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Research Application Summary

Characterisation of Baobab in selected wild populations in Malawi

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Abstract

Adansonia digitata L. is a multi-purpose indigenous fruit tree with high nutritional and economic value. However, limited studies have been undertaken on *Adansonia digitata* particularly in Malawi. This study was conducted to characterize five selected wild baobab populations using morphometric characteristics. A total of 135 trees and 1350 fruits were assessed. Results showed significant differences ($P \leq 0.05$) in diameter at breast height, fruit width and length, fruit-length-width ratio and fruit weight between populations. Karonga population had largest tree diameter (309.05±19.50cm), Salima population had the longest fruits (15.49±0.20cm) and Karonga population had the widest fruits (8.43±0.10cm). Neno population produced smallest fruits but with the highest fruit-length, and width ratio (2.07±0.03). The diversity of fruit shapes found were: fusiform, ovate, spheroid, ellipsoid pointed, rhomboid, ellipsoid, high-spheroid, obvate, spheroid-emarginate, oblong, oblong pointed and oblong compressed. Many trees had grey bark colour (94%) with most of them having a smooth bark (92%). The dominant tree shape was roundish (56%). The majority (65%) of trees had spreading growth habit. The dominant trunk shape was cone-shape (56%). The study has revealed high *Adansonia digitata* L. tree diversity existing in Malawi that can be used in selection. Further studies should investigate the relationship between tree growth characteristics and fruit quality and productivity.

Key words: *Adansonia digitata,* characterization, domestication, fruit traits, Malawi, tree descriptors

Résumé

Adansonia digitata L. est un fruitier indigène à usage multiple avec une valeur nutritionnelle et économique élevée. Cependant, un nombre limité d'études ont été entreprises sur *Adansonia digitata* L. particulièrement au Malawi. Cette étude a été réalisée pour caractériser cinq populations sauvages de baobabs sélectionnées en utilisant les caractéristiques morphométriques. Un total de 135 arbres et 1350 fruits ont été évalués. Les résultats ont montré des différences significatives ($P \leq 0,05$) de diamètre à hauteur de poitrine, largeur et de la longueur de fruits, du rapport longueur de fruit sur largeur de fruit et le poids des fruits entre populations. Les populations de Karonga avaient le plus grand diamètre d'arbre (309,05 ± 19,50cm), les populations Salima avaient les fruits les plus longs (15,49 ± 0,20cm) et celles de Karonga avait les fruits les plus larges (8,43 ± 0,10cm). Les populations de Neno ont produit les plus petits fruits, mais avec les fruits de rapport longueur-largueur de fruit le plus élevé (2,07 ± 0,03). La diversité des formes de fruits trouvées était: fusiforme, ovoïde, ellipsoïde, ellipsoïde pointue, rhombique, sphéroïde, ellipsoïde, high-ellipsoïde, obvate, sphéroïde-échancré, oblong, oblong pointu et oblongue comprimé. Beaucoup (94%) d'arbres avaient la couleur de l'écorce grise avec la plupart (92%) d'entre eux ayant une écorce lisse. La forme dominante (56%) d'arbre était arrondie. La majorité (65%) des arbres ont une habitude de croissance étalée. La forme dominante de tronc était en forme de cône (56%). L'étude a révélé une forte diversité de *Adansonia digitata* L. au Malawi qui peut être utilisée dans la sélection. D'autres études devraient étudier la relation entre les caractéristiques de croissance des arbres et la qualité des fruits et la productivité.

Mots clés : *Adansnia digitata*, caractérisation, domestication, traits des fruits, Malawi, les clés de descriptions des abres

Introduction

The baobab (*Adansonia digitata* L.) tree is indisputably an important under-utilised fruit tree (Cuni Sanchez *et al.*, 2011). The fruit pulp is presently exported to European and US markets as a food additive (De Smedt *et al.,* 2011). In Malawi an informal trade is booming (Munthali, 2012). Numerous commercial products are made from the fruit such as soft drinks (cool and hot drinks), milk drinks, ice drinks and natural fruit smoothes (Gruenwald, 2009), cereal and energy bars, sport and energy drinks, vitamin and mineral supplements, diet supplements, high fiber products, energy strips, cereal additives, yogurt with prebiotic activities, fruit juices, ice creams and shakes, powdered shakes and mixtures, cakes and biscuits (Sacande *et al.,* 2006). The medicinal values include anti-constipation preparations, anti-fever products and chewable tablets (Munthali, 2012). Manufactured cosmetic products include shower and non-shower products (soaps, gels, face lift creams, body moisturizers, shampoos and hair conditioners) (Munthali, 2012). Further, different parts of the baobab tree such as bark, wood, leaves, flowers, capsules, gum, seeds are used (Wickens and Lowe, 2008; Buchmann *et al.*, 2010). Commercialization of baobab products is contributing to the improvement of livelihood of many communities in its geographical distribution. Unfortunately, currently trade is reliant on dwindling natural populations. Trade, could be sustained only through improved management of existing wild populations and artificial regeneration. Information on species variation, population structure and reproductive biology are prerequisite in formulation of conservation, improvement and domestication strategies (Munthali *et al.*, 2012). Thus, the present study aimed at investigating phenotypic variation in Baobab in Malawi with a motive to generate information for the formulation of conservation, management, improvement and domestication strategies

Materials and methods

The study was conducted in five districts in Malawi (Table 1). The districts were selected because of the abundance of wild populations of Baobab trees and marketing of baobab products. Twenty-one to thirty trees were randomly sampled in each population. Ten ripe fruits were collected from each tree.

Table 1. Location, physical description of populations and number of families sampled

Population	Coordinates	Silviculture zone*	Altitude	Mean annual rainfall (mm)	Mean annual temperature	Soil type
Chikwawa (n=21)**	16°02'S, 34°50'E	A	<200	710-850	>25	Vertisols
Karonga (24)**	09°56'S 33°56'E	L	475-1000	>1600	23-25	Ferrisols dominant; regosols
Mangochi (n=30)	14°25'S, 35°16'E	BA	200-1200	710-850	20-25	Alluvial calcimorphic soils above the vertisols
Neno (=30)	15°25'S, 34°40'E	J	900-1500	1200-1600	19-21	Sandy ferrallitic
Salima (n=30)	13°47'S, 34°28'E	BA	200-1200	710-850	20-25	Alluvial calcimorphic soils above the vertisols

*Adopted from Hardcastle (1978), ** number of trees sampled

Data on tree descriptors (trunk shape, growth habit, bark texture and colour) of *A. digitata* was analysed using descriptive statistics. Data on diameter at breast height (dbh) and fruit traits (fruit-length, width, length-width ratio and fruit weight) were tested for normality with Kolmogorov-Smirnov test. After the normality test was met, all the data were subjected to analysis of variance (ANOVA) using MINITAB for Windows Release 13.30. Differences between treatment means were separated using Fischer's least significant differences (LSD) at the 0.05 level. Data on diameter at breast hight (dbh), and fruit traits were analysed using the following functional model:

$Y_{ij} = \mu + P_i + e_{ij}$

Where Y_{ij} is the response variable in the i[th] population;

μ is the overall mean;

P_i is the fixed effect of population (i= 1, 2, 3, 4);

e_{ij} is the random error, $e_{ij} \sim N(0, \delta e^2)$.

Results

Fruit shape

High fruit shape variations were found in all five populations. Karonga population had the highest diversity (13 fruit shapes) followed by Mangochi population (11 fruit shapes) and Chikwawa (10 fruit shapes), whilst Salima and Neno had eight fruit shapes each (Figure 1). The observed diversity of fruit shapes was constituted by the following: fusiform, ovate, spheroid, ellipsoid pointed, rhomboid, ellipsoid, high-spheroid, obvate, spheroid-emarginate, oblong, oblong pointed and oblong compressed.

Figure 1. Variations in fruit shapes of accessions from the five populations.

Trunk variation

Tree descriptors varied from one tree to another. Pooling the 135 trees, 94% had a grey bark colour whilst 6% had reddish-brown colour. Trees with smooth bark texture were dominant (92%), the rest (8%) had rough bark texture. Roundish tree shape was preponderant (56%), followed by semi-circular trees (33%) and ellipsoid trees were a minority (11%). Most trees (65%) had a spreading growth habit. Trees with dropping growth habit consituted (20%) and the least observed was erect growth habit (15%). Four types of trunk shapes were observed. The common shape (56%) was cone-shaped followed by cylindrical shape (21%), concave shape (17%) and bell-shaped trees were less common (7%) (Figure 2).

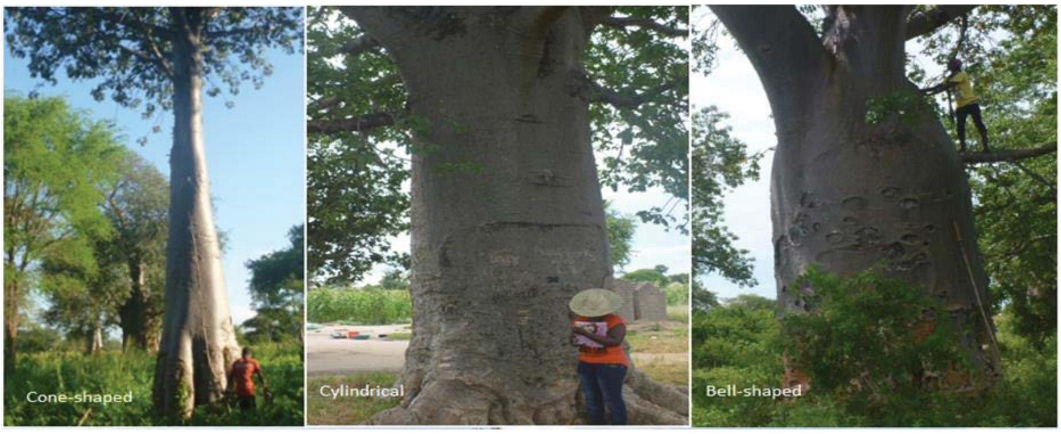

Figure 2. Variation of tree trunk shapes

Variation in diameter at breast height and fruit traits

There was significant ($P \leq 0.05$) variation in diameter at breast height (dbh), fruit length, fruit width, length-width ratio and fruit weight (Table 2). The dbh ranged from 104.09cm to 422 cm. Trees from Karonga population had the largest girth (309.05±19.5cm), followed by trees from Chikwawa (273.14±10.7cm) and Salima (231.23±12.9cm). The smallest tree diameters were found in Neno population (186.89±9.51cm). The longest fruits (15.49±0.20cm) were from Salima population and the shortest fruits were from Neno population (14.26±0.18cm). The widest fruits were from Salima population (7.98±0.08cm). The smallest fruits in width (6.99±0.07) were from Neno. Neno population also had the highest length-width ratio (2.07±0.03) whilst smallest length-width ratio was found in Mangochi population (1.96±0.03). Salima population produced the heaviest fruits (196.03±5.04g) and the lighter fruits were from Neno population (130.15±3.36). High variation was found in diameter at breast height, fruit length, length-width ratio and fruit weight (CV=22.8 to 46.1). Moderate variation was found in fruit width (CV=17.4). Based on the minimum and maximum values in (Table 2), variation in fruit length (26.6%), fruit width (31.6%), fruit length-width ratio (3.7%) and fruit weight (3.3%) were observed.

Table 2. Quantitative characteristics of baobab tree and fruits sampled from five populations

Population	Diameter at breast height (cm)	Fruit length (cm)	Fruit width (cm)	Length and width ratio	Fruit weight (g)
Chikwawa	273.14±10.70b	15.36±0.28ab	7.59±0.09b	2.05±0.04ab	147.45±4.62c
Karonga	309.05±19.50a	14.28±0.21bc	8.43±0.10a	1.74±0.02c	170.28±5.72b
Mangochi	226.70±10.90c	14.85±0.20b	7.68±0.07b	1.96±0.03b	156.08±3.73c
Neno	186.89±9.51d	14.26±0.18c	6.99±0.07c	2.07±0.03a	130.15±3.36d
Salima	231.23±12.90c	15.49±0.20a	7.98±0.08b	1.97±0.03b	196.03±5.04a
Grand mean	235.84±6.38	14.83±0.09	7.71±0.04	1.96±0.01	160.39±2.11
Minimum	104.09	7	3.8	0.15	14.4
Maximum	422	26.3	12.1	4.04	440
P-value	<0.001	<0.001	<0.001	<0.001	<0.001
LSD	35.42	0.58	0.23	0.08	12.62
CV%	26	22.8	17.4	24.5	46.1

Mean values are followed by the standard error (SE) of the mean and Means followed by the same letter within a column are not significantly different .

Discussion

High fruit shape diversity has been found in this study (Fig.1). The results are similar to what has been reported in Sudan (Gurashi and Kordofani, 2014), Kenya (Stadlmayr *et al.,* 2013) and descriptors for Baobab (*Adansonia digitata*) (Kehlenbeck *et al.*, 2015). The tree-to-tree variation of most plants may be a reflection of genetic variability and an adaptation to irregular environmental conditions (Padonou *et al.,* 2014). However, some fruit shapes are yet to be described because they do not conform to the existing descriptors as presented by Kehlenbeck *et al*. (2015). Discovery of unique shapes may imply that rich diversity exist in the species. Thus, there is a need to further investigate the morphology of the fruits in wild populations. This study is yet to characterize the fruits in terms of frequencies of fruit shapes such as fusiform, ovate, spheroid, ellipsoid pointed, rhomboid, ellipsoid, high-spheroid, obvate, spheroid-emarginate, oblong, oblong pointed and oblong compressed. These shapes determine the quality of the fruit and productivity. Such information is pertinent in conservation, management, improvement and domestication of the species. The observed variation present great potential for high genetic gains following selection at population and tree to tree level.

Most of the trees belong to the four trunk shapes (Fig. 2). This study will further investigate the relationship of vegetative characteristics and fruit traits. Such information will be fundamental in selection of elite trees for conservation, improvement, domestication and clonal forestry. High fruit trait variation (CV=22.8 to 46.1) may imply high influence of environmental factors on the traits (Munthali *et al.,* 2012). This is an area for further study such as conducting provenance and clonal evaluation. Field observation showed that all sizes of fruits are sold on the market at varying prices. Thus, fruit size may not be the right trait to classify populations into superiority. This study is yet to access the variation in pulp content and quality which are important variables in nutrition and quality of processed and export products.

Conclusion

The preliminary results of the study have revealed high diversity in fruit shapes, fruit size and tree descriptors. The results suggest great potential in domestication. Further the results have indicated potential of using clonal forestry in developing ideotypes. Clonal forestry may as well accelerate planting of the elite trees, ultimately sustaining productivity and supply of Baobab products. Further investigations will look at nutrition of Baobab pulp at population and tree to tree level. Insitu conservation should be done on all the four populations since they contain different genotypes.

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