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Research Application Summary

Morphological variation of baobab fruits and seeds traits in smallholders farming systems in Benin: a preliminary study on baobab leaves production

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Abstract

Baobab (*Adansonia digitata* L.) leaves are important non-timber forest product (NTFP) in rural areas and increasingly in urban areas in Africa. However, the overharvesting of the leaves constitutes a threat for natural stands of baobab. This paper presents preliminary findings of an on-going study aimed at developing best agro-ecological practices for production of baobab leaves in smallholder farming systems across three biogeographical regions (Sudano-Guinean, Sudanian and Guineo-Congolian) in Benin. Specifically the study assesses the effect of organic manure (compost versus animal excrements), dose of organic manure, density of sowing and frequency of leaves harvesting on the growth leaves biomass of leaves at seedling stage. Thirty to forty fruits were collected from 30 trees in each of the three regions and used in a split-split plot design. Seeds were extracted and conserved at ambient temperature for one month before sowing. Preliminary observations of characteristics of fruits and seeds showed that fruits from the Sudanian region were the biggest (median diameter - 89.9 cm and length - 19.9 cm) and the heaviest (46.60 ± 6.98 g). The Sudano-Guinean region had intermediate values of the morphological traits except for the seeds weight which intermediate values were observed in the Guineo-Congolian region (44.89 ± 6.38 g per 100 seeds). These variations could affect growth of seedlings.

Key words: *Adansonia digitata*, Benin, domestication, density of sowing, frequency of harvest, organic manure

Résumé

Les feuilles de Baobab (Adansonia digitata L.) sont d'importants produits forestiers non ligneux (PFNL) dans les zones rurales et de plus en plus dans les zones urbaines d'Afrique. Cependant, la surexploitation des feuilles représente une menace pour les peuplements naturels de baobab. Cet article présente les résultats préliminaires d'une étude en cours visant à développer les meilleures pratiques agro-écologiques pour la production de feuilles de baobab dans les systèmes de petits exploitants agricoles dans trois régions biogéographiques (Sudano-Guinéenne, Soudanienne et Guinéo-Congolaise) au Bénin. Plus précisément, l'étude a évalué l'effet du fumier organique (compost versus excréments

d'animaux), la dose de fumier organique, la densité de semis et la fréquence de récolte des feuilles sur la biomasse des feuilles en croissance. Trente à quarante fruits ont été recueillis à partir de 30 arbres dans chacune des trois régions et utilisés dans un dispositif de split-plot. Les graines ont été extraites et conservées à une température ambiante pendant un mois avant le semis. Les résultats préliminaires sur les caractéristiques des fruits et des graines ont montré que les fruits de la région soudanienne étaient les plus gros (diamètre médian - 89,9 cm et longueur - 19,9 cm) et les plus lourds (46,60 ± 6,98 g). La région soudano-guinéenne présentait des valeurs intermédiaires des traits morphologiques, à l'exception du poids dont les valeurs intermédiaires ont été observées dans la région guinéo-congolaise (44,89 ± 6,38 g pour 100 graines). Ces variations pourraient affecter la croissance des semis.

Mots clés: Adansonia digitata, Bénin, domestication, densité de semis, fréquence de récolte, fumier organique

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Background and Literature summary

Baobab (*Adansonia digitata* L.) is an agroforestry tree species very common in Africa (Kyndt *et al*., 2009). Regional consultations organised by the International Centre for Underutilised Crops (ICUC) have accorded high priority to enhanced research and development of baobab (Sidibe and Williams, 2002). Bioversity International classified baobab tree among the 10 top agroforestry tree species to be conserved and domesticated in West Africa (Eyog Matig *et al.*, 2002) largely because of its value in food preservation. National research efforts, especially in Benin, Nigeria, Burkina-Faso, Mali and Senegal have provided data on food values, agronomy, ethnobotany knowledge, ecology and genetic diversity of baobab (Diop, 2010). In Benin, baobab is the second common wild tree providing leafy vegetables after *Vitex doniana*. It is ranked as the first most important traditional leafy vegetables in the arid zone of Benin. The leaves are generally consumed fresh in rainy season but in dried form (common practices in the arid zone) in dry season (Dansi *et al.*, 2008). As such, fresh leaves are collected, dried, pounded and sieved into powder in the rainy season when they are abundant for use during the dry season when fresh leaves are scarce. However, it is preferred fresh (Dansi *et al.*, 2008), but non availability in dry season constrains local people to dry the leaves for use in dry season. This practice leads to forced harvest of all the leaves that may affect fruit and seed production. In the north and central Benin, baobab is said, when regularly consumed, to give stoutness and facilitate good growth, dentition and bones' solidification in children. According to certain communities, baobab leaves have curative, regulative and stimulative properties besides food qualities and are sometimes used as neutraceutical (Dansi *et al.,* 2008). Thus, it is important to integrate production of baobab leaves into farming systems. The overall objective of this research is to develop best agro-ecological practices to improve the production of the daily used baobab leaves by building capacity of local farmers and NGOs on how to propagate and grow baobab seedlings in small garden plots using environmentally friendly practices. Specifically, the study aims at assessing the effects of

different doses of two source of organic manures (compost of organic waste versus organic manure from animals; cow dung for Sudano-Guinean and Sudanian regions and poultry dropping for Guineo-Congolian region; leaves harvesting frequencies on baobab leaves production under on-station conditions in the three regions; and the density of sowing on baobab growth.

Study description

The study is being conducted in three bio-geographical regions of Benin (Sekou in the Guineo-Congolian region, Soclogbo in the Sudano-Guinean region and Tanongou in the Sudanian region). The experiment is an on-station research with participatory on-field assessment with communities. Already, baobab capsules have been collected from 30 trees randomly chosen in each region. Thirty to forty capsules were collected from each tree. These capsules were assessed for their morphological traits (total length, median diameter and weight). They were then broken and seeds extracted. For each baobab tree, five random samples of 100 seeds were selected and measured their weight. Subsquently, descriptive statistics (minimum-min, maximum-max, and coefficient of variation-cv) for each morphological trait of capsules and seeds were calculated. Bio-geographical regions were compared using analysis of variance followed by a Student-Newman and Keuls tests. Finally, a correlation analysis was performed to examine relationship between seeds weight and capsules morphological traits. All analyses were done using the R software version 3.1.1. (R Core Team, 2015).

An experiment to study baobab leaves production has also been set up. Four factors are being tested (Table 1).

Table 1. Factors being tested in the frame of the experiment and their modalities

Factors	Modalities
Type of organic matter	Compost versus organic manure from animals: poultry for the Guineo-Congolian region and cow dung for the Sudanian and Sudano-Guinean regions
Doses of organic matter	- 0 (control), 10, 20 and 30 tons/ha for the compost and the poultry dropping - 0 (control), 30, 60 and 90 tons/ha for the cow dung
Density (spacing) of sowing	15 cm × 15 cm, 20 cm × 20 cm and 30 cm × 30 cm
Frequency of leaves harvest	Every 14, 21 and 30 days; starting 30 days after planting

Figure 1. Experimental sites for the on station trial for baobab leaves production

Results

Morphological variation of fruits traits across biogeographical regions

Table 2 summarizes the range of each morphological parameter and its variability (assessed by the coefficient of variation, cv).

Table 2. Minimum (min), maximum (max) and coefficient of variation (cv) of the weight, length, median diameter of the capsules of baobab and of the weight of 100 seeds of baobab for the study regions.

Regions	Weight of capsules (g)			Length (cm)			Median diameter (cm)			Weight of 100 seeds (g)		
	Min	Max	cv	Min	Max	cv	Min	max	cv	min	max	cv
Guineo - Congolian	9.80	709.00	75.3	6.20	41.00	30.931	9.06	126.00	20.40	30.63	57.58	14.22
Sudano-guinean	10.00	802.00	83.08	6.40	30.50	31.23	25.98	130.06	27.513	28.87	58.20	15.50
Sudanian	56.00	784.00	40.39	8.90	35.00	18.35	56.20	261.00	15.41	31.62	62.36	14.99
Whole sample	9.80	802.00	69.19	6.20	35.00	30.25	9.06	261.00	24.13	28.87	62.36	15.45

There was a significant variation of the median diameter (df=2, F=475, p-value<0.001), total length (df=2, F=500.5, p-value<0.001) and weight (df=2, F=409.8, p-value<0.001) of the boabab seed among the three biogeographical regions. The mean value of the median diameter was higher in the Sudanian region (mean=89.29, sd =13.76) but lower in the Sudano-Guinean region (mean=67.82, sd=18.66). Capsules from the Sudano-Guinean region had intermediate diameter of 75.77 cm (sd=15.46). In terms of the length of capsules, the highest value was observed in the Sudanian region (mean=19.94, sd=3.66) while the lowest was observed in the Guineo-Congolian region (mean=14.55, sd=4.50). Intermediate value was observed in the Sudano-Guinean region (mean=14.84, sd=4.64) (Figure 2). Similar trend was observed for the weight of capsules (Figure 2).

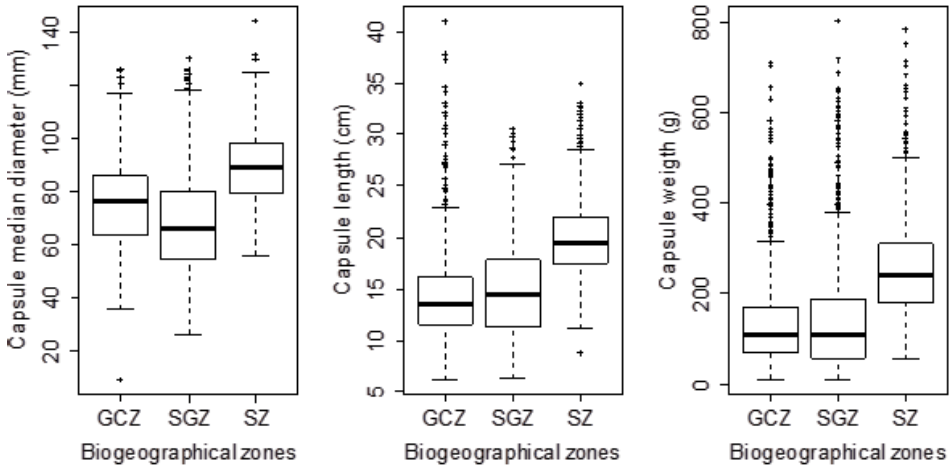

Figure 2. Variation of the capsules traits across the biogeographical regions

Variation in seed weight across biogeographical regions

The weight of 100 seeds was significantly different (F=17.36, df=2, p-value<0.001) among the regions. Heaviest seeds were observed in the Sudanian region (46.60 ± 6.98 g) while the lightest seeds were observed in the Sudano-Guinean region (42.08 ± 6.52 g) (Figure 3). Seeds from the Guineo-Congolian region had intermediate weight of (44.89 ± 6.38 g /100 seeds).

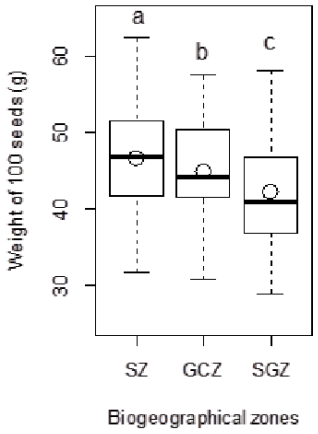

Figure 3. Variation of 100 seeds weight across the three biogeographical regions. SZ= Sudanian region, GCZ=Guineo-Congolian region and SGZ=Sudano-Guinean region. Boxplot with different letter indicates significant differences of means. Dot circle of each boxplot indicates mean values.

Correlation between capsules traits and seeds weight. Figure 4 shows the correlation plot between capsules' morphological traits and seed weight. Only significant (p<0.05) correlations were displayed. There were stronger correlations between capsules weight and capsule diameter (0.81), capsules weight and capsule length (0.74) than between capsule

length and capsule diameter (0.45). Although significant, the correlations between seeds weight and capsules traits (diameter and weight) were weak. The correlation (0.26) between seeds weight and capsules median diameter (Figure 4) was higher than the correlation between seeds weight and capsules weight (0.21). These correlations suggest that the higher the median diameter of capsules or the heavier the capsules, the heavier were the seeds.

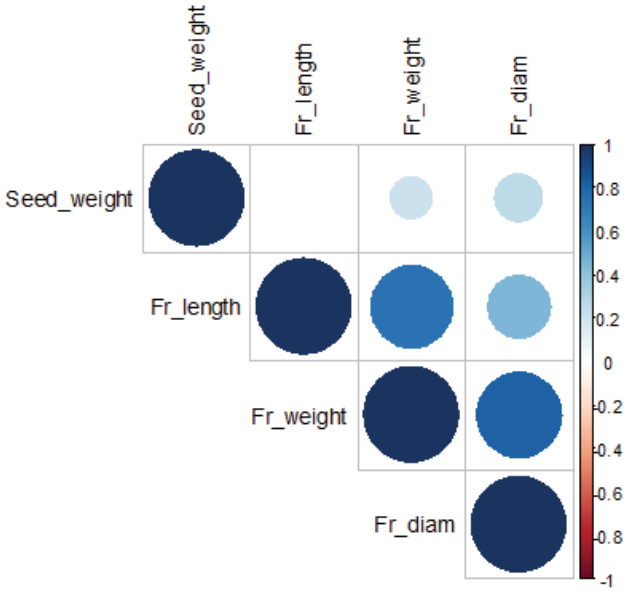

Figure 4. Correlation plot between morphological traits of capsules and seeds weight – only significant (p-value < 0.05) correlations are displayed.

Discussion

Deep knowledge on baobab leaves production as vegetables is a promising way for sustainable management of natural stands of the species. The current findings, in terms of morphologlical traits of capsules, suggest that larger and heavier capsules are found in the drier region while smaller and lighther capsules were found in the wetter region. Similar findings were reported by Assogbadjo *et al.* (2010) in Benin arguing that the observed variation in baobab fruits is probably influenced by both genetic and environmental factors (temperature and rainfall). Our study also revealed that the seeds were heavier in the Sudanian region than in the Guineo-Congolian region which in turn, had heavier seeds than the ones from the Sudan-Guinean region. Several scholars found a close relationship between environment (particularly rainfall) and seed weight. Some studies suggest that plants growing in areas with lower rainfall tend to develop both smaller fruit and light seed weights (Raddad, 2007; De Smedt *et al.,* 2011). Our data suggests that this does not apply to baobab since the heaviest seeds were observed in the driest area. Assogbadjo *et al.* (2005) found that weight of baobab kernels was inversely related to drought: the drier the provenances, the lower the kernels weight. Therefore,

the observed trend in the weight of seeds could be due to the differences in the remaining part of the seeds (overall seed weight – kernel weight). The latter was estimated to be 2/3 of the total seed (Assogbadjo, A.E., pers. comm.).

The variation in baobab provenances with respect to their seed morphometric traits could be due to the fact that these species grow over a wide range of climatic conditions (Niang *et al.*, 2015). Taking into account the potential adaptation of baobab to the latitudinal gradients in Benin (Assogbadjo *et al.*, 2010), the use of local seed provenances is often recommended in restoration and conservation strategies because they are thought to be better adapted to local habitat conditions.

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