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Ecological adaptation of the shea butter tree (*Vitellaria paradoxa* C.F. Gaertn.) along climatic gradient in Bénin, West Africa

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Abstract

The ecological adaptation of shea butter trees was assessed based on their dendrometric and production traits in four shea butter tree parks occurring in different climatic zones of Bénin. A total of 99 rectangular plots of 50 × 30 m were established within the four parks according to a random sampling scheme. In each plot, all trees with a diameter at breast height (dbh) >10 cm were inventoried and measured for stem and crown diameters, and total height. The production of 120 productive shea butter trees was quantified. Collected data were used to compute structural parameters for each park. Moreover, stem diameter and height structures of the trees were established. Principal component analysis was performed on the dendrometric variables, and the first three components were correlated with the climatic parameters. Results revealed significant differences between parks in most of the dendrometric and production parameters of shea butter trees. For all the four parks, stem diameter and height structures present a Gaussian shape with left dissymmetry. In the Guinean zone, shea butter trees develop large crowns but produce little quantities of fruits, whereas in the Sudanian regions, the opposite trend was observed.

Key words: climate, morphology, parks, structure, *Vitellaria paradoxa* C. F. Gaertn, West Africa

Resume

L'adaptation écologique des arbres à karité a été évaluée en en considérant leurs caractéristiques dendrométriques et de production dans quatre dans quatre parcs à karité situés dans des zones climatiques différentes au Bénin. Au total, 99 placeaux rectangulaires de 50 × 30 m furent établies dans les quatre parcs selon un schéma d'échantillonnage aléatoire. Dans chaque parcelle, tous les arbres dont le diamètre à 1,3 m du sol est supérieur à 10 cm ont été inventoriés et mesurés en diamètre du tronc et de la couronne ainsi qu'en hauteur totale. On a aussi quantifié la production de 120 arbres à karité productifs. Les données collectées ont permis de calculer des paramètres structuraux pour chaque parc. De plus, on a établi les structures en diamètre et en hauteur des d'arbres. Une Analyse en composantes principales fut réalisée sur les variables dendrométriques, et les trois premières composantes furent mises en relation avec les paramètres climatiques. Les résultats obtenus ont montré des différences significatives entre parcs pour la plupart des paramètres dendrométriques et de production des arbres à karité. Pour les quatre parcs, les structures en diamètre et en hauteur des arbres présentent une courbe de Gauss avec une dissymétrie gauche. Dans la zone guinéenne, les arbres à karité développent de larges couronnes mais produisent de petites quantités de fruits alors que dans les régions soudaniennes, on observe une tendance inverse.

Introduction

In Africa, forests contain many tree species, which play an important role in the subsistence of rural people (Dah-Dovonon, 2000; Vodouhê *et al.*, 2009). The expansion of agriculture has changed many of these forests into

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agroforestry systems, resulting in the necessity of conserving some tree species with high socio-economic value. These fruit trees provide an opportunity to diversify income, and the mixture of perennial and annual crops represents an environmentally sound land management system conducive to moisture and soil conservation (Maiga, 1987; Nyberg & Högberg, 1995; Jonsson, Ong & Odongos, 1999; Traoré, 2003). In recognition of the economic, nutritional and ecological importance of trees, many farmers preserve individual trees during land-clearing operations. This practice is common in Bénin, where some well-known and commonly utilized tree species such as *Adansonia digitata* L., *Tamarindus indica* L., *Vitellaria paradoxa* C. F. Gaertn are conserved within the parklands by local farmers. In such a traditional system of land use, trees are randomly arranged (Sinclair, 1999; Boffa, 2000).

In Bénin, most of the parklands are constituted of shea butter trees and four important parklands of shea butter trees located in different climatic regions were identified in the country (Gnanglè, 2005). shea butter tree is a mesopharenophyte that belongs to the family of Sapotaceae. Two species of the genus *Vitellaria* exist: *V. paradoxa* in West Africa and *V. nilotica* in East Africa (FAO, 1988). The mean height of the species is 10 m but can reach 15 m with a mean stem diameter of 50 cm (Arbonnier, 2000). In Bénin, shea butter trees can be found from Atchérigbé (7°52′N and 2°03′W) to Malanville (11°52′N and 3°23′W) (Gbedji, 2003). The species is productive from 15 to 20 years, with an annual kernel production of 2.2 kg per tree (Gbedji, 2003). It is of great socio-economic importance serving as a source of income for local communities. It has gained increasing importance at international level in the production of chocolate and in the cosmetic industries (Becker & Statz, 2003).

There is a high spatial variability in the morphology and productivity of *Vitellaria* in parklands according to bioclimatic regions in Bénin (Gbedji, 2003; Gnanglè, 2005). Environmental conditions with particular emphasis on climatic parameters impact on the morphology and productivity of the trees. Natural selection related to rainfall variations in Bénin may produce differences in important traits among *Vitellaria* populations, as is the case of baobab trees in Bénin (Assogbadjo, Sinsin & Van Damme, 2005). Moreover, within the context of climate change, a real variation in climatic conditions including rainfall, relative humidity and temperature was observed in Bénin from 1970 to 2008 (Glèlè Kakaï, 2009). Therefore, studies on the ecological adaptation of the shea butter trees along climatic gradient were found to be important. This could help assessing the future production of shea butter tree parklands with changes in climate.

This study was set up to analyse the structure of shea butter trees in parklands located in different climatic regions of Bénin. The specific objectives were (i) to assess the structural and production characteristics of shea butter trees in the four parklands; (ii) to relate the morphological and production parameters of the shea butter trees to climatic parameters of the regions where they grow; and (iii) to establish and analyse the variability in stem diameter and height components of shea butter tree populations in different climatic regions. The main assumption was that the morphology of shea butter trees is determined by environmental conditions (such as climate patterns, soil properties and phytosociological patterns of vegetation).

Materials and methods

Study area

The research was conducted in four shea butter tree parklands (Savè, Parakou, Bemberèkè and Kandi districts) that cover the distribution range of the species in Bénin. In total, fifteen sites were identified including two in Savè district, three in Parakou, six in Kandi and four in Bembéréké (Fig. 1). The climatic patterns of the four parklands (Table 1) reveal decreasing aridity from Kandi (in Sudanian zone) to Savè (in Sudano-Guinean zone). The vegetation of the four regions is dominated by woodlands and riparian forests. The woodlands are dominated by *Isoberlinia doka* Craib. and *Uapaca togoensis* Pax, whereas the riparian forests are constituted, among others of *Pterocarpus santalinoides* L'Herit. ex DC. and *Mitragyna inermis* Willd.

Inventory design

The inventory design followed a random sampling scheme and was constituted of rectangular plots of 30 × 50 m spread out in the four parks. Each plot was associated with four quadrats of 10 × 10 m (Glèlè Kakaï & Sinsin, 2009). The minimum sample size, N of the plots that were considered for the inventory, to guarantee a standard error of d equal 15% for the mean basal area of the shea butter trees was computed as follows (Dagnelie, 1998):

$$N = \frac{t^2_{1-\alpha/2} CV^2}{d^2} \quad (1)$$

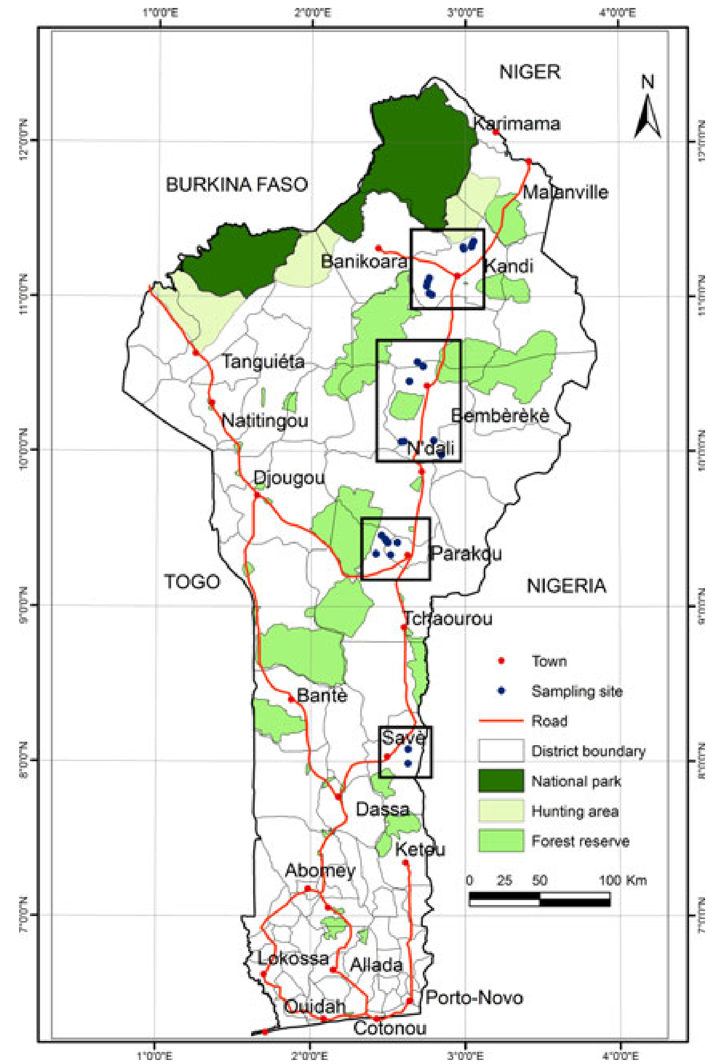

Fig 1 Location of the sampling points on the map of Bénin

Table 1 Climatic patterns of the four parklands for the period 1960–2008

Climatic zone	Parkland	T_{min} (°C)	T_{moy} (°C)	T_{max} (°C)	H_{min} (%)	H_{moy} (%)	H_{max} (%)	Sunstroke (h)	T_{ev} (mmHg)	Rainfall (mm)
Sudano-Guinean	Savè	21.2	27.1	32.1	47.8	68.2	92.2	6.1	25.1	1175.3
	Parakou	21.3	27.1	32.9	43.2	60.6	83.1	6.8	21.4	1147.2
Sudanian	Bemberèkè	20.9	27.2	33.4	41.8	57.4	77.3	7.3	20.4	1190.1
	Kandi	21.3	27.9	34.4	35.3	52.4	74.4	8.2	19.7	1007.4

T_{min}, minimal temperature; T_{moy}, mean temperature; T_{max}, maximal temperature; H_{min}, minimal humidity; H_{moy}, mean humidity; H_{max}, maximal humidity; T_{ev}, Vapour pressure.

In Eq. 1, $t_{1-\alpha/2}$ is the critical value of the *t*-distribution that converges to the normal distribution for larger samples ($N > 30$) and equals to 1.96 for a probability value of $1-\alpha/2$ that was equal to 0.975 ($\alpha = 0.05$); CV = coefficient of variation of the basal area of the shea butter tree in parklands and was equal to 76.1% (Gbedji, 2003); d = margin error of the estimation of dendrometric and production parameters to be computed ($d = 15\%$). With these values, N equalled 98.8 and was rounded to 99.

The 99 plots were distributed among the four parks according to their size that was approximated. Thus, 30 plots were constituted in the Sudano-Guinean zone, (seventeen plots in Savè, thirteen in Parakou) while 69 plots were constituted in the Sudanian zone (26 in Bembèrèkè and 43 in Kandi). The design of the forest inventory was then made up of the parks (as the main factor), and the plots were considered as replicates.

Data collection

Data were collected in the four parks in March 2009. In each plot, diameter at the breast height, crown diameter and height were measured on all shea butter trees using a calliper, pentadecameter and blum-leiss, respectively. To measure the crown diameter, four radii of the projection of the crown on the ground were measured. The first radius was taken randomly (Rondeux, 1999). To estimate the number of fruits, 30 trees were selected within four to six plots in each park, and these trees comprised the different class sizes of the trees. The number of fruits per tree was estimated by randomly selecting three main fruit branches of similar middle diameter; the number of fruits on each branch was recorded and the mean number, n_f, was determined. The estimated number of fruits Nf per tree was then extrapolated by multiplying the number of main branches that carried fruits with the mean number of fruits per branch. In addition, ten trees from the 30 trees in each park were randomly selected and for each tree, the length, width and circumference were measured. Thus, in total, 400 fruits were measured for the four parks.

In each rectangular plot, the number of seedlings and saplings (dbh < 10 cm) was recorded in each of the four quadrats located inside the plot. Climatic parameters were also considered for each park: rainfall, sunstroke, relative humidity and temperature. These climatic variables were obtained from the Agency for Air Navigation Safety in Africa and Madagascar (ASECNA).

Data analysis

Characterizing the structure of shea butter tree populations along climatic gradient. The structure of shea butter tree populations was described along climatic gradient through the morphometric parameters of the species in parks and the stem diameter structures of the trees.

For each plot, the following morphometric parameters were computed:

The tree density of the plot (*N*): i.e. the average number of shea butter trees per sample plot, expressed as stems per hectare.

The basal area of the stand (G): i.e. the sum of the cross-sectional areas at 1.3 m above ground level of all shea butter trees on a plot expressed as m^2 per ha:

$$G = \frac{\pi}{4s}\sum_{i=1}^{n} 0.0001 d_i^2 \tag{2}$$

d_i being the diameter (in cm) of the i-th tree of the plot and *s* the unit area of the plot (*s* = 0.15ha).

The mean diameter of the tree (*D*): i.e. the diameter of the tree with mean basal area expressed in cm was calculated as:

$$D = \sqrt{\frac{1}{n}\sum_{i=1}^{n} d_i^2}\ , \tag{3}$$

with *n* being the number of trees found on the plot and d_i, the diameter of the i-th tree (in cm).

The Lorey's mean height (*H*): i.e. the average height of all trees found in the plot, weighted by their basal area, expressed in metres (Philip, 2002) was calculated as:

$$H = \frac{\sum_{i=1}^{n} g_i\, h_i}{\sum_{i=1}^{n} g_i} \qquad \text{with} \qquad g_i = \frac{\pi}{4}\, d_i^2\ , \tag{4}$$

with g_i and $h_i$being the basal area (in m^2 per ha) and the total height (in m) of the tree *i*.

The mean crown diameter ($d_h$in m) was computed as follows:

$$d_h = 2\sqrt{\sum_{i=1}^{4} r_i^2/4}, \tag{5}$$

r_i = radii i (i = 1,…,4) of the projection of the crown on the ground (see Data collection).

The mean density of recruitments (N_r): i.e. the average number of recruitments (seedlings and saplings) of shea butter trees per hectare, expressed as plants/ha, was calculated as:

$$N_r = \frac{1}{4}\sum_{i=1}^{4} dr_i \quad \text{with} \quad dr_i = \frac{n_i}{sq}\ , \tag{6}$$

with dr_ibeing the density of seedlings and saplings in quadrat *i*; n_i being the number of recruitments of shea butter trees and *sq*, the unit area of the quadrat (sq = 0.01 ha).

The mean and coefficient of variation of the dendrometric parameters were computed for each park. Data on dendrometric parameters in the four parks were subjected to one-way analysis of variance (ANOVA). Normality and equality of variance did not hold to allow ANOVA on the raw data. Thus, logarithmic transformation was applied to the parameters before performing ANOVA to normalize the data and stabilize their variances.

The Student–Newman–Keuls test was applied after the ANOVA test to classify the parks according to the mean value of the parameters.

To relate the dendrometric parameters of shea butter trees to the climatic variables, a principal component analysis (PCA) was applied to the morphometric parameters. Three principal components were retained and linked with the climatic variables, using Pearson correlations.

To establish the stem diameter structures of *V. paradoxa* populations, trees of the species were grouped for each park, into stem diameter classes of 10 cm width. The observed frequency distribution of diameter classes was adjusted to a three-parameter Weibull distribution because of its flexibility (Johnson & Kotz, 1970):

$$f(x) = \frac{c}{b}\left(\frac{x-a}{b}\right)^{c-1} \mathrm{e}^{-\left[\frac{x-a}{b}\right]^{c}}, \qquad (7)$$

where x = tree diameter; a = 10 cm for the diameter structure and 2 m for the height structure; b = scale parameter linked to the central value of diameters and heights; c = shape parameter of the structure. The parameters b and c were estimated using maximum likelihood method (Johnson & Kotz, 1970). The log-linear analysis (Agresti, 2010) was performed in SAS Institute Inc (2003) for each case to test the adequacy of the observed structure to the Weibull distribution. The considered model is (Caswell, 2001):

$$\text{Log Frequency} = \mathrm{F} + \mathrm{F}_{\text{-Class}} + \mathrm{F}_{\text{-Adjustment}} \qquad (8)$$

with F = mean frequency of the classes; $\mathrm{F}_{\text{\_Class}}$ = nonrandom gap linked to the differences in frequency between classes; $\mathrm{F}_{\text{\_Adjustment}}$ = nonrandom gap linked to differences between observed and theoretical frequencies. The hypothesis of adequacy between both distributions was accepted if the probability of the test value was higher than 0.05.

Assessing the production of shea butter tree along climatic gradient. Apart from the number of fruits per tree that was already known, we averaged fruit size variables (length, width, circumference) over the ten fruits that were measured.

The mean and standard deviation of these four parameters were computed for each park. The Kruskal–Wallis test was used to compare the four parks according to the four parameters referred to above. This nonparametric test was used because the hypotheses of uses of the ANOVA did not hold, despite logarithmic transformation being applied to the data.

The impact of climatic conditions on the morphology of the shea butter tree was tested and described using the PCA on the morphometric parameters. Three principal components were also retained here and linked with the climatic variables, using Pearson correlations.

Results

Structural characteristics of shea butter trees along climatic gradient

There was no significant difference ($P > 0.05$) in tree mean height between parks but significant differences ($P \leq 0.05$) for tree density, the diameter at breast height, the basal area, the crown diameter and the density of seedlings and saplings (Table 2). The highest stem mean diameter and basal area were recorded in Savè (Sudano-Guinean zone). On the contrary, tree densities were the highest in Bembèrèkè and Kandi (Sudanian zone) according to Student–Newman–Keuls test. The density of the recruitment varied between 17.7 stems per ha (in Savè) and 33.5 stems per ha (in Kandi), whereas adult tree density varied from 17.3 trees per ha (in Savè) to 39.2 trees per ha (in Bembèrèkè).

The stem diameter structures of the shea butter tree in the four parks were bell-shaped, a characteristic for non-degraded populations (Fig. 2). However, the structure in the Sudanian parklands was positively asymmetric (shape parameter c of Weibull distribution <3.6), often found for populations with relatively more young individuals. In the Sudano-Guinean parklands, there was weak and nonsignificant ($P > 0.05$) left asymmetry (shape parameter c of Weibull distribution equal to 3.6). In the Sudano-Guinean parklands, the 40–60 cm dbh (diameter at breast height) classes were the most represented. Individuals with dbh >90 cm were in smaller proportion. In the Sudanian zones, trees with >90 cm dbh were recorded, but with low

Table 2 Comparison of the parks: mean (m) and standard deviation (s) of the dendrometric parameters and probability values (Prob.) of the ANOVA

	Savè		Parakou		Bembèrèkè		Kandi		
	Sudano-Guinean		Sudano-Guinean		Sudanian		Sudanian		
Parameters	m	s	m	s	m	s	m	s	Prob
Tree density, N (trees per ha)	17.3[a]	2.5	19.1[a]	1.6	39.2[b]	5.4	33.6[b]	4.3	0.001
Diameter, D (cm)	49.3[a]	0.04	44.3[a]	0.1	47.4[a]	0.1	37.9[b]	0.1	0.001
Weighted height, H (m)	12.6[a]	1.1	12.6[a]	1.4	12.9[a]	1.3	13.4[a]	3.3	0.615
Basal area, G (m^2 per ha)	1.3[a]	0.2	1.1[a]	0.5	1.2[a]	0.3	0.7[b]	0.3	0.001
Crown diameter, d_h (cm)	7.6[a]	0.8	7.4[a]	1.2	7.9[a]	1.1	6.9[b]	1.6	0.021
Density of recruitments N_r (stems per ha)	17.7[a]	15.6	15.7[a]	8.9	22.1[b]	14.2	33.5[c]	21.8	0.001

Means followed by the same letter on the same line are not significantly different at Prob. = 0.05 (Student Newman and Keuls test).

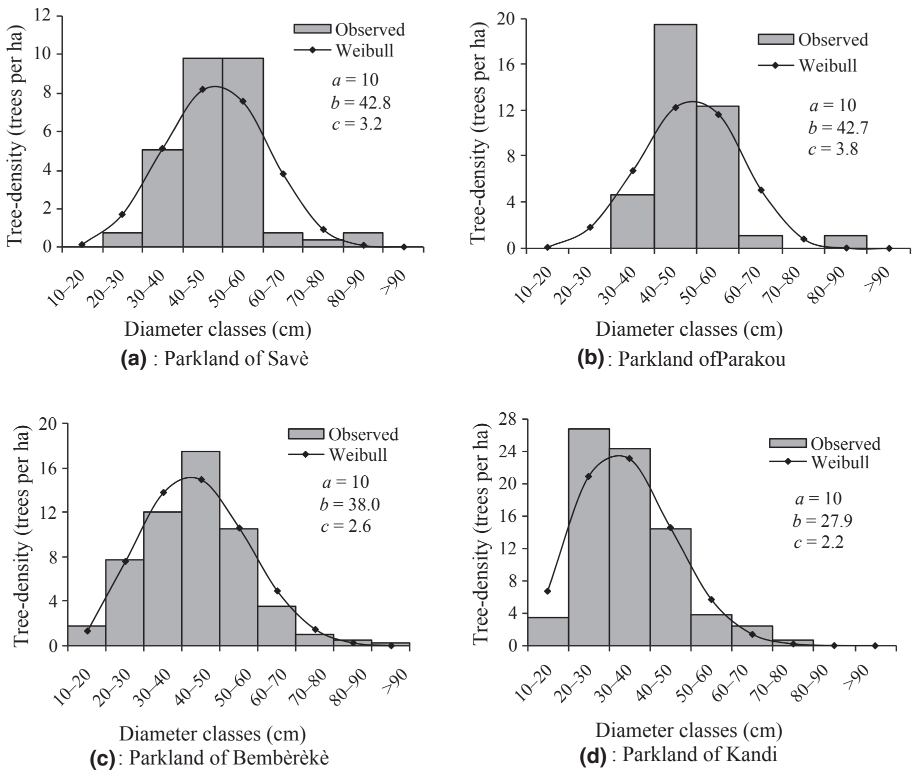

Fig 2 Stem diameter structures of *Vitellaria paradoxa* in the four parks

density. The 20–50 cm dbh classes were the most common across parks. The fit of the observed size distributions to the Weibull distribution was good for all parklands (Kandi: chi-square = 2.05, $P = 0.84$; Bembèrèkè: chi-square = 0.71, $P = 0.99$).

In situ production of shea butter trees

The number of fruits per tree differed significantly ($P \leq 0.05$) between parks (Table 3). The production of shea butter trees was higher with an increase in latitude of

Table 3 Comparison of the parks: mean (m) and standard deviation (s) of production parameters and probability values (Prob.) of the Kruskal–Wallis test

	Savè		Parakou		Bembèrèkè		Kandi		
Production parameters	m	s	m	s	m	s	m	s	Prob.
Number of fruits, Nf (cm)	225.1	5.5	250.2	4.5	250.5	5.3	305.3	8.1	0.001
Circumference of fruits, Cf (cm)	12.2	0.7	14.3	0.7	13.4	0.9	14.4	0.8	0.063
Length of fruits, Lf (cm)	9.0	0.8	9.6	0.7	8.8	0.6	10.5	0.6	0.055
Width of fruits, Wf (cm)	2.7	0.1	2.6	0.0	2.7	0.2	2.6	0.1	0.654

the regions (warm regions). Trees in Savè parkland (9°N) produced on average 225 fruits per tree, while those in Kandi parklands (12°N) produced 305.3 fruits per tree. The circumference, length and width of fruits did not differ significantly between parks ($P > 0.05$).

Spatial climatic variability and morphological traits of shea butter trees

Dendrometric traits of trees. The results of the PCA indicated that the first three axes explained 73.4% of the variation in morphological traits. Except for the trees' mean height, the first principal component was correlated with all the five traits; this axis then characterized the morphology of trees (Fig. 3). The second component was only correlated with trees height.

Correlations between the first component and the climatic variables revealed that rainfall and relative humidity have positive impact on the morphometric traits. In moist region, shea butter trees were at low density but individuals had bigger and larger crowns than those in the dry region. Correlation between the second component and the climatic parameters showed that in regions with long sunstroke and high vapour pressure, trees were taller than those in the moist regions. Indeed, rainfall and relative humidity negatively impacted on the height of shea butter trees (Table 4).

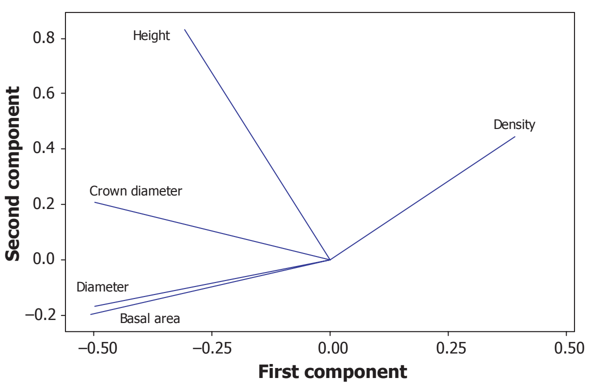

Fig 3 Projection of the dendrometric parameters of the shea butter trees in the system axis defined by the principal components

Table 4 Correlation between principal components related to morphological parameters of *Vitellaria paradoxa* and climatic variables

	Axis 1	Axis 2
Climatic parameters		
Rainfall	0.24*	−0.40***
Insolation	−0.31**	0.45***
Relative humidity	0.31**	−0.44***
Vapour pressure	−0.18	0.33***

*Significant at 0.05; **Significant at 0.01; ***Significant at 0.001.

Morphological traits of Vitellaria paradoxa *fruits.* The first two principal components explained 70.4% of the overall variation in fruits traits. The first component is linked to the size of the fruits, whereas axis 2 was related to the number of fruits per tree (Fig. 4). The morphological traits of the fruits were not correlated with climatic variables, and this suggests that factors other than climate explained the variability in fruit traits. However, fruit production was negatively affected by high rainfall and relative humidity in the moist region, whereas in dry regions high values of insolation and vapour pressure lead to higher fruit production (Table 5).

Discussion

Structural traits of shea trees in parklands

Except for the tree height, all other tree morphometric traits differed across parks. Parks located in the Sudanian

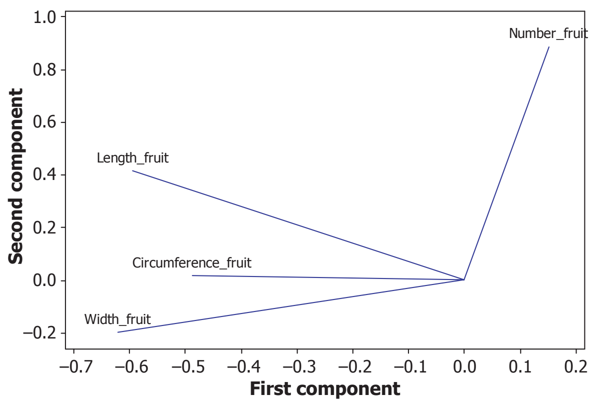

Fig 4 Projection of the fruit mensurations of the shea butter trees in the system axis defined by the first two principal components

Table 5 Correlation between principal components related to fruits menstruations and climatic variables

	Axis 1	Axis 2
Climatic parameters		
Rainfall	0.03	−0.34***
Insolation	0.03	0.29**
Relative humidity	−0.05	−0.26**
Vapour pressure	−0.06	0.34***

**Significant at 0.01; ***Significant at 0.001.

zone had the highest adult tree density. This high density of shea butter trees in the dry region may be linked to the greater importance given to the species and the greater diversity of uses and useforms of the plant in agroforestry systems in this region (Gbemavo, 2010). The significant tree-to-tree variability in shea butter tree morphology among parklands is important for a participatory domestication programme. However, multi-location provenance/progeny tests of the species are needed to estimate heritability and genotype by environment interaction of productivity in different environments. Moreover, a relatively high density of young individuals was found in the Sudanian zone. As it is, the semi-arid conditions in the Sudanian zone seemed to be more suitable for the recruitment of the species as found in this study. However, a high dryness (Sahelian zone) negatively impacts on the development of the species and its regeneration capacity (Dah-Dovonon & Gnanglè, 2006). In fact, diameter class structure of the trees in the Sudanian parklands revealed a left asymmetric distribution, indicating the predominance of young shea butter trees.

Production of shea butter trees in parklands

Results from this study showed that fruit production increased from the Sudano-Guinean to the Sudanian zone. This suggests that domestication programmes should develop separately, ideotypes for the fruit production according to the climatic zones. The results also showed that high rainfall and relative humidity reduced fruit production. The optimum production was found in the Sudanian zone where rainfall is about 1000 mm. As stated by Centre Technique Forestier Tropical (CTFT) (1989), shea butter trees yield better in Sudanian climate with 500–1000 mm rainfall and with 5–8 months of dry period in a year; the production is then about 2.2 kg kernel per tree (CTFT, 1989). No variability in the fruits' morphological traits was observed along climatic gradient in this study. This indicated that morphological differences in shea butter trees observed between individuals might be a plastic response to differences in microhabitat factors mainly the soil as it has already been observed for the African baobab (Assogbadjo, Sinsin & Van Damme, 2005).

Morphological traits of shea butter trees along climatic gradient

In the moist region where rainfall and relative humidity are high, shea butter trees are larger than in drier regions. In fact, variation in the traits along environmental gradients reflects variation in the relative importance of adaptive mechanisms of plants along these gradients (Meng, Ni & Harrison, 2009). Different aspects of the environment are important at different spatial scales, such that the association of traits in a given location is a consequence of a hierarchy of environmental filters (Keddy, 1992). Because climatic conditions in Bénin are getting drier (Glèlè Kakaï, 2009), it is possible that shea butter trees may become more productive in the near future in the Sudano-Guinean zone. Another consequence of the drying trend is the expansion of the distribution range of the species to the Guinean zone of the country (South-Bénin). However, as noticed from the present study, recruitment of seedlings is likely to be significantly decreased with increasing aridity in the Sudanian zone and affect the survival of the species.

Limitations of the method used

Our study was mainly based on the link between morphological traits of shea butter trees in inventoried parks and climatic conditions of the regions where the parks were established. Such a methodology neglects the possible significant variation in agricultural practices from one park to another. It was indeed noticed that the spatial pattern of *V. paradoxa* became progressively aggregated from cultivated field to fallow and then to forest (Kelly, Bouvet & Picard, 2004). Another limitation of the methodology used in the study originates from the climatic data considered. Mean values of the climatic variables were used to link morphological traits of shea butter trees to environmental conditions of the regions where they grow.

Conclusion

The shea butter tree is distributed in Bénin according to the agroecological zones. Our study showed that many internal and external factors impact the dendrometric and production parameters of shea trees in parklands. All these factors play important roles in the reproductive stage of the species. Moreover, natural regeneration of the species in this agroforestry system will be significant only with a fallow period, which is unfortunately difficult to be followed owing to lack of cultivable arable land in the country. In the short term, assisted regeneration of the species should be applied by protecting the recruitments from animals.

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