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Natural Variation in Fruit and Seeds Characteristics of *Adansonia digitata* L. in Kordofan States, Sudan

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Abstract

The main aim of this paper was to assess the variation of the baobab seed sources and their extended areas in Kordofan states, Sudan. Fifty (50) fruits were sampled in each of the three climatic zones of Kordofan for morphological assessment. The experiment investigated the morphological characteristics of the fruit (length, weight, diameter and thickness of fruit cover), seed (weight, number of seed/fruit, width and thickness), pulp and powder weight as well as fiber weight in addition to morphometric characters. The obtained data was analyzed using analysis of variance by SAS software version 6.12. and the means were separated using Duncan New Multiple Range Test. The results showed that fruits length, thickness of fruits cover, seed weight, number of seed/ fruit, seed length, seed width and fiber weight were significantly different in the three seed sources. While seeds from Kadugli showed high significant compared with Elnhoud and Kazgail. The significant variation in fruit and seed morphometric characters among and within the provenances of *Adansonia digitata* may reflect the overriding impact of both environmental and genetic variation and this can be assumed to reflect true genetic variation and adaptation to different environmental conditions and soil type. It is concluded that a multi-site field seed sources trial is required for more useful information about the studied seed sources for the eco-climatologically adaptations.

Keywords

Baobab, Morphologic Characterization, Variation, and Kordofan

1. Introduction

Adansonia digitata L. (Bombaceae family) is a native deciduous tree from the African savannas. The English common name is baobab also known as cream of tartar tree, lemonade tree and monkey bread tree. In Sudan it's locally known as Homeria or Tabeldi; the fruit are named "gunguleiz" [10]. The Tebeldi tree has many ranges of uses extended from food and beverages to medicinal uses and also it is a good fodder for the domestic animals. Cattle and goats eat the leaves and flowers that would otherwise fall to the ground, the roots can be tapped where water is a problem [18].

The baobab tree, *Adansonia digitat*, is an important member of the family Bombaceae which consists of around 20 genera and around 180 species [12]. According to [7] *A. digitata* is a deciduous tree up to 20 m high, branches short, stout and stiff, wide spreading, Bark smooth, grey or pink, fibrous, trunk which attains 10-14 m or more in girth and often becomes deeply fluted. The tree sheds its leaves during the dry season. Leaves are digitate, normally having 5

leaflets when mature, the leaflets have entire margins and are elliptic to obviate- elliptic, with acuminate apex and ad current base. Mature fruit size may reach a diameter of 20 cm. The flowers bloom during the wet season and the dry season as well. They are very large and suspended on long peduncles. The fruit is bottle or cu-cumber shaped and develops 5-6 month after florescence. It has a woody outer shell, covered by velvety yellowish, sometimes greenish hairs [18].

A. digitata is widespread throughout the hot drier part of the tropical Africa. It extended from northern Transvaal and Namibia to Ethiopia, Sudan and the southern fringes of the Sahara. In Sudan, the baobab tree is most frequently found on sandy soils and by seasonal streams in low rainfall woodland savanna. It form belt in central Sudan, in Kordofan, Darfur, Blue Nile, Upper Nile and Bahr El Gazal [1]. It is often associated with *Tamarindus indica* L. Areas where the baobab can be grown are restricted to these with not more than one day of frost per year [21]. The baobab tree can reach an age of several hundred or thousand years under suitable environmental conditions ([20] and [22]).

The baobab tree has an extensive root system and high water holding capacity. It survives well in dry conditions and it is fire resistance [10]. This adaptation allows it to grow in zones with 100-1000mm annual rainfall, but trees are often stunted in the lower rainfall areas. Measurements on exposed root show that they are relatively shallow less than 1.8m but spread out to a distance greater than the height of the tree [8]. The extensive shallow root system is probably the best adaptation to exploiting the low annual rainfall.

Ecotypes from different areas in Sudan are widely known to have different fruits in terms of size, shape and sweetness. Fruits of baobab are very variable in size and shape ([24] and [18]).

Genetic selection makes it possible to select plants with particularly good characteristics. It has been shown that the vitamin C content is variable depending on the origins. Agronomical studies by the Forest Research Institute in Mali have shown that baobab can easily graft. The advantage is that the plant will be smaller, which facilitates collection of the fruits, furthermore, grafting short the time until flowering, while plants grown from seeds start flowering after 8-23 years, grafted plants will start flowering in only 4 years [18]. However, grafted plants give 30% less fruit [14].

[3] in his investigation on propagation technique of baobab (*Adansonia digitat*) concluded that the morphological characterization of seeds of baobab tree varies according to their source, otherwise, the germination and the growth of seedlings vary with the seeds origin and substrate type. He also stated that the vegetative propagation of the baobab tree is possible in Benin.

Therefore the objective of this research was to identify variation in morphometric characteristics on baobab fruits, seeds and powder from three seed sources in Kordofan states Sudan.

2. Materials and Methods

2.1. Fruits Sources

Mature and healthy fruits of *Adansonia digitata* were collected from three different fruit sources in various parts of Kordofan region -Sudan. The fruits sources used were namely provenances of Kadugli, Elnhoud and Kazgail representing eastern, western and central of Kordofan. It was collected during 20 – 30 February 2015.

2.2. Fruit Collection and Processing

Adansonia digitata mature and healthy fruits were collected from selected trees grown in plantations at the specified geographic areas. Four sites within each area were selected randomly and a sample of two trees was marked in each site for fruit collection and included central areas. Fruits were collected from the tree crown by shaking with long hooked sticks or by hand from under the trees. In total 50 of fruits were collected from the marked trees. Collected fruits were then transported to the University of Kordofan, Elobied-Sudan, for assessment.

2.3. Measured of Fruits Characters

After collection, fruits and seeds characters were measured included:

- Fruit: weight, length, diameter and thickness of fruit cover
- Weight of powder (pulp)
- Seed: weight and Number of seed/fruit

Analysis of variance was carried out using SAS statistical software version 6.12 [17] to determine the significance in variations among treatments applied. Duncan Multiple Range Test was used to separate between means.

Weighing the fruit | the fruit pulp | the shell after pulp extraction

Figure 1. *Some photos from the lab work showing the fruit, the pulp and the shell.*

3. Results

3.1. Morphometric Characters

Analysis of variance (ANOVA) for fruits, seed and powder morphometric data showed highly significant differences between the seed sources on thickness of fruits coat, number of seed, fiber weight, seed diameter and seed thickness. It also showed significant differences on fruits length and seed length. However, there were no significant differences between the seed sources in fruits diameter, seed weight and powder as shown in Table 1.

3.2. Fruits Length

Fruit length ranged from 16.3 to18.1 mm and these were recorded in Elnhoud and Kadugli seed sources, respectively (Table 2). Kadugli seed sources had significantly longer seed compared with the other two seed sources. In this connection Kazgail seed sources ranked in the second place recording seed length of (17 mm). However, Elnhoud and Kazgail had no significant differences between them.

3.3. Thickness of Fruit Cover

The same trend with the thickness of fruit cover seems to be the case with the Thickness of fruit cover characteristic. In this connection, Kadugli seed sources recorded a significantly thick with fruit cover recorded (4.6 mm). Kazgail and Elnhoud seed sources showed no significant differences and ranked second place recording thickness of fruit cover (3.9 mm) and (3.4 mm), respectively as shown in Table 3.

3.4. Number of Seeds / Fruit

The three seed sources showed significant differences between them in this character. The number of seeds per fruit ranged from (120 to 157) seeds. The highest number of seed 157 was obtained from Kazgail seed source ranking at the top, while the lowest number of seeds 120 was recorded by Kadugli seed source, but no significant differences between Kazgail and Elnhoud seed sources as shown in Table 2.

Table 1. *ANOVA on fruits, seed and powder Characteristic of Adansonia digitata differences seed sources in Kordofan States Sudan.*

Source of variation		Fruits											
		Length			Weight			Diameter			Thickness of fruit cover		
	df	SS	M S	F Value	SS	MS	F Value	SS	MS	F Value	SS	M S	F Value
		82	41	3.1*	5080	2580	1.2n	1016.3	508.1	1.5n	37.7	18.9	10.4***
		Seed Weight			Number of seed/per fruits			Length			width		
Sources		SS	M S	F Value	SS	M S	F Value	SS	M S	F Value	SS	M S	F Value
	2	3477.3	1738.7	1.6n				26.5	13.3	16***	19.1	9.5	19.8***
		Seed thickness			42665	21333	5.7**	Powder			Fiber weight		
		SS	M S	F Value				SS	M S	F Value	SS	M S	F Value
		10.9	5.3	15.7***				94.2	47.1	2.8n	130.6	65.3	19.3***

***significant at 0.001; **significant at 0.01; *significant at 0.05; n non significant

Table 2. *Variation in mean fruit, seed and powder characteristics of Adansonia digitata differences seed sources in Kordofan States Sudan.*

Seed sources	Fruits				Seeds					Powder (g)	Fiber weight (g)
	Length (cm)	Weight (g)	Diameter (cm)	Thickness of fruit cover (mm)	Weight (g)	Number of seeds/per fruit	Length (mm)	Width (mm)	Thickness (mm)		
Kadugli	18.1^{A}	142.6^{A}	61.4^{A}	4.6^{A}	67.7^{A}	120^{B}	11.7^{A}	8.5^{A}	7^{A}	8^{A}	3.9^{A}
Elnhoud	16.3^{B}	142.6^{A}	60.4^{A}	3.4^{B}	75.8^{A}	156^{A}	10.9^{B}	7.7^{C}	6.4^{B}	6.1^{AB}	1.7^{B}
Kazgail	17^{AB}	132.4^{A}	66.4^{A}	3.9^{B}	79.3^{A}	157^{A}	10.9^{B}	8^{B}	6.5^{B}	6.5^{AB}	3.2^{A}

Means with the same letter on the same column are not significantly different at p= 0.05 by Duncan New Multiple Range Test.

3.5. Seed Length

The seed length varied significantly between the seed source. Kadugli seed source recorded the highest seed length of (11.7 mm), followed by Kazgail and Elnhoud seed sources (10.9 mm) as shown in Table 2.

3.6. Seed Width

Seed width data showed significant differences between the seed sources Kadugli recorded the longest seed width (8.5 mm). Kazgail in the second seed sources (8 mm) and Elnhoud seed sources in the last (7.7 mm) as shown in Table 2.

3.7. Weight of Powder/Fruit

The powder/fruit varied significantly between the seed source. Kadugli seed source recorded the highest value powder weight/fruit of (8g), followed by Kazgail and Elnhoud seed sources (6.5g, 6.1 g) as shown in Table 2.

3.8. Weight of Fiber/Fruit

The fiber weight/fruit varied significantly between the seed sources. Kadugli and Kazgail highest value fiber weight (3.9, 3.2 g) respectively. Elnhoud seed sources recorded lower value fiber weight/ fruit (1.7 g) as shown in Table 2.

4. Discussion

In the present study, the variation in fruit morphological traits, seed measured and weight per fruit were registered among baobab fruit sampled in the three different climatic zones of Kordofan States. Variation on fruit and seed measured and weight, between seed sources were due to evolutionary responses of fruit and seed to their specific habitats. Regionally, variation in fruit weight was also detected in some West Africa countries. In Nigeria for instance the fruit weighted 496g as stated by [15]. This result exceeded the records from Sudan which recorded 436 g [1]. The reason could also be attributed to the site and site condition and may be to the genetic composition of the trees. Production of a large number of seeds is to maximize the potential fitness by producing a larger number of seeds and increase the chance of establishment of resulting seedlings through great allocation of maternal resources to individual seeds [26]. Observed phenotypic variation is general assumed to reflect the inherent genotypic variation among the provenances grown under uniform conditions. In this context [11] stated that there were no significant variations in fruit shape within individual baobab trees. Although [4] confirmed that morphological variability could occur within a tree in term of capsule shape. That was on baobabs from Benin where [4] suggested a high heritability of this trait. Seed characteristics delineated significant differences among and within provenances from different regions and might reflect the true genetic variations among these provenances as a response of differences in environmental variation [2]. The significant variation in fruit and seed morphometric characters among and within the provenances of *Adansonia digitata* may reflect the overriding impact of both environmental and genetic variation and this can be assumed to reflect true genetic variation and adaptation to different environmental conditions and soil type. The three seed sources used in the present work showed variation in fruit (length and thickness) seed (weight, length, width and number of seeds) and fiber weight. The same finding was found by [1] who reported that *Acacia karoo* displayed significant differences among geographical sources in seed characteristics like seeds weight, number/kg, length and width. Phenotypic variation is determined by genotype and environment interaction and is assumed to express genotypic variation when environmental conditions are controlled ([23] and [16]). It has been shown that seed width was also affected by other factors. As reported by [9], variability in seed size (width, length and thickness) was probably a consequence of a compromise between the requirements for dispersal (which would favor small seeds) and their requirements for seedling establishment (which would favor larger seeds) [6]; [25]; [19], 2014; [2]. It has been shown that seed width was also affected by other factors. As reported by [9], variability in seed size (width, length and thickness) was probably a consequence of a compromise between the requirements for dispersal (which would favor small seeds) and their requirements for seedling establishment (which would favor larger seeds) [6]; [25]; [19] and [2]). Seed width is usually one of the parameters that remain not variable within or among seed lots from deferent provenances, while seed length is mostly variable characteristics affected by environmental condition [13]. The observed big variation in fruits is probably influenced by both genetic and environmental factors. Phenotypic differences observed between capsules might be due to genetic drift, natural selection or plastic responses to differences in micro-habitat factors. A considerable variation in fruit shape was also pointed by [11] A high influence of soil composition on the morphological characteristics of baobab tree was already observed by [5].

5. Conclusion and Recommendations

The study concluded to the variations in morphometric characteristics of baobab fruits. Given the degree of variation reported in this study, selection for improvement of fruit traits would be more effective among trees within the same climatic zones than among zones. These variations are very important to address and to link that with the quality of the fruit pulp in further studies. The results pointed at more investigation to look for documenting the specified species to the specific provenance. Furthermore, the indigenous knowledge together with scientific research could help in programs of promoting the baobab products. Since the seed are used for oil extraction, the number of seed per fruit is very important. The baobab with high number of seeds could be considered. However, the seed weights might indicate to the oil content in some cases. The use of local seed sources is often recommended in restoration and conservation strategies because they are thought to be better adapted to local habitat conditions.

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