(RESEARCH ARTICLE)

Morphological characterization of selected cayenne pepper (*Capsicum annuum* L.) accessions in southwest Nigeria

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Abstract

Pepper is a widely cultivated and utilized spice crop worldwide. It is commonly used in soups and as a condiment to add flavour and colour to food items and contains abundant sources of natural micronutrient antioxidants. The main goal of this work was to characterize cayenne pepper using morphological markers. For this purpose, fifty-seven accessions of cayenne pepper were collected from different regions in Southern and Northern Nigeria, where the cayenne pepper has been grown for some years. The selected accessions were planted at the Teaching and Research Farm, The Federal University of Technology, Akure between December 2020 and April 2021. Data collected on agronomic parameters, which include the number of fruits harvested, fruit weight, fruit length, number of seeds and seed weight, and colour of fruit at maturity, were subjected to multivariate analyses. Results showed that fruit diameter, fruit length, fruit weight, seed weight and number of fruits harvested are traits that most characterize the accessions. Accessions T40, T45, T13, T56, T81, T16, T12 and T15 are most distinct from other pepper accessions. Accession T13 performed best in terms of fruit weight. Accessions T2 and T17 performed best in terms of fruit diameter, fruit length, fruit weight and seed weight. Accession T45 performed best in terms of fruit diameter, number of fruits harvested, seed weight and fruit weight. Further studies on this work are recommended using another location.

Keywords: Capsicum; Accessions; Morphology; Diversity; Characterization; Multivariate Analysis

1. Introduction

Pepper is a widely cultivated and utilized spice crop worldwide (Idowu-Agida, 2014), it holds a significant position as a vegetable crop, ranking just after tomato and onion (Hill, 2013). Pepper cultivation is widespread across many regions in Nigeria, with the primary production area located in the northern region between Latitude 10°N and 12°30'N. The consumption of pepper in Nigeria is substantial, accounting for approximately 40% of the average daily intake in Africa. It is commonly used in soups and as a condiment to add flavour and colour to meats, fish, and other food items (Tokiko and Haruko, 1998)

The fruits of Capsicum are known to be abundant sources of natural micronutrient antioxidants, including vitamins C and E and carotenoids, which play a crucial role in preventing or reducing chronic and age-related diseases. Pepper stands out as a rich source of vitamins A and E and has been reported to contain more vitamin C than any other vegetable crop (Dipeolu and Akinbode, 2007), making it effective in flu-cold prevention. It has been recognized as a potential therapeutic agent in cancer treatment (Bernster, 2009). Additionally, pepper exhibits various beneficial effects such as stimulating saliva and gastric juice production, raising body temperature, relieving cramps, improving complexion, and soothing gout (Abdel, 2008).

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Capsicum species can be categorized based on various fruit/pod characteristics, encompassing pungency, colour, shape, intended use, flavour, and size (Velderrain, 2018).

The considerable diversity present in pepper (*Capsicum spp.*) germplasm holds promise for enhancing fruit yield and quality. To achieve this, the evaluation and characterization of the variation in cayenne pepper accessions become crucial to identify suitable genotypes for improvement programs. Understanding the nature and extent of diversity is essential for breeders as it aids in selecting genetically diverse parents for purposeful hybridization in heterosis breeding (Kim *et. al.,* 2014). There is a need to characterize the different available cultivars to determine the ones suited for the southern region in terms of yield and other quality parameters. Thus, this study aims to characterize some accessions of cayenne pepper "Shombo" using morphological traits and to identify accessions that are most distant from others based on the traits studied.

2. Materials and Methods

The different accessions were collected from the Nigerian Horticultural Research Institute (NIHORT), Ibadan, Nigeria and other locations across the Northern and Southern parts of Nigeria. Seeds from the different accessions collected were planted at the Teaching and Research Farm, The Federal University of Technology, Akure between December 2020 and April 2021.

The study was designed following a Randomized Complete Block Design (RCBD), consisting of 57 accessions that were replicated three times, each plot measuring 2 m x 2 m with an alley of 1m between plots. Plant spacing of 30 x 30 cm was used for the study with a total of eleven (11) stands per plot.

Data were collected on agronomic and yield parameters which include the number of fruits harvested, fruit weight, fruit length, number of seeds and seed weight, and colour of fruit at maturity.

Minitab version 17 was used to analyse the morphological data. The mean separation was done using Tukey HSD. Multivariate analysis such as principal component analysis and single linkage cluster analysis was employed for variability studies using PAST 4.0.

2.1. Morphological and agronomic characteristics

Morphological marker assessment was carried out visually through the observation of differences in appearance without specialized biochemical or molecular techniques, such markers include the relative difference in plant height and colour, distinct differences in response to abiotic and biotic stresses, and the presence/absence of other specific morphological characteristics. Although agronomical characterization provides useful information to users, these characteristics are normally subjected to environmental influences and must be assessed during a fixed vegetative phase of the crop (Oyelakin *et. al.,* 2021). Morphological traits that are controlled by a single locus can be used as genetic markers, provided their expression is reproducible over a range of environments (Kumar, 1999).

3. Results and Discussion

Morphological characteristics, though influenced by the environment, are the simplest and very common and important in the evaluation process of crops. The dendrogram drawn from single linkage cluster analysis (SLCA) grouped the fifty-seven (57) genotypes into seven (7) distinct clusters based on their level of similarity (Figure 1). Table 1 shows the distribution of the genotypes into the 7 different clusters. Cluster 2 had 13 accessions and this made it the cluster with the highest number of accessions while cluster 4 had just one accession (T45). The grouping into different clusters implies that, among the 57 pepper accessions, some genotypes were distinct from one another while others were similar. Those that are in the same cluster share common attributes and are genetically similar to one another. Accession T45 being the only accession in its cluster means that it is not similar to any of the accessions studied. Similar research was carried out by Bianchi *et al*. (2016); they reported the grouping of 30 pepper accessions into eight different clusters by the dendrogram based on morphological characters and added that wide phenotypic variability that has been observed might be due to the exchange of pepper seeds by rural farmers. Also, Gurung *et al*. (2020) reported the hierarchical clustering of 27 chili accessions into 10 clusters.

The scores of the major characters describing the first three principal component axes are presented in Table 2. The first three components with eigen values greater than 1.0 together explained 70.72% of the total variance. The first principal component axis (PC 1) accounted for 26.55% of the total variation.
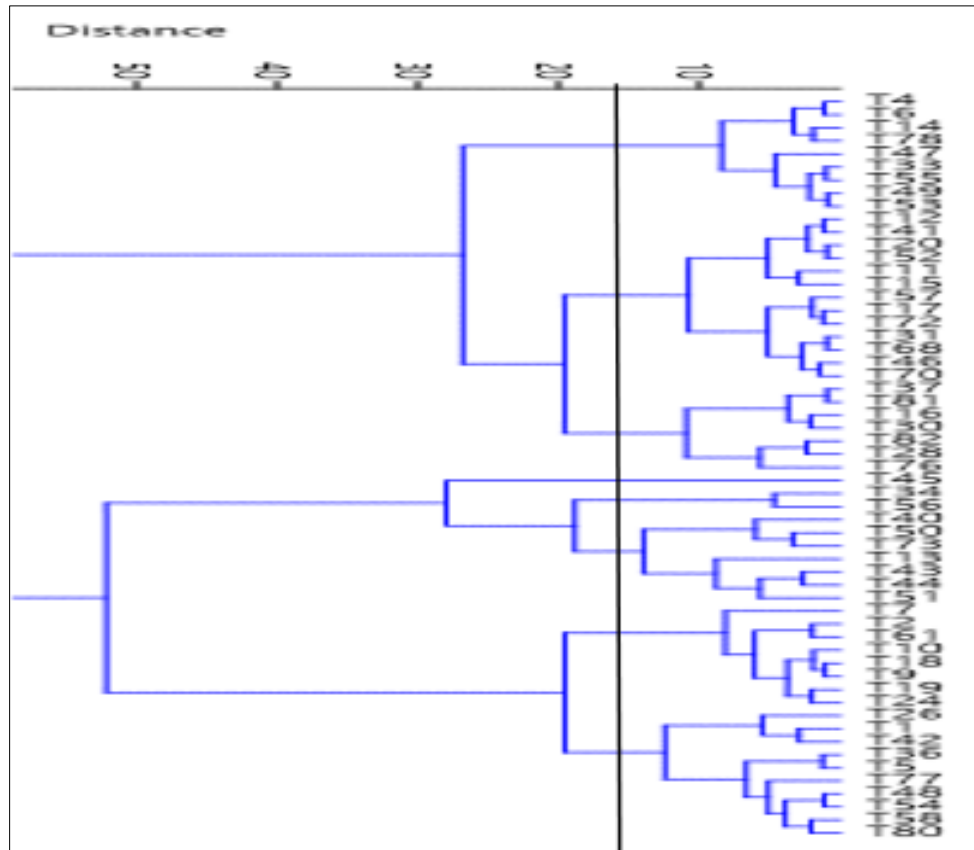
Figure 1 Dendrogram resulting from single linkage cluster analysis of fifty-seven Cayenne Pepper accessions

Table 1 Distribution of Genotypes into the Different Clusters

Cluster	I	II	III	IV	V	VI	VII
Genotypes	T4, T6, T14, T78, T47, T33, T55, T49, T53	T12, T41, T20, T52, T11, T15, T57, T17, T72, T31, T68, T46, T70	T81, T37, T16, T30, T82, T28, T76	T45	T34, T56, T40, T50, T73, T13, T43, T44, T51	T7, T2, T61, T10, T18, T9, T19, T24	T26, T1, T42, T36, T5, T77, T48, T54, T58, T80

Table 2 Eigen vector for Agronomic Characters of the first three Principal Components

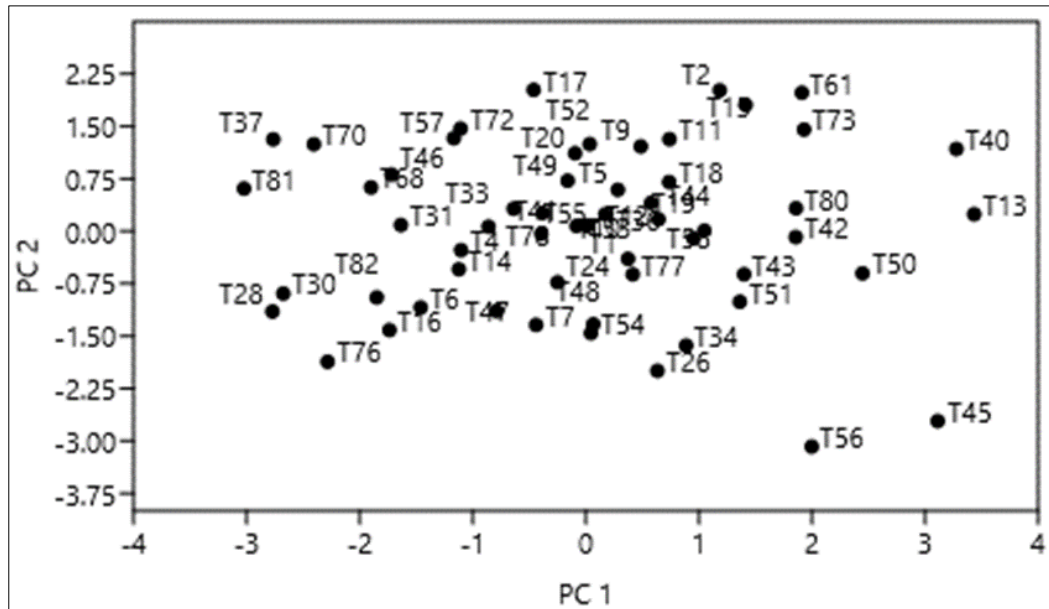|	PC 1	PC 2	PC 3
Fruit Length	**-0.37**	**0.56**	-0.12
Number of Fruits Harvested	0.23	-0.13	**0.58**
Fruit Diameter	0.17	**0.62**	**0.62**
Fruit weight	**0.86**	0.25	**-0.40**
Seed weight	0.18	**-0.47**	**0.33**
Eigenvalue	1.39	1.31	1.01
% Variance	26.55	25.03	19.14
% Cumulative	26.55	51.58	70.72

Figure 2 Configuration of fifty-seven Cayenne Pepper accessions under PC 1 and PC 2
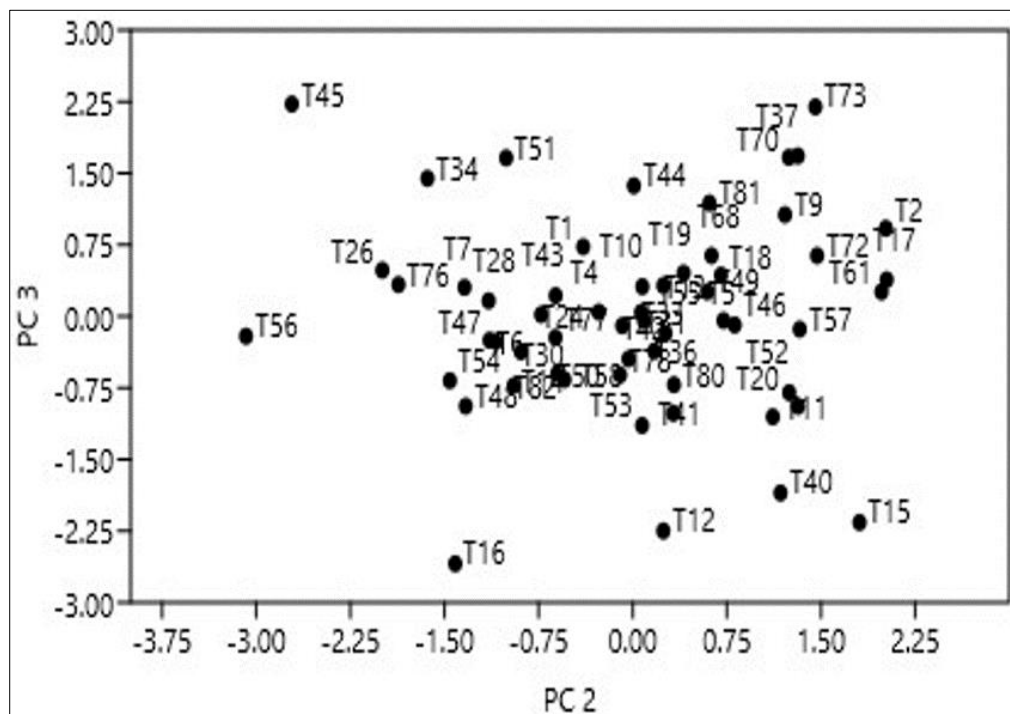

Figure 3 Configuration of fifty-seven Cayanne pepper accessions under PC 2 and PC 3

PC 1 is positively loaded with fruit weight (0.86) and negatively loaded with fruit length (-0.37). PC 2 is positively loaded with fruit diameter (0.62), fruit length (0.56), fruit weight (0.25) and negatively loaded with seed weight (-0.47). PC 3 is positively loaded with fruit diameter (0.62), number of fruits harvested (0.58), seed weight (0.33) and negatively loaded with fruit weight (-0.40). Fruit diameter, fruit length, fruit weight, seed weight and number of fruits harvested which contributed significantly to the variability among the pepper accessions means that they are traits that can be used to discriminate the pepper accessions. Gurung *et al*., (2020) found wide genetic variation in 27 pepper accessions based on fruit characters. This observation is in line with this study. Rafaella *et al.* (2018) observed wide differences in agronomic traits of 116 Capsicum accessions studied, especially in the fruit shape and colour. Albrecht *et al.* (2012)

reported that the variability observed in plant accessions might be due to the wide geographic distribution in different climatic and environmental conditions and this helps to select genotypes that are more adapted to local conditions. An inverse relationship was observed between fruit weight and seed weight in PC 2 and PC 3. This implies that pepper fruits with large weight are not necessarily high seed producers.
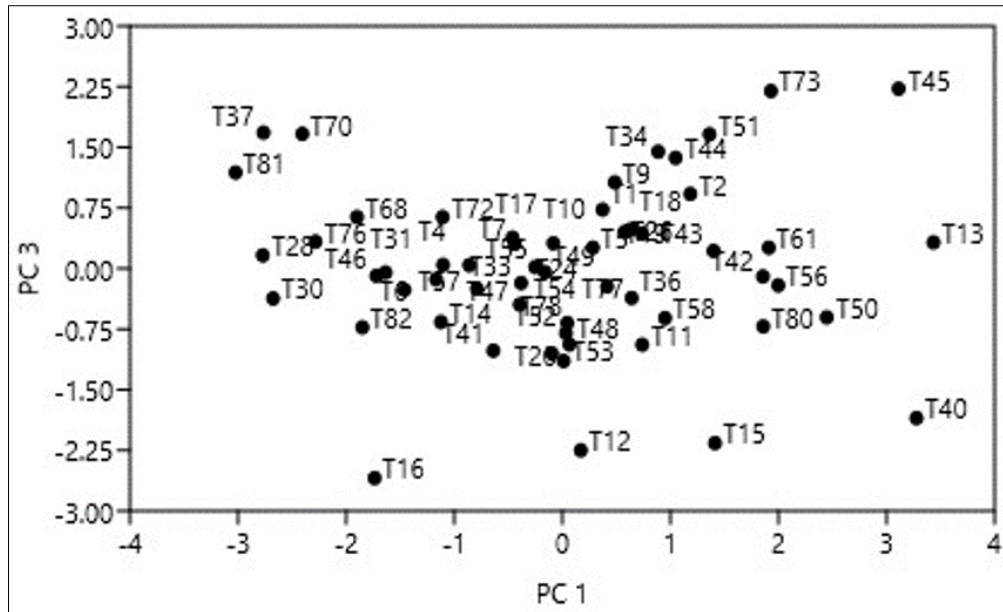

Figure 4 Configuration of fifty-seven Cayenne pepper accessions under PC 1 and PC 3

Configurations of the 57 genotypes along the first three principal component axes are shown in Figures 2, 3 and 4. The ordination of the genotypes on axes 1 and 2 (Figure 1) revealed that T40, T13, T45, T56 and T81 were most distant from all other genotypes and characters (fruit weight, fruit length, fruit diameter and seed weight) associated with PC 1 and PC 2 described them. Figure 2 displayed the graphing of axes 2 and 3 and showed that genotypes T45, T56, T16, T12, T15, T40 were most distant from other genotypes and characters (fruit weight, fruit length, fruit diameter, seed weight and number of fruits harvested) associated with PC 2 and PC 3 described them. Figure 3 shows another configuration of the genotypes along axes 1 and 3 and reveals that T45, T13, T40, T15, T12, and T16 were most distant from other genotypes and characters (fruit weight, fruit length, fruit diameter, number of fruits harvested and seed weight) associated with PC 1 and PC 3 described them. Configurations of the 57 accessions along the first three principal component axes show that the genotypes T40, T45, T13, T56, T81, T16, T12 and T15 are most distant from other genotypes. This finding is similar to that of Constantino *et al.* (2020) who reported wide variation in twenty-two pepper accessions for attributes related to size and weight and also identified accessions that are most desirable based on the traits. Selection for heterotic breeding can be made among the distinct and desirable accessions.

T13 had the highest positive interaction with PC 1 while T18 had the highest negative interaction it (Figures 2 and 4). This means that T13 performed best in terms of fruit weight and length while T18 performed poorest. T2 and T17 had the highest positive interaction with PC 2 while T56 had the highest negative interaction (Figures 2 and 3). This indicates that T2 and T17 performed best in terms of fruit diameter, fruit length, fruit weight and seed weight while T56 performed poorest. Also, T45 had the highest positive interaction with PC 3 while T16 had the highest negative interaction it (Figure 3 and 4). This means that T45 performed best in terms of fruit diameter, number of fruits harvested, seed weight and fruit weight while T16 performed poorest.

4. Conclusion

Fruit diameter, fruit length, fruit weight, seed weight and number of fruits harvested are traits that most characterize the accessions. Accessions T40, T45, T13, T56, T81, T16, T12 and T15 are most distinct from other pepper accessions. T13 performed best in terms of fruit weight. T2 and T17 performed best in terms of fruit diameter, fruit length, fruit weight and seed weight. T45 performed best in terms of fruit diameter, number of fruits harvested, seed weight and fruit weight. Further studies on this work is recommended using another location.

Recommendations

This study should be repeated in another location. Molecular markers should also be used to classify the accessions because it is not affected by the environment.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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