^{c}	11.2 ± 0.86^{e}	5.4 ± 0.70^{ef}	2.1 ± 0.36^{f}	26.5 ± 4.53^{ef}	Absent	Absent
AS/005	67.1 ± 3.32^{i}	3.2 ± 0.69^{f}	12.2 ± 1.60^{d}	5.3 ± 0.46^{ef}	1.3 ± 0.26^{h}	29.1 ± 5.65^{e}	Absent	Absent
AS/006	66.5 ± 4.32^{i}	5.5 ± 1.30^{b}	8.7 ± 0.51^{gh}	4.2 ± 0.30^{h}	1.3 ± 0.35^{h}	32.5 ± 3.58^{b}	Absent	Absent
AS/007	70.2 ± 2.98^{h}	5.6 ± 0.81^{b}	10.2 ± 0.76^{f}	4.5 ± 0.72^{g}	1.0 ± 0.26^{i}	25.6 ± 2.93^{g}	Absent	Absent
AS/009	74.7 ± 5.52^{g}	5.5 ± 1.03^{b}	7.6 ± 1.56^{i}	4.5 ± 0.48^{g}	1.4 ± 0.36^{g}	27.1 ± 6.91^{e}	Absent	Absent
AS/013	58.5 ± 7.22^{k}	3.1 ± 0.63^{f}	9.5 ± 1.24^{g}	4.6 ± 0.45^{g}	1.2 ± 0.2^{h}	20.0 ± 3.00^{h}	Absent	Absent
AS/014	74.2 ± 6.31^{g}	2.3 ± 0.46^{g}	9.4 ± 1.23^{g}	4.5 ± 0.63^{g}	1.5 ± 0.36^{g}	22.8 ± 4.58^{f}	Absent	Absent
AS/016	66.8 ± 6.35^{i}	4.3 ± 0.69^{d}	10.6 ± 0.71^{f}	4.9 ± 1.24^{f}	0.7 ± 0.13^{j}	30.9 ± 4.70^{c}	Absent	Absent
AS/017	63.7 ± 7.02^{j}	2.8 ± 0.72^{g}	10.3 ± 1.63^{f}	4.9 ± 0.83^{f}	1.1 ± 0.46^{i}	28.3 ± 4.92^{e}	Absent	Absent
AS/019	72.0 ± 5.66^{h}	5.1 ± 1.23^{bc}	9.3 ± 0.81^{g}	4.3 ± 0.36^{h}	1.5 ± 0.25^{g}	31.9 ± 3.19^{c}	Absent	Absent
AS/020	58.2 ± 4.35^{k}	5.2 ± 0.81^{bc}	7.8 ± 0.63^{h}	4.1 ± 0.57^{h}	0.7 ± 0.20^{j}	21.8 ± 3.17^{g}	Absent	Absent
AS/010	91.9 ± 4.51^{c}	4.0 ± 0.52^{e}	18.5 ± 1.42^{a}	9.1 ± 0.69^{a}	3.7 ± 0.46^{c}	8.4 ± 1.39^{k}	2.6 ± 0.27^{d}	1.6 ± 0.30^{c}
AS/012	84.4 ± 5.27^{e}	5.1 ± 0.92^{bc}	14.9 ± 1.23^{c}	7.8 ± 0.60^{c}	4.4 ± 0.43^{a}	15.8 ± 3.41^{i}	3.7 ± 0.57^{c}	1.8 ± 0.26^{b}
AS/015	101.8 ± 6.31^{b}	4.9 ± 0.33^{c}	16.2 ± 1.63^{b}	8.4 ± 0.63^{b}	3.6 ± 0.71^{d}	16.3 ± 4.82^{i}	3.6 ± 0.54^{c}	1.8 ± 0.90^{b}
AS/018	86.6 ± 7.36^{d}	4.5 ± 1.00^{d}	18.3 ± 1.26^{a}	7.6 ± 0.88^{d}	4.0 ± 0.36^{b}	14.7 ± 0.99^{j}	4.1 ± 0.77^{a}	1.9 ± 0.4^{ab}
AS/022	64.2 ± 5.72^{j}	4.0 ± 0.81^{e}	16.3 ± 1.26^{b}	7.9 ± 0.13^{c}	3.6 ± 0.42^{d}	3.9 ± 0.74^{l}	3.9 ± 0.71^{b}	1.2 ± 0.30^{d}
AS/021	107.0 ± 5.31^{a}	3.7 ± 0.26^{f}	14.7 ± 1.36^{c}	7.5 ± 0.61^{d}	2.5 ± 0.45^{e}	27.5 ± 6.36^{e}	2.5 ± 0.46^{d}	1.9 ± 0.31^{a}
AS/023	50.6 ± 3.78^{l}	3.4 ± 0.70^{g}	12.2 ± 1.36^{d}	5.8 ± 0.82^{e}	2.8 ± 0.41^{e}	15.8 ± 4.16^{i}	2.1 ± 0.26^{e}	0.9 ± 0.10^{e}

Mean values (± standard error) followed by different superscripts within columns are significantly different at (5%) using Duncan's Multiple Range Test (DMRT)

Table 5: Data on Quantitative Reproductive Traits of *Crassocephalum* Accesssions

Accession No	Days to 50% flowering	Days to maturity	Number of capitulum per plant	Capitulum diameter (cm)	Number of head per peduncle	Number of florets per head	Number of filled achenes per head	Number of unfilled achenes per head	Achene length (cm)	Pappus length (cm)
AS/001	68.0±5.09^{f}	149.0±7.04^{ij}	43.0±4.78^{k}	3.3±0.18^{e}	1.0±0.01^{g}	526.0±12.56^{a}	287.0±14.12^{d}	213.0±9.10^{b}	0.35±0.02^{a}	1.1±0.01^{c}
AS/002	68.0±7.21^{f}	139.0±8.56^{k}	35.0±3.43^{h}	3.4±0.09^{e}	1.0±0.01^{g}	322.0±9.90^{i}	215.0±9.06^{i}	107.0±2.99^{i}	0.25±0.02^{b}	1.0±0.01^{d}
AS/003	68.0±4.60^{f}	145.0±2.16^{j}	55.0±6.08^{h}	3.4±0.26^{e}	1.0±0.01^{g}	497.0±14.06^{e}	308.0±12.96^{c}	188.0±9.10^{c}	0.15±0.02^{b}	1.2±0.01^{c}
AS/004	65.0±3.29^{h}	162.0±8.10^{g}	36.0±4.20^{h}	3.7±0.05^{d}	1.0±0.01^{g}	372.0±8.91^{g}	184.0±9.56^{k}	189.0±9.56^{c}	0.35±0.02^{a}	2.0±0.01^{a}
AS/005	73.0±6.21^{e}	156.0±7.90^{i}	41.0±0.98^{l}	3.1±0.55^{g}	1.0±0.01^{g}	516.0±18.00^{c}	361.0±15.01^{b}	155.0±12.00^{e}	0.35±0.02^{a}	1.1±0.01^{c}
AS/006	68.0±4.26^{f}	157.0±6.86^{h}	20.0±1.70^{o}	3.7±0.47^{d}	1.0±0.01^{g}	376.0±10.16^{g}	258.0±12.66^{f}	118.0±8.39^{h}	0.25±0.02^{b}	1.1±0.01^{c}
AS/007	67.0±2.78^{g}	154.0±4.56^{i}	52.0±2.18^{h}	2.9±0.02^{g}	1.0±0.01^{g}	363.0±15.50^{h}	274.0±10.23^{e}	89.0±9.08^{l}	0.35±0.02^{a}	1.1±0.01^{c}
AS/009	69.0±3.22^{f}	162.0±4.56^{g}	33.0±6.10^{n}	3.3±0.08^{f}	1.0±0.01^{g}	352.0±16.09^{h}	248.0±12.26^{g}	104.0±6.58^{j}	0.35±0.02^{a}	1.1±0.01^{c}
AS/013	69.0±5.90^{f}	179.0±2.00^{f}	45.0±2.78^{k}	5.1±0.78^{a}	1.0±0.01^{g}	519.0±9.06^{b}	361.0±13.77^{b}	158.0±13.66^{d}	0.15±0.02^{b}	1.2±0.01^{c}
AS/014	72.0±7.54^{e}	139.0±6.12^{k}	33.0±0.88^{n}	3.5±0.38^{e}	1.0±0.01^{g}	372.0±10.63^{gh}	230.0±2.93^{h}	141.0±5.55^{f}	0.20±0.00^{b}	1.0±0.01^{d}
AS/016	71.0±5.26^{ef}	157.0±3.06^{h}	42.0±2.78^{k}	4.0±0.98^{c}	1.0±0.01^{g}	377.0±12.04^{g}	276.0±11.16^{e}	101.0±10.06^{k}	0.25±0.02^{b}	1.0±0.01^{d}
AS/017	66.0±6.69^{h}	161.0±3.16^{g}	43.0±0.98^{k}	4.3±0.08^{b}	1.0±0.01^{g}	360.0±19.67^{h}	257.0±10.42^{f}	103.0±16.07^{j}	0.25±0.02^{b}	1.0±0.01^{d}
AS/019	70.0±7.22^{ef}	176.0±3.09^{f}	47.0±2.33^{i}	3.4±0.81^{e}	1.0±0.01^{g}	439.0±13.06^{f}	198.0±14.71^{j}	242.0±12.06^{a}	0.25±0.02^{b}	1.2±0.01^{c}
AS/020	70.0±6.09^{ef}	150.0±9.26i^{j}	41.0±0.58^{k}	3.3±0.66^{f}	1.0±0.01^{g}	508.0±12.04^{d}	374.0±12.16^{a}	134.0±9.16^{g}	0.15±0.02^{b}	1.3±0.01^{b}
AS/010	92.0±8.11^{de}	236.0±2.23^{e}	223.0±9.07^{b}	1.9±0.01^{j}	11.0±2.18^{b}	167.0±10.22^{k}	139.0±10.11^{o}	28.0±0.89^{m}	0.25±0.02^{b}	0.9±0.01^{e}
AS/012	93.0±6.23^{de}	244.0±6.46^{d}	200.0±6.18^{c}	1.7±0.05^{j}	12.0±1.22^{ab}	174.0±8.88^{j}	155.0±12.86^{l}	20.0±2.58^{o}	0.25±0.02^{b}	0.9±0.01^{e}
AS/015	95.0±5.28^{d}	265.0±6.56^{a}	236.0±9.11^{a}	2.1±0.58^{h}	9.0±0.67^{d}	136.0±4.23^{n}	108.0±7.22^{p}	28.0±1.09^{m}	0.23±0.03^{b}	1.0±0.01^{d}
AS/018	94.0±6.56^{d}	260.0±9.22^{b}	194.0±6.08^{d}	2.1±0.24^{h}	10.0±1.80^{c}	156.0±16.00^{lm}	136.0±5.90^{o}	21.0±2.57^{n}	0.23±0.03^{b}	1.0±0.01^{d}
AS/022	101.0±6.23^{c}	258.0±7.11^{bf}	168.0±9.78^{e}	2.1±0.88^{h}	6.0±0.78^{f}	156.0±9.56^{lm}	142.0±10.00^{m}	15.0±0.09^{p}	0.23±0.03^{b}	0.9±0.01^{e}
AS/021	105.0±7.26^{a}	247.0±6.90^{d}	143.0±6.44^{g}	2.2±0.14^{h}	13.0±2.18^{a}	158.0±12.11^{l}	138.0±6.21^{l}	20.0±2.03^{o}	0.23±0.03^{b}	1.2±0.01^{c}
AS/023	104.0±8.9^{b}	253.0±7.26^{c}	152.0±9.02^{f}	2.0±0.38^{i}	7.0±2.18^{e}	159.0±9.90^{l}	143.0±12.01^{m}	15.0±3.30^{p}	0.23±0.03^{b}	0.9±0.01^{e}

Mean values (± standard error) followed by different superscripts within columns are significantly different at (5%) using Duncan's Multiple Range Test (DMRT)

Table 6: Principal Component Analysis of Quantitative Morphological Traits of Accessions

Traits	PC 1	PC 2	PC 3
Leaf length (cm)	**0.92**	-0.19	0.03
Leaf width (cm)	**0.70**	**0.22**	-0.08
Petiole length (cm)	**0.41**	**0.23**	-0.06
Internode length (cm)	0.04	**0.27**	**0.54**
Peduncle length (cm)	**-0.29**	-0.16	0.17
Plant height (cm)	0.12	**0.84**	-0.09
Days to 50 % flowering	**0.80**	**-0.24**	0.01
Days to maturity	**0.71**	**-0.24**	-0.03
Number of capitula/plant	**0.73**	**0.38**	-0.13
Capitulum diameter (cm)	**-0.30**	-0.14	-0.18
Number of head/peduncle	0.18	0.11	-0.07
Number of floret/head	**0.24**	**-0.52**	0.14
Number of filled achene/head	**-0.60**	**0.36**	**-0.25**
Number of unfilled achene/head	-0.12	-0.05	0.09
Achene length (cm)	0.05	0.18	**0.57**
Pappus length (cm)	-0.14	0.06	**0.44**
Eigenvalues	**2.72**	**2.34**	**1.51**
% Variance	**29.31**	**22.47**	**10.01**
Cumulative % Variance	**29.31**	**51.78**	**66.79**

NB = Eigen values ≥ 0.2 are in bold

Table 7: Correlation Coefficients of Quantitative Morphological Traits of *Crassocephalum* Accessions

	LW	**PL**	**IL**	**PDL**	**PH**	**D50%FL**	**DM**	**NCPP**	**CD**	**NHPP**	**NFPH**	**NFAH**	**NUAH**	**AL**	**PPL**
LL*	0.63**	0.52**	0.89**	0.91**	-0.17	-0.70**	-0.01	0.28*	0.09	0.19	0.22*	0.33*	0.18	0.29*	-0.21*
LW		0.91**	0.51**	0.53**	0.15	0.83**	0.67**	0.22*	0.17	0.33*	0.09	0.27*	-0.19	0.17	0.36*
PL			0.50**	0.58**	0.21*	-0.61**	0.77**	0.35*	0.22*	0.09	0.21*	-0.31*	0.31*	0.21*	-0.23*
IL				0.99**	-0.09	-0.76**	-0.08	0.26*	-0.34*	0.08	-0.32*	0.18	0.02	0.22*	0.08
PDL					-0.05	-0.78**	-0.07	-0.11	0.08	0.19	0.18	0.26*	-0.39*	-0.28*	-0.24
PH						0.11	0.32*	0.16	0.36*	0.37*	0.04	-0.36*	0.23*	0.04	0.21
D50%FL							-0.02	0.24*	0.19	0.18	0.30	0.04	-0.27*	0.34*	-0.37*
DM								0.35*	0.21*	0.23*	0.29*	-0.09	0.17	0.12	0.23*
NCPP									0.80**	0.94**	0.84**	0.62**	0.13	0.68**	0.42*
CD										0.76**	0.11	0.79**	0.07	0.72**	0.19
NHPP											0.83**	0.59*	0.61**	0.69**	0.53**
NFPH												0.14	0.12	0.54*	0.39*
NFAH													-0.06	0.64**	0.19
NUAH														0.24*	0.47*
AL															0.18

,**Significant at 0.05 or 0.01 probability level respectively

LL = Leaf length (cm), LW= Leaf width (cm), PL= Petiole length (cm), IL=Internode length (cm) , PDL=Peduncle length (cm), PH = Plant height (cm), D50%FL = Days to 50% flowering, DM = Days to maturity, NCPP= Number of capitula/plant, CD= Capitulum diameter (cm), NHPP = Number of head/peduncle, NFPH= Number of floret/head, NFAH = Number of filled achene/head, NUAH = Number of unfilled achene/head, AL = Achene length (cm), PPL = Pappus length (cm)