MORPHOLOGICAL CHARACTERIZATION AND VARIETAL DELINEATION OF *Vitellaria paradoxa* (SHEA BUTTER) TREES FOUND ON THE UNIVERSITY OF ILORIN MAIN CAMPUS

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Abstract

The present study reports on the morphological characterization and varietal delineation of *Vitellaria paradoxa* at the University of Ilorin Permanent Site. Forty trees were randomly sampled from two areas, (protected and disturbed), and used for this study. Thirty-eight descriptors, including both qualitative and quantitative variables, from growth forms and leaf descriptors to inflorescence and fruit descriptors, were used to assess the morphological variability. The data collected was subjected to R-software and SPSS version 16 for analysis. Result showed significant variation ($P \leq 0.05$) in quantitative morphological characteristics across the trees. There existed positive cross correlations ($P \leq 0.05$) between leaf blade length, leaf blade width and leaf petiole length. Dendrogram constructed using Average Linkage Groups from these characters produced eight cluster groups, each with distinctive characteristics that differentiated them from the other groups. These groups could serve as local shea varieties in the study area and could be a base for any *Vitellaria* development and breeding programmes.

Keywords: Variety, Morphology, Shea butter

Introduction

The Shea-butter tree, *Vitellaria paradoxa* Gaertn, is a major component of woody flora of the Sudan and Guinea Savannah vegetational zones of sub-Saharan Africa (Lovett and Haq, 2000). It is indigenous to sub-Saharan Africa, and generally only found in semi-arid to arid areas north of the humid forest zone (IPGR, 2006). The species' range forms an almost unbroken belt approximately 5,000km long by 500km wide from Senegal to Uganda (IPGR, 2006).

Shea tree is an important economic crop because of the heavy demand for its butter in the international market mainly as a substitute for cocoa butter in the production of chocolate (Chidiogo *et al*., 2013). Shea butter is the most important product of *V. paradoxa*, which is extracted from the dried kernels. This oil is widely utilized locally for domestic purposes, as skin moisturizer and as an illuminant (Lovett and Haq, 2000). The shea tree also has a unique resource for poverty alleviation and employment generation for both rural women and youth (Chidiogo *et al*., 2013).

Vitellaria is one of the most diversed tropical species, but little is known about its pattern of variation within its natural range (Bouvet *et al*., 2004), and only few studies have been undertaken on patterns of phenotypic or genotypic diversity (Lovett and Haq, 2000). The knowledge and understanding of the extent of genetic variation of shea genotypes is important for conservation and improvement of the crop (Enaberue1 *et al*., 2014), and is essential for its efficient use in breeding programs.

The extent of diversity in the accessions is paramount for improvement and utilization of genetic resources. Genetic diversity is therefore the backbone of conservation of plant genetic resources (Okolo *et al*., 2009), for both present and future use.

Genetic diversity of species also helps formulate appropriate sampling strategies for both *in situ* and *ex situ* conservations, with the aim to protect the variability of taxa so as to preserve ecological processes, rate of establishment, survival and fecundity (Miller, 2000).

So far, genotype studies were performed based on morphological characters leading to the identification of several phenotypes including the domesticated *V. paradoxa* (Nafan *et al*., 2007; Sanou *et al*., 2005, 2006; Ugese *et al*., 2010). Further, using fruit morphology, nut color, crown shape and habitat types, phenotype variation was noticed for the shea tree in Cameroon (Nafan et al., 2007; Lamien et al., 2007). Another study on phenotypic variation of agromorphological traits of the shea tree in Mali used 12 morphological traits, related to tree morphology, fruit size and leaf form (Sanou *et al*., 2006).

A preliminary step in the identification of the various genotypes of the shea trees that may exist in Nigeria is to identify the phenotypes. Little of such studies have been carried out in Nigeria. University of Ilorin has one of the largest campuses in Nigeria with approximately 15,000 hectares of land in the Guinea savanna. This vast area of land houses many species of trees one of the must abundant of which is shea (Acheneje and Olorunmaye, 2015). There is thus need to assess the levels of genetic diversity within and between populations of shea trees in the study area.

This research, therefore, seeks to morphologically characterize the Shea trees on the University of Ilorin campus as amongst the preliminary studies of the variability and varietal composition of the Shea trees in Nigeria.

Materials and methods

The study was conducted at the University of Ilorin, Ilorin, which lies between latitude 8°30´N and longitude 4° 33´E/ latitude 8.500°N and 4.550°E.

Data collection

To study the genetic variations that exist within the *Vitellaria* population, forty (40) trees were randomly selected, twenty-five (25) from the protected areas in which the tree stands are found in close canopy formation with their conspecies and other tree species; and fifteen (15) from the disturbed areas in which trees occur far apart (solitary) from one another. In all the trees selected, thirty-eight traits including both qualitative and quantitative ones related to growth forms, leaves characteristics, inflorescence descriptors, fruits and seed descriptors were used to access variations in *Vitellaria* populations using IPGRI Shea Descriptors manual (IPGRI, 2006).

Data analysis

The data collected were subjected to independent sample t-test and analysis of variance to compare means of various quantitative traits between the two locations (protected and disturbed) and frequencies of occurrence of qualitative traits were estimated.

Correlations between different quantitative variables were determined to establish relationships between characters in the population.

The number of group to build was chosen based on the R-square values of the cluster dendrogram to classify the trees into groups based on their relationships.

These analyses were performed using Excel® and SPSS version 16.

Results

Variations exist in all the morphological characteristics used in characterizing *Vitellaria paradoxa.*

Growth forms and leaf Morphology

Trunk circumference, trunk surface, shape of fissure, bark colour, crown shape, branching density and branching pattern were the growth form descriptors examined.

There was significant difference ($P \leq 0.05$) in trunk circumference across trees and locations. Two forms of trunk surfaces- rough and very rough- were observed in the population.

The shape of the fissures varies between rectangular, square, diamond and irregular.

Four categories of bark colours recorded are ash-grey, dark grey, dark brown and black.

Crown shape varies between pyramidal, spherical, oblong, semicircular and elliptic. Some Vitellaria trees have dense branching density; some are medium, while others are sparse. The patterns of branching observed were erect, opposite, verticillate, plagiotropic and irregular.

A total number of twelve (12) leaf descriptors were used. There was no significant difference in the leaf blade length, width and petiole length ($P \geq 0.05$) across trees and locations. The shortest leaf blade length was 12.2cm and the longest was 27.2cm. The smallest leaf blade width was 5.3cm and the widest was 11.5cm. The shortest petiole length was 4.9cm and the longest was 11.5cm.

There were significant positive cross correlations ($P \leq 0.05$) between leaf blade length, leaf blade width and leaf petiole length.

Five different shapes of leaves were observed. These are elliptic, broadly elliptic, Narrowly-elliptic, oblong and obovate-oblong. Leaf apex shapes are acute, retuse and obtuse. Leaf base shapes include oblique, rounded and cuneate. Two leaf-margin types were observed: entire and undulate. Leaf colurs range between light green, green, dark green to pinkish green. Pubescence was observed on both the upper and the lower surfaces of the leaves.

Fruits and seeds morphology

There was significant difference in the weight and diameters of fruits ($P \leq 0.05$), but no significant difference was found ($P \geq 0.05$) between trees with respect to fruits length. The heaviest fruit was 49.83g and the least was 16.79g. The highest average fruit length was 6.28cm and the least was 3.5cm, 15. 4.77cm was the highest average fruit diameter and the least was 2.92cm.

Four different fruits shapes (plate 1) were examined, which are spheroid, ellipsoid, oblong and ovoid. Fruits surfaces were either smooth or rough. Fruit apex shape assumed four forms – deeply depressed, slightly depressed, rounded and pointed. The concentration of pubescence varies from sparse to dense with some intermediate.

Plate1: variation in fruits shapes and sizes

Plate2: Fruits and seeds measurement

Plate 3: Variation in number of seeds/fruits

Plate 4: Different colours, shapes and sizes of seeds

The colours of the pericarp depend on the colours of pubescence and three of those were identified, these are green, yellowish green and brown. Two mesocarp colours observed are green and yellow. Some trees have fruits with single seed, some have a mixture of single and double-seeded fruit and others have single, double and triple-seeded fruits (Plate 3).

Variations were observed in seed length, width and weight with significant difference ($p \leq 0.05$) between trees. The highest seed length was 4.6cm and the least was 2.97cm. The seed width varies from the highest 3.08cm to lowest 2.23cm. The highest average seed weight was 19.83g and the lowest was 9.47.

There was significant difference ($p \leq 0.05$) in all the characters across the two locations (fig. 1) with exceptions of fruits diameter and thickness of mesocarp. Similarly, figure 2 shows significant difference ($p \leq 0.05$) in fruits and seeds weight in the two locations, in which disturbed areas have higher mean values for fruit and seed weight.

The seeds assumed only three shapes, which are oval, ovoid and ellipsoid. Some trees have seed with uniform surface patterns, some have regular striations and others have patches. The seed coat colours observed are creamish, dull brown, brown and dark brown (Plate 4).

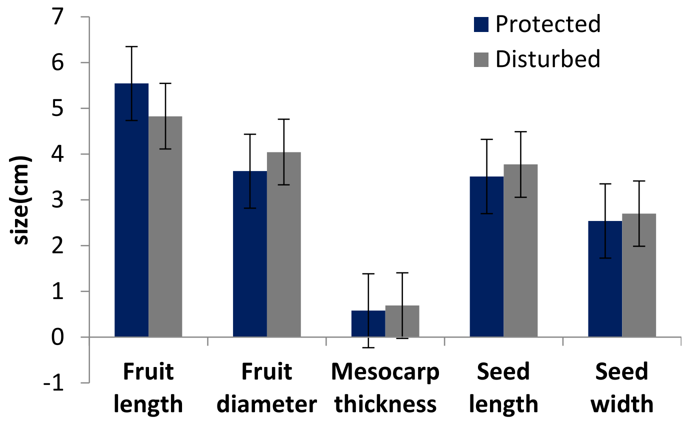

Fig. 1: Fruits and seeds sizes in the two locations

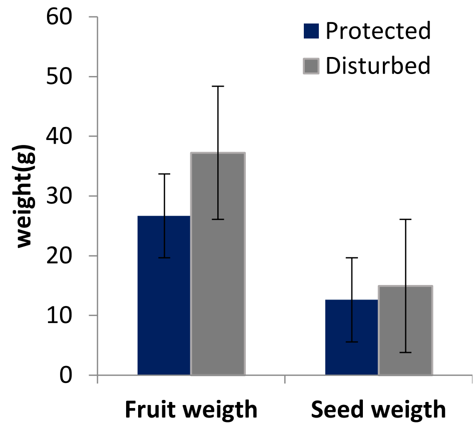

Fig 2: Fruits and seeds weight in the two locations

Grouping of trees in the study area

Dendrogram, using Average Linkage Group generated 8 sub-clusters (groups) of shea trees. Duncan Multiple Range Test was used to assess the variation amongst the 8 groups with respect to quantitative characters (Table 1).

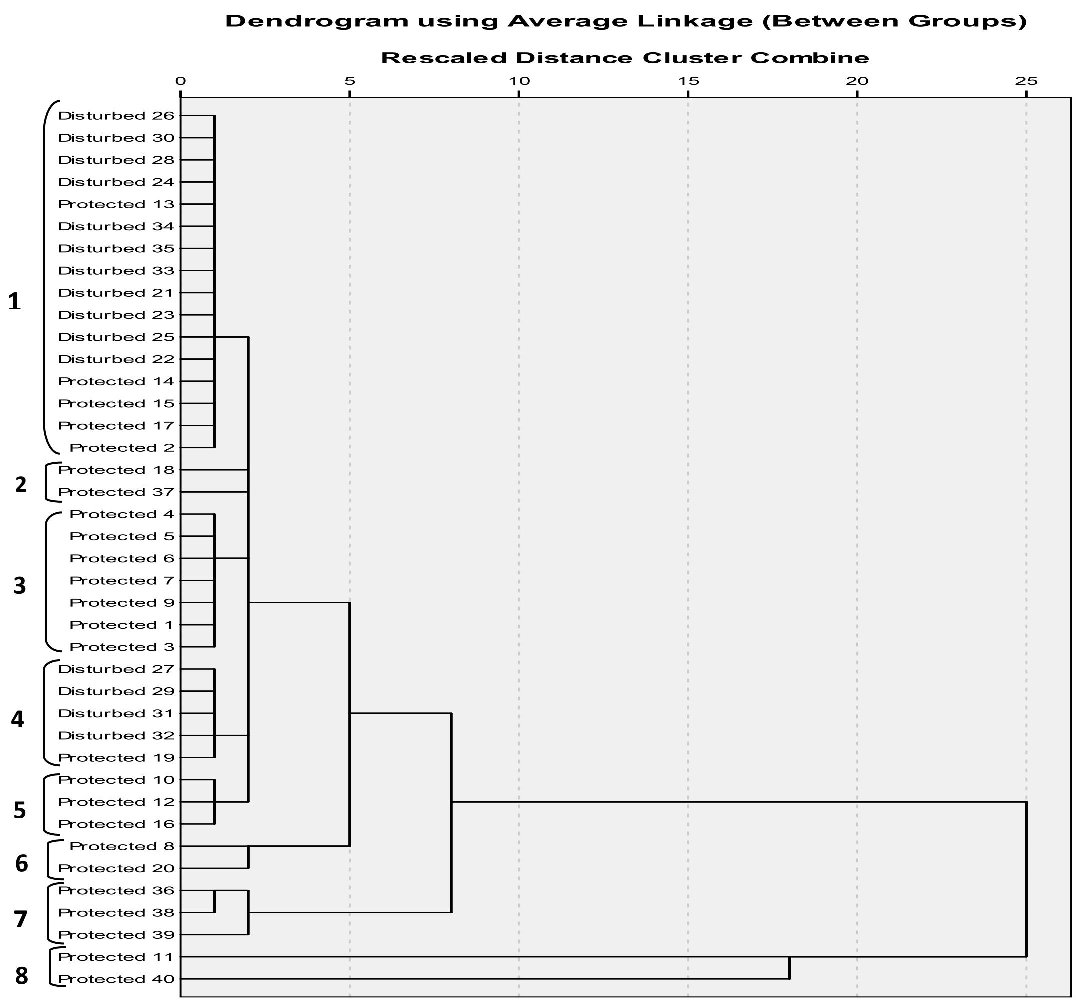

Fig. 3: Dendrogram showing the overall variation in the shea population

The dendrogram constructed from all the characteristics of *Vitellaria* revealed two main clusters, I and II. All together, there are 8 cluster groups at the base of the chart. Members of each cluster group have some level of similarity in their characteristics which are distinct and vary significantly ($p \leq 0.05$) from those of the members of other groups (Table 1).

Varietal delineation in V. paradoxa

Group 1: Members of this group are distinct from members of other groups because they had the highest mean values for trunk circumference and intermediate mean values for leaf blade length, leaf blade width, petiole length, fruit length, fruit diameter, fruit weight, seed length and seed weight.

Group 2: Members of this group had the highest leaf blade length and high trunk circumference. Other characters are: intermediate leaf blade width, petiole length and fruit length; and low mean values of fruit diameter, fruit weight, seed length and seed weight.

Group 3: The distinctive characteristics here are: low mean values for trunk circumference, intermediate leaf blade length, and leaf blade width and petiole length. Other characters are lower values for fruit length, fruits diameter, fruits weight, seed length and seed weight.

Group 4: Members of this group are characterized by high mean values for trunk circumference, intermediate values of leaf blade width, fruits length, seed length and seed weight; and lower values for leaf blade length. Others characters include highest values for fruit diameter, fruit weight and seed width.

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Group 5: Members of this group had high mean values for trunk circumference; and least values for leaf blade length, leaf blade width and petiole length. They have intermediate values of all the fruits and seeds characters.

Group 6: This group is characterized by intermediate trunk circumference, and leaf characteristics. However, they have the lowest values for fruit and seeds characteristics.

Group 7: This group had intermediate mean values for trunk circumference, leaves, fruits and seeds characteristics.

Group 8: Members of this group had the least value for trunk circumference and intermediate values for leaf blade length, fruits, and seed length. They however assumed the least values for fruit weight, seed width and seed weight

Table 1: Mean separation of the 8 groups of *Vitellaria* in the study area

Characters / Groups	Trunk circumference	Leaf blade length	Leaf blade width	Petiole length	Fruit length	Fruit diameter	Fruit weight	Thickness of mesocarp	Seed length	Seed width	Seed weight
Group 1	249.8438 ± 50.5667^{a}	19.8881 ± 2.8556^{ab}	8.2437± 1.3449^{ab}	8.4169± 1.8430^{ab}	4.6588± .6123^{ab}	3.8281± .4432^{ab}	32.9569± 6.4037^{ab}	.6512± .1619^{a}	3.6444± .3744^{ab}	2.6469± .2316^{a}	13.8712± 3.2356^{ab}
Group 2	166.5000 ± 34.6482^{b}	24.2950 ± 2.2274^{a}	7.4900± .7213^{ab}	7.4850± 1.5769^{ab}	4.5850± .2051^{ab}	3.4100± .0141^{b}	25.5650± 1.7324^{b}	.5800± .2263^{a}	3.3900± .2970^{b}	2.4300± .0990^{a}	11.0500± 2.2345^{b}
Group 3	127.0714 ± 11.9464^{bc}	20.1357 ± 3.1442^{ab}	8.2771± 1.8116^{ab}	8.3214± 1.5142^{ab}	4.0900± .2588^{b}	3.4243± .3165^{b}	23.5643± 4.4414^{b}	.5314± .1637^{a}	3.2571± .1103^{b}	2.4057± .1066^{a}	10.5514± .8750^{b}
Group 4	165.4000 ± 27.1717^{b}	18.0720 ± 2.4392^{b}	7.2340± .9042^{ab}	7.2560± .2964^{ab}	4.9720± .5072^{ab}	4.1300± .3817^{a}	40.0000± 5.4823^{a}	.6600± .2011^{a}	3.7660± .3587^{ab}	2.6540± .1581^{a}	14.6780± 1.7428^{ab}
Group 5	143.0667 ± 44.2562^{b}	17.7967 ± 2.9657^{b}	6.8800± 2.0526^{b}	6.9633± 1.5044^{b}	4.5600± .0917^{ab}	3.8933± .5178^{ab}	34.0633± 8.6531^{ab}	.5133± .1336^{a}	3.7433± .2572^{ab}	2.7233± .0462^{a}	14.3833± 1.0347^{ab}
Group 6	115.5000 ± 20.5061^{bc}	22.8150 ± 2.2415^{ab}	8.6300± .1414^{ab}	9.2500± .8202^{ab}	5.2800± 1.4142^{a}	4.1650± .0071^{a}	42.6450± 10.1611^{a}	.7600± .1131^{a}	4.0900± .7213^{a}	2.5900± .1556^{a}	14.6300± 2.4749^{ab}
Group 7	107.2667 ± 9.0892^{bc}	19.0200 ± 1.6564^{ab}	7.6133± .7674^{ab}	8.2267± 1.1856^{ab}	5.0700± .2402^{ab}	3.5833± .1274^{ab}	31.5667± 6.0822^{ab}	.5800± .1442^{a}	3.5500± .1609^{ab}	2.6167± .1332^{a}	14.7233± 2.5127^{ab}
Group 8	59.8500± 1.6264^{c}	22.8500 ± 6.1518^{ab}	9.7900± 2.4183^{a}	9.6150± 1.5344^{a}	4.6900± 1.0889^{ab}	3.9600± .0849^{ab}	37.4300± 8.4429^{a}	.7400± .2546^{a}	3.7850± .4738^{ab}	2.7200± .1698^{a}	15.9900± 3.5780^{a}

Means with the same alphabet(s) across the groups are statistically the same, while those that have different alphabet(s) are statistically different at $p \leq 0.05$.

Table 3.2 above presents the overall clustering in *Vitellaria paradoxa* with respect to the entire descriptors used. However, the means separation was done using only the quantitative variables

Discussion

This study has shown great variations within the *Vitellaria* population in the University of Ilorin Campus. Quantitative and qualitative characters revealed wide variations. Similar studies carried out in some West African countries have shown the existence of a high intra-specific variation (Chevalier, 1948; Ruyssen, 1957) among shea trees.

Variations in growth forms such as canopy density, branching pattern, canopy shape may be genetic, although, environment, age, and or resource status of a tree could partially be responsible.

Variations in leaf characteristics confirmed the results of Nafan *et al*., (2007), Sanou *et al*., (2005 and 2006) and Ugese *et al*., (2010). Leaves' quantitative traits did not differ between protected and disturbed locations probably because environment has less effect on them.

Wide variation in fruits and seeds characters agreed with the works of Nafan *et al*., (2007), Lamien *et al*., (2007), Sanou *et al*., (2006) and Okolo *et al*., (2009). Fruits in the disturbed area have, on the average, higher quantitative characters because *Vitellaria* require space for proliferation and production of bigger fruits and seeds. Trees in the protected area are closely parked with their con-species and other tree species, competing on light and space. This perhaps contributed to the low yield in terms of fruits and seeds sizes and weights.

The dendrogram revealed cluster groups with no clear aggregation based on locations. This is probably because characters under assessment are large in number, and that local environmental differences due to density and competition might not account for much variation in shea population. Distribution of qualitative variables amongst the groups does not follow any order because members of the same group may have varied qualitative traits.

Conclusion

The variations observed within *Vitellaria* population is expected because, according to Hamrick *et al*., (1991), species with high level of genetic diversity within populations are woody perennial species that live long and whose seeds are dispersed mainly by animals. Other characters are out crossing insect pollination and wide spread occurrence. Such factors may explain the percentage of genetic variation found within shea population.

Location has some mild effects on some quantitative characters such as fruits and seeds sizes and weights. Consequently, trees in isolated stands tend to have bigger and heavier fruits as shown by the results but did not have effects on qualitative characters such as fruits and seeds shapes and colours. However, this locational effect did not affect the grouping of trees as indicated by the dendogram.

The knowledge and understanding of the extent of genetic variation of shea trees is important for conservation and improvement of crops (Enaberue1 *et al*., 2014), and is essential for its efficient use in breeding programs.

Recommendation

On the bases of the findings of this study, further research is recommended to differentiate between genetic and environmental variances, as that would help eliminate locational effects when delineating varietal differences.

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