Fruit Productivity of "*African locust bean*" along a climatic gradient in Burkina Faso

Ezechias Sowionfu SOME[1*],
Larba Hubert BALIMA[2],
AdjimaTHIOMBIANO[3],

Abstract

Parkia biglobosa (Jacq.) R. Br. ex G. Don is highly valued species in many domains as food. However, the overexploitation of its fruits is one of the main causes of the species' vulnerability. Accurate assessment of annual fruit production could contribute in better conservation of the species. This study aims to assess fruit productivity of *Parkia biglobosa* and the relative proportion of the Non-Timber Forest Products (NTFPs) derived from the fruit. Fruit productivity was determined using a sample of 144 trees distributed across 6 diameter classes at 8 sites identified in two climatic zones. Seeds and husks were dried separately and then weighed. The weight of the pulp was obtained by subtracting the weight of the husk and seeds from the total weight of the fruit. The result revealed that fruit productivity is higher in the sudanian climatic zone than in the sudan-sahelian zone in Burkina Faso. The relative proportion of the NTFPs derived from the fruit varies according to climatic zones. Stem diameter at breast height (DBH) was the dendrometric parameter that better predicted fruit productivity of *P. biglobosa.* The best allometric equations of fruit production for both zones are: Total fruit biomass (Kg) = 0.8 DBH - 14.5 and Total fruit biomass (kg) = 5 ln DBH - 13.6. The observed variations in *P. biglobosa* NTFP productivity may reflect the species' response to climate change. However, since the species is also exposed to considerable anthropogenic pressure, validating this hypothesis requires an ethnobotanical study to ascertain that anthropogenic influences are comparable across the different climatic zones.

Keywords: *Parkia biglobosa*; biomass; Non-Timber Forest Products (NTFPs); allometric model

Productivité fruitière du néré (*Parkia biglobosa*) le long d'un gradient climatique au Burkina Faso

Résumé

[1]Laboratory of Biology and Plant Ecology, Life and Earth Sciences institute, Université Joseph Ki Zerbo, Tél: 70304562, Ouagadougou, Burkina Faso
[2] Laboratory of Biology and Plant Ecology, Ecole Nationale Supérieure/ Institut des Sciences et Technologie; Tel: 70852095, Ouagadougou, Burkina Faso;
[3]Laboratory of Biology and Plant Ecology, Life and Earth Sciences institute Université Joseph Ki Zerbo, Tél: 70238261, Ouagadougou, Burkina Faso.
Corresponding author: Ezechias Sowionfu SOME,some.ezechias@yahoo.fr ,Tel : (+226)70304562/76680634, ORCID: 0009-0005-7071-4222
DOI : https://doi.org/10.64707/revstsna.v45i01.2082

Parkia biglobosa (Jacq.) R. Br. ex G. Don est une espèce très prisée dans de nombreux milieu comme complément alimentaire. Cependant, la surexploitation de ses fruits est l'une des principales causes de la vulnérabilité de l'espèce. Une évaluation précise de la production annuelle de fruits pourrait contribuer à une meilleure conservation de l'espèce. L'objectif de cette étude est d'évaluer sa productivité fruitière et la proportion relative des produits forestiers non ligneux (PFNL) dérivés du fruit. La productivité des fruits a été déterminée à partir d'un échantillon de 144 arbres répartis en 6 classes de diamètre sur 8 sites identifiés dans deux zones climatiques du Burkina Faso. Les graines et l'enveloppe ont été séchées séparément et pesées. Le poids de la pulpe a été déterminé par la soustraction du poids des graines et de l'enveloppe du poids total du fruit. Le poids moyen de la pulpe a été calculé à partir du poids des fruits après avoir pesé directement les graines et les gousses. Les résultats ont révélé que la productivité des fruits est plus élevée dans la zone climatique soudanienne que dans la zone soudano-sahélienne. La proportion relative des PFNL dérivés du fruit varie selon les zones climatiques. Le diamètre à hauteur de poitrine (DHP) a été le paramètre dendrométrique qui prédisait le mieux la productivité fruitière de *P. biglobosa.* Les meilleures équations allométriques de production de fruits pour les deux zones sont: Biomasse fruitière totale (Kg) = 0,8 DHP - 14,5 et Biomasse fruitière totale (kg) = 5 ln DHP - 13,6. Les variations observées dans la productivité des PFNL (produits forestiers non ligneux) de *P. biglobosa* peuvent refléter la réponse de l'espèce au changement climatique. Cependant, étant donné que l'espèce est également exposée à une pression anthropique considérable, la validation de cette hypothèse nécessite une étude ethnobotanique afin de vérifier que les influences anthropiques sont comparables entre les différentes zones climatiques.

Mots-clés : *Parkia biglobosa* ; biomasse ; produits forestiers non ligneux (PFNL) ; équations allométriques.

Introduction

In Burkina Faso, agriculture is predominantly rainfed, making rural populations highly dependent on natural resources to satisfy their subsistence needs and to cope with climatic variability (OUÉDRAOGO, 2012). Among these resources, plant species play a central role in local livelihoods. Numerous studies have emphasized the importance of plants in human nutrition, particularly as dietary supplements or safety nets during periods of food shortage (THIOMBIANO *et al*., 2012; FAO *et al*., 2018; GLEW *et al*., 2005).

The nutritional contribution of plants is largely mediated through non-timber forest products (NTFPs), especially wild and semi-domesticated fruits, which are essential for food security and poverty reduction in rural areas (LAMIEN *et al*., 2008; LEBMEISTER *et al*., 2015). Among these species, *Parkia biglobosa* (Jacq.) R. Br. ex G. Don occupies a prominent position. The species is widely distributed in the savannas and agroforestry parklands of the sudanian and sudano-sahelian climatic zones of Burkina Faso and West Africa more broadly. According to ARBONIER (2009), *P. biglobosa* is characteristic of guinean and sudanian savannas and exhibits a strong capacity to tolerate a wide range of climatic conditions, although its distribution and performance remain strongly influenced by rainfall gradients, soil properties, and land-use practices (LAMIEN *et al*., 2008).

Parkia biglobosa provides a wide array of goods and ecosystem services to local communities in West Africa (SINA, 2006; SACANDE & CLETHERO, 2007; MUSARA *et al*., 2020). Its fruit components are particularly valuable. The pod shell is used in saponification and natural dye production (DIATTA *et al*., 2020) and has also been shown to possess potential for weed control (SOURABIÉ *et al*., 2021). The pulp, processed into flour, is widely consumed and contributes to the prevention of malnutrition, cardiovascular diseases, and certain cancers (PARKOUDA *et al*., 2021; AHODEGNON *et al*., 2018). Fermented seeds are transformed into soumbala, a condiment extensively used in Burkina Faso and several other West African countries (OUOBA et *al*., 2003; OUOBA et *al*., 2006). In addition to their nutritional role, the seeds are used in the treatment of hypertension (ODETOLA et *al*., 2006; COULIBALY et *al*., 2017) and play an important role in traditional rites and cultural practices (ROUVILLE, 1984; OUÉDRAOGO, 1995).

Despite its high socio-economic importance, *P. biglobosa* is increasingly threatened by overexploitation. According to HOUNDONOUGBO et *al*. (2020), although the species plays a crucial socio-economic role at local and regional scales, it remains at an early stage of domestication and is declining in its natural habitats. The depletion or potential extinction of *P. biglobosa* could therefore seriously disrupt the socio-economic balance of rural communities that depend on its products.

In response to these concerns, several studies have focused on different aspects of the species, including its biosystematics and genetic improvement (OUÉDRAOGO, 1995), stand structure and domestication potential (AVANA-TIENTCHEU *et al*., 2019), fruit yield (OUÉDRAOGO, 1995; LAMIEN *et al*., 2008), and the impact of pests, which may limit the reliability of raw yield data for food forecasting purposes (LAMIEN, 2006). Other studies have examined population structure and regeneration dynamics (AVANA-

TIENTCHEU *et al.*, 2019), genetic diversity and population differentiation (LOGOSSA *et al.*, 2018; LOMPO *et al.*, 2020), and fruit yield variability at local and regional scales (LAMIEN *et al.*, 2008). Together, these works highlight the high ecological plasticity of *P. biglobosa* and the combined influence of environmental conditions and anthropogenic pressures on its productivity. Nevertheless, quantitative information on fruit productivity across contrasting climatic zones remains fragmented, and standardized methods for estimating fruit yield under field conditions are still limited.

Estimating fruit productivity in tropical tree species is inherently challenging due to irregular fruiting patterns, long reproductive cycles, tree size heterogeneity, and the difficulty of conducting long-term monitoring in natural and agroforestry systems (HENRY *et al.*, 2011). Consequently, fruit production is often estimated using allometric relationships based on easily measurable dendrometric parameters. Although crown dimensions are frequently assumed to be good predictors of fruit yield, recent studies suggest that diameter at breast height (DBH) may provide more robust and operational estimates, particularly in heterogeneous landscapes (ABENGMENENG *et al.*, 2023). However, the relative performance of these predictors may vary depending on ecological context, underscoring the need for zone-specific allometric models.

Assessing the fruit productivity of *P. biglobosa* is therefore of particular importance given its major contribution to food security, nutrition, and rural livelihoods through NTFPs. The fruits provide pulp, seeds, and pods with distinct nutritional, medicinal, and economic values, and variations in the relative proportions of these components may reflect adaptive responses to climatic constraints, with direct implications for local use and valorization (GLEW *et al.*, 2005; PARKOUDA *et al.*, 2021). Understanding how fruit productivity and fruit component allocation vary along climatic gradients is thus essential for sustainable management, domestication strategies, and climate-resilient agroforestry planning.

Against this background, the present study aims to provide communities, practitioners, and decision-makers with robust information on the fruit productivity of *P. biglobosa* across climatic zones in Burkina Faso. Specifically, it seeks to (i) assess fruit productivity along a sudanian to sudano-sahelian climatic gradient; (ii) determine the relative proportions of NTFPs derived from the fruit; and

(iii) develop predictive allometric models for fruit productivity based on dendrometric parameters. We hypothesize that fruit productivity is higher in the sudanian zone, that the relative proportions of fruit components vary according to climatic conditions, and that crown diameter is the most reliable predictor of fruit productivity, an assumption tested against alternative predictors, particularly DBH.

I. Materials and methods

1.1. Study Sites

The study was conducted in Burkina Faso; a country located in the heart of West Africa in the Gulf of Guinea. The criteria for selecting the sites were the presence and abundance of individuals of the species. In total, eight (08) sites were selected across the two climatic zones where the species was encountered during the second national forest inventory, with four (04) sites in the Sudano-Sahelian climatic zone and four (04) in the Sudanian zone (Figure 1). To account for environmental and morphological variability within the same zone, a minimum distance of 10 km was maintained between the different sites. According to SINA (2006) and VISSCHER *et al*. (2008), the phenotypic expression of a genotype depends on the environmental conditions in which the individuals developed.

1.2. Data Collection

Data collection took place between April and May, 2016 corresponding to the fruit maturity period of *P.a biglobosa*, i.e. from mid-April to mid-June (SINA, 2006), when over 80% of trees are fruiting. In total, 144 trees distributed across six DBH classes were sampled, with three individuals per class and 18 trees per site. Selection criteria included tree health status, accessibility, and a minimum distance of 100 meters between individuals to minimize biases related to heritability, defined as the proportion of trait variation attributable to genetic factors (VISSCHER *et al*., 2008).

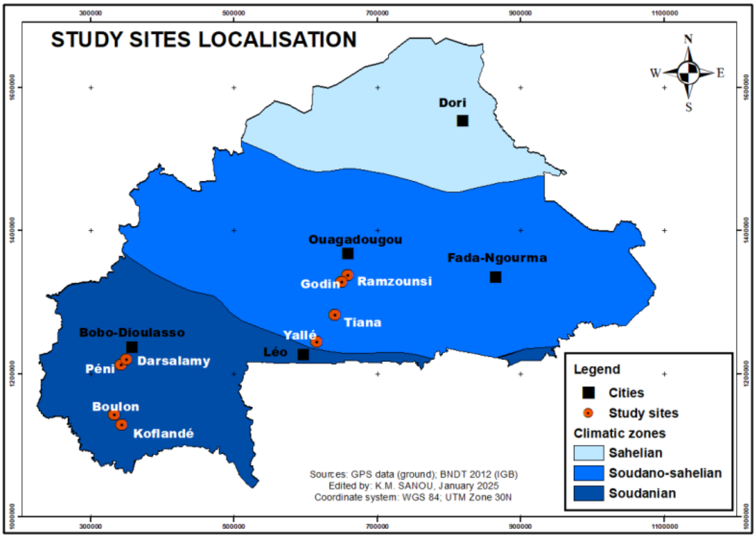

Figure 1: Distribution of *Parkia biglobosa* study sites

For each tree, the dendrometric measurements concerned total height, crown height, crown diameters in four directions (East-West (EW), North-South (NS), Northeast-Southwest (NE-SO), Northwest-Southeast (NW-SE)), and trunk circumferences at 50 cm and 130 cm above the ground. Total height was measured using a 'Suunto' clinometer and a pole for shorter individuals. Crown diameters and circumferences at 50 cm and 130 cm above the ground were measured using a tape measure. The trunk circumferences allowed for the calculation of their respective diameters. For multi-stemmed individuals, the quadratic mean was calculated to define the diameter at the considered level of the individual.

Fruit quantification was based on a classification of branches into diameter classes with 3 cm intervals, ranging from less than 5 cm to more than 20 cm. One or two orthogonally oriented branches were selected per class depending on abundance, and all fruits on those branches were counted to estimate total fruit production per tree.

Additionally, a sample of 05 fresh pods were collected per tree, ensuring balanced sampling from all four sides and the center of the crown while avoiding edge effects (SINA, 2006). These samples were oven-dried at 65 °C for 72 hours, with weights recorded every 24 hours until stabilization using a precision scale (0.01 g accuracy, OHAUS brand).

To assess the proportion of non-timber forest products (NTFPs) derived from the fruits, after drying, the five pods collected were opened, the pulp macerated in water, and seeds manually extracted. Seeds and husks were dried separately and then weighed. The weight of the pulp was obtained by subtracting the weight of the husk and seeds from the total weight of the fruit.

1.3. Data Processing

Measured circumferences were converted into diameters at breast height (DBH, 1.30 m), allowing for classification of trees into six diameter classes (10 cm intervals), based on field-observed extremes : 15 cm ≤ DBH < 25 cm; 25 cm ≤ DBH < 35 cm; 35 cm ≤ DBH < 45 cm; 45 cm ≤ DBH < 55 cm; 55 cm ≤ DBH < 65 cm; and DBH ≥ 65 cm.

For multi-stemmed individuals, the quadratic mean diameter was used. Fruit production per tree was estimated using all measured fruit-bearing branch diameters, grouped into 3 cm classes. A proportional rule of three was applied to estimate production per class, and total production was obtained by summing across all classes.

From the collected samples, total dry biomass per tree was extrapolated. The average component weight per pod was then multiplied by the estimated total number of pods per tree to calculate total production. The proportion of NTFPs was calculated using the formula :

$$\text{NTFP proportion} = \frac{\text{NTFP Weight}}{\text{Pod Weight}} X\ 100$$

1.4. Data Analysis

Various statistical analyses were performed using R version 4.3.0. Normality tests were conducted to determine the appropriate test type (parametric or non-parametric) for assessing the significance of differences in mean productivity across climatic zones or to verify residual normality when determining allometric equations. Comparative tests included analysis of variance (ANOVA) for normally distributed data and the Kruskal-Wallis test for non-normal data.

Allometric equations were developed through multiple steps:

1. Correlation Testing: Correlations between different dendrometric parameters were analyzed. Strongly correlated parameters were excluded from the same equation.

2. Discriminant Analysis: This identified parameters most correlated with fruit production, reducing the number used for developing equations.

3. Equation Development: Simple tests were conducted to establish equations. The best-fit equation had the highest R^2, the lowest residual sum of squares, normal residuals, constant **variance (homoscedasticity), a low Akaike Information** Criterion (AIC), and consistent p-values.

II. Results

2.1. Fruit productivity according to the climatic gradient

The fruit productivity of *P. biglobosa* in the study area was significantly higher in the Sudanian climatic (26.25 ±26.25kg) zone compared to the sudano-sahelian (8.85±12.14kg) zone (Figure 2), with a P-value < 0.001, indicating a highly significant difference.

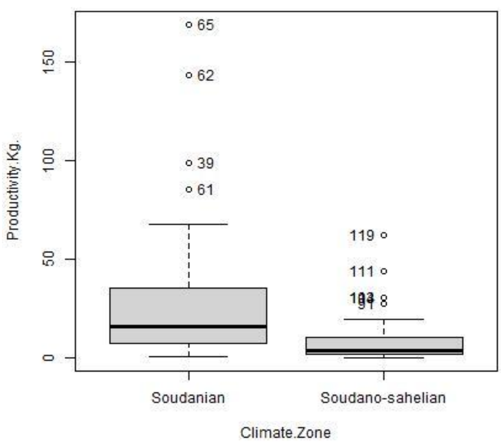

Figure 2: Average fruit productivity by climatic zone

Moreover, the ANOVA analysis of fruit productivity (Figure 2) revealed a significant variation across diameter classes (P< 0.001). This variation remained significant within each climatic zone, with P = < 0.001 in the sudanian zone and P = 0.03 in the sudano-sahelian zone. Figure 3 shows the increase in fruit productivity as a function of diameter-at-breast-height classes during this study.

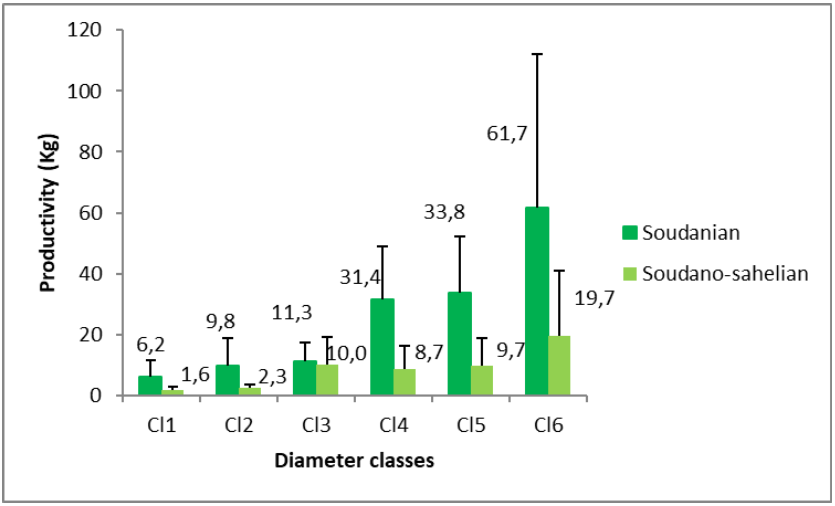

Figure 3: Fruit productivity by diameter class at 1.30 m across different climatic zones

2.2. Proportion of fruit components based on climatic zone

The proportion of fruit components varies according to climatic zones. ANOVA analyses indicate that the proportion of the husk (Figure 4) varies significantly with climatic zone ($P < 0.001$). The values are **38.67%** in the sudanian zone and **44.20%** in the sudano-sahelian zone. Similarly, the fruit pulp proportion (Figure 5) varies significantly with climatic zone ($P < 0.001$), with values of **39.13%** in the sudanian zone and **34.90%** in the sudano-sahelian zone. However, the seed proportion (Figure 6) does not vary significantly with climatic zone ($P = 0.11$), with values of **22.20%** in the sudanian zone and **20.91%** in the sudano-sahelian zone.

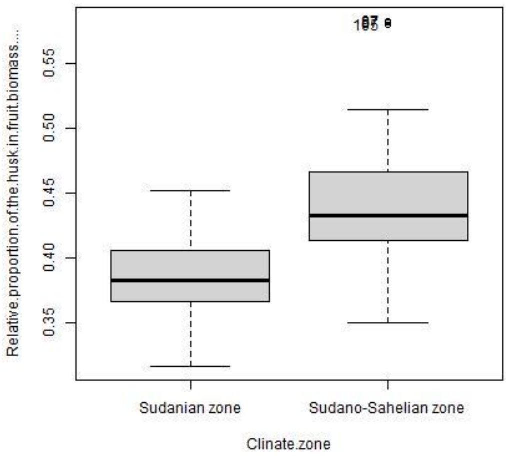

Figure 4: Relative proportion of the husk in the *Parkia biglobosa* pod mass according to climatic zones

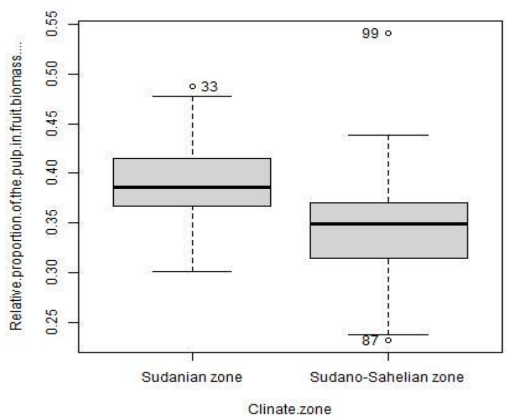

Figure 5: Relative proportion of the pulp in the *Parkia biglobosa* pod mass according to climatic zones

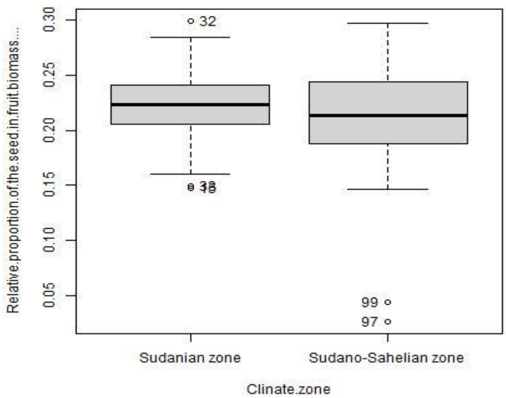

Figure 6: Relative proportion of the seed in the *Parkia biglobosa* pod mass according to climatic zones

2.3. Prediction models for productivity

a) Discriminant analysis

A discriminant analysis was conducted to identify dendrometric variables most correlated with fruit productivity. Diameter at 1.30 m (DBH) showed the strongest correlation ($r = 0.73$; $p < 0.001$). Other significant correlations included diameter at 50 cm, crown diameter (DMH), total height, and both small and large crown axes. These results are detailed in Table I.

Table I: Correlation of dendrometric parameters with fruit productivity

Dendrometric parameter	Productivity in sudanian zone	Productivity in sudano-sahelian zone
Diameter at 1.30 m	0.73***	0.46***
Diameter at 50 cm	0.66***	0.39***
Crown Diameter (DMH)	0.55***	0.28***
Crown Height	0.64***	0.40***
Total Tree Height	0.59***	0.34***
Small Crown Axis	0.53***	0.43***
Large Crown Axis	0.56***	0.47***

Values represent correlation coefficient
Significant codes: *** 0.001; ** 0.01; * 0.05.

b) Correlation between dendrometric parameters

The correlations between the diameter at 1.30 m of the tree and the other dendrometric parameters were examined for the two climatic zones (sudanian and sudano-sahelian). The information shows a strong correlation between these parameters and the diameter at 1.30 m from the ground. These results are summarized in Table II.

Table II: Correlation between dendrometric parameters with diameter at 1.30

Dendrometric Parameter	Diameter at 1.30 in sudanian zone	Diameter at 1.30 in sudano-sahelian zone
Diameter at 0.50 m	0.94***	0.95***
Mean Diameter of the Crown (MDC))	0.83***	0.63***
Large Crown Axis	0.83***	0.88***
Small Crown Axis	0.81***	0.81***
Crown Height	0.75***	0.61***
Total Tree Height (HT)	0.73***	0.57***

Values represent correlation coefficient
Significant codes: *** 0.001; ** 0.01; * 0.05

The DHP (diameter at 1.30 m) being the parameter most correlated with productivity and having a strong correlation with the others, it was the only parameter retained in the allometric equations used for the estimates.

c) The best allometric equations

Since productivity values differ significantly across climatic zones, allometric equations were developed separately for each zone. Their development relied on combining productivity data with dendrometric measurements. The best equations obtained which had the highest R^2, the lowest residual sum of squares, a low Akaike Information Criterion (AIC), and consistent p-values are presented in Tables III and IV.

Table III: Selected allometric equations

Climatic Zone	*No.*	*Equations*	*AIC*	*RSE*	*R^2 (Multiple)*	*R^2 (Adjusted)*	*p-value*
Sudanian Zone	S1	Biomass (Kg) = 0.8 × DHP - 14.5	537.43	12.96	0.53	0.52	2.842e-12
	S2	Biomass = 33.2 × ln(DHP) - 102.7	541.98	13.41	0.50	0.49	2.661e-11
	S3	Biomass = $7.6 \times 10^{-3} \times DHP^2 + 3.5$	539.84	13.20	0.51	0.51	9.3e-12
Sudano-sahelian Zone	SS1	Biomass = 5 × ln (DHP) - 13.6	274.90	3.84	0.26	0.24	1.919e-07
	SS2	Biomass = 5.7 × ln(LCA) - 9	224.41	4.086	0.25	0.23	1.231e-06
	SS3	Biomass = $6.5 \times 10^{-4} \times DHP^2 + 3.1$	239.13	4.26	0.11	0.09	3.083e-05

AIC: Akaike Information Criterion; **RSE**: Residual Standard Error; **R^2 (Multiple)**: Multiple R-squared; **R^2 (Adjusted)**: Adjusted R-squared, LCA: Large Crown Axis

Table IV: Best equations by climatic zone

Climatic Zone	*No.*	*Equations*	*AIC*	*RSE*	*R^2 (Multiple)*	*R^2 (Adjusted)*	*p-value*
Sudanian Zone	S1	Biomass (Kg) = 0.8 × DHP - 14.5	537.43	12.96	0.53	0.52	2.842e-12
Sudano-sahelian Zone	SS1	Biomass = 5 × ln (DHP) - 13.6	274.90	3.84	0.26	0.24	1.919e-07

Discussion

3.1. Effect of climate on tree productivity

The present study demonstrates that fruit productivity of *P. biglobosa* varies a lot across climatic zones, with significantly higher values observed in the sudanian zone compared to the sudano-sahelian zone. This pattern underscores the strong influence of climatic and edaphic conditions on reproductive performance in this species. The sudanian zone is characterized by higher and more regular rainfall, longer growing seasons, and generally better soil moisture and fertility conditions, which are conducive to enhanced flowering intensity, fruit set, and fruit development. In contrast, the sudano-sahelian zone is subject to greater rainfall variability and more frequent water stress, which may limit assimilate availability during key phenological stages, thereby reducing fruit productivity.

These findings are consistent with earlier reports highlighting the strong site dependent variability of *P. biglobosa*. According to LISAN (2006), annual fruit production ranges from 25 to 130 kg per tree depending on both the year and the site, reflecting interannual climatic fluctuations as well as local environmental constraints. Such wide variability confirms that environmental conditions play a central role in determining fruit biomass accumulation, particularly in savanna ecosystems where water availability is a key limiting factor.

Beyond broad climatic gradients, several studies have emphasized the combined effects of site conditions and provenance on fruit productivity. A multi provenance trial conducted in Oyo, Nigeria, involving accessions from diverse West African countries, revealed a progressive increase in fruit-related traits—total fruit weight, number of clusters per tree, number of pods per cluster, and cluster weight over a three-year monitoring period (2015-2017). Importantly, provenances originating from Nigeria and Burkina Faso consistently ranked among the most productive after three years (ADEMOLA *et al*., 2025). These results suggest that while favorable environmental conditions enhance fruit production, genetic adaptation to local conditions also contributes significantly to observed differences among populations.

The relationship between tree size and fruit productivity constitutes another key aspect of the present discussion. Dendrometric parameters such as diameter at breast height (DBH), crown diameter, and total height are widely recognized as integrative indicators of tree vigor and resource acquisition capacity. Recent work conducted in the Guinea savanna zone of Ghana demonstrated strong correlations between DBH and crown diameter, total height, and crown ratio in *P. biglobosa* (ABENGMENENG and DAAYENG., 2023). Such structural relationships imply that larger trees possess a greater photosynthetic surface and storage capacity, enabling higher allocation of assimilates to reproductive organs.

Similarly, a demographic and allometric study carried out in the Plateau and Pobè districts of Benin revealed highly significant relationships between DBH and total height in *P. biglobosa* (FACHOLA *et al.,* 2019). These findings support the use of DBH as a reliable proxy for estimating aboveground biomass, leaf area, and overall physiological status. In the context of fruit production, DBH therefore emerges as a key predictor of fruiting potential, particularly in environments where direct measurement of crown or leaf traits may be constrained.

In addition to environmental and allometric controls, genetic factors appear to exert a decisive influence on reproductive performance. A genetic study conducted in sudanian savannas showed that male reproductive success expressed in terms of seed production and effective pollen dispersal was significantly higher in trees with a DBH between 60 and 75 cm (LOMPO *et al*., 2020). This result suggests the existence of a size-related reproductive threshold, beyond which individuals are able to fully express their genetic reproductive potential. Such thresholds may reflect a balance between growth and reproduction, whereby only sufficiently developed individuals can sustain high reproductive output without compromising structural stability or long-term survival.

Taken together, these findings indicate that fruit productivity in *P. biglobosa* is governed by a complex interaction between climatic conditions, site-specific edaphic factors, tree allometry, and genetic background. Climatic factors determine the overall suitability of the environment and constrain resource availability, while genetic and structural attributes regulate how efficiently individual trees convert available resources into reproductive output. This dual control mechanism has important implications for conservation, domestication, and sustainable management strategies. In particular, it highlights the need to account for both climatic zone and tree size when selecting individuals for seed collection, agroforestry integration, or genetic improvement programs aimed at enhancing fruit productivity under current and future climate conditions.

3.2. Effect of climatic zone on fruit composition

Significant differences in NTFP constituent proportions were observed between climatic zones, with higher pulp content in the sudanian zone and higher pod content in the sudano-sahelian zone. Similar variations have been reported by DAO *et al*. (2021) and PARKOUDA *et al.* (2021), who highlighted significant differences in the composition and physicochemical characteristics of *P. biglobosa* pulp across different ecoregions of Burkina Faso. These findings confirm the influence of ecological conditions on the structuring of fruit constituents.

In contrast, the proportion of seeds remains generally stable regardless of the climatic zone. This stability suggests that the species maintains a minimal and relatively constant allocation of resources to sexual reproduction despite environmental variability. Comparable observations have been reported in morphometric studies on *P. biglobosa*, which indicate lower inter-zonal variability in reproductive traits compared to vegetative or protective traits (TEKLEHAIMANOT *et al*., 1998). This relative invariance in seed proportion may reflect an evolutionary constraint aimed at preserving the reproductive capacity of the species.

Furthermore, the relative increase in the proportion of pods in more arid zones could be explained by a physiological adaptation strategy intended to limit water loss and protect seeds from dehydration. Such a strategy, involving the thickening of the epicarp at the expense of the pulp, corresponds to a classical drought tolerance mechanism (HUC, 2011). Similar mechanisms have been described in other woody and fruit-bearing species subjected to water stress, where the thickening of protective fruit tissues contributes to reducing water permeability and preserving seed integrity (TEKLEHAIMANOT *et al*., 1998)

Our results partially corroborate those (OUEDRAOGO *et al*., 2012 and AMUSA *et al*., 2014) who suggest local adaptation to climatic conditions. Consequently, the variability observed in the proportion of fruit constituents may also reflect genetic differentiation associated with climatic gradients.

Moreover, although the proportion of seeds does not vary significantly between zones, their nutritional quality is likely influenced by environmental conditions. Indeed, GUISSOU *et al*. (2020) reported significant variability in the nutritional composition of *P. biglobosa* seeds depending on the harvest site. These findings are supported by comparative studies showing that the biochemical profiles of seeds and pulp vary according to geographic origin and ecological conditions, confirming the strong interaction between environmental and genetic factors in determining the fruit's use value (DAO e*t al*., 2021; TERMOTE *et al*., 2022).

Thus, the differences observed in the pulp-to-pod ratio appear to reflect not only an adaptive response of *P. biglobosa* to climatic constraints, but also a potential indicator of genetic differentiation and phenotypic plasticity. This interpretation fits within the broader conceptual framework of plant phenotypic plasticity in response to environmental change, which has been widely documented in the literature (NICOTRA *et al.,* 2010; AITKEN & WHITLOCK, 2013), and further supports the hypothesis that both genetic and plastic adaptive mechanisms operate in *P. biglobosa.*

3.3. Prediction of productivity

Correlation tests show that the correlation between fruit production and diameter at breast height (DBH, measured at 1.30 m above ground) is stronger than the correlation with other dendrometric parameters. This suggests that DBH provides more reliable productivity prediction equations. This result corroborates the conclusions of earlier studies by GIBBS *et al*. (2007), HENRY *et al*. (2011), and BONDÉ *et al*. (2018), who demonstrated that DBH alone offers a good representation of stem and foliage biomass variability. DOTCHAMOU *et al*. (2018) utilized DBH in developing their allometric equations for determining the fruit productivity of *P. biglobosa,* due to it is easy to quantify. The use of semi- or total destruction methods for estimating fruit production would no longer be necessary, as these methods are costly and labor-intensive (HOUMEY *et al.,* 2012). On the other hand, the correlation values in the Sudano-Sahelian zone are very low, which could be explained by various factors such as threats to the plant, tree age, silvicultural practices, and tree health. TIMMER et *al*., **(**1996) mentions that producers often practice pruning to increase the fruit production of *Parkia biglobosa*. GUISSOU *et al*. (2016) showed that mycorrhization leads to significant variations in plant response according to their provenance for each fruit tree species. A significant increase in height and total dry mass of *P. biglobosa* from two provenances, as well as increases in tamarind and jujube from one provenance, were recorded following mycorrhizal activity. In a study by PADAKALE *et al.* (2015) in *P. biglobosa* parks, two types of threats were identified: human threats and natural threats. Identified human activities include grazing, harvesting of plant parts, collection of firewood, overexploitation of fruits, harvesting unripe fruits to avoid theft, illegal charcoal production, and the use of trees for mortar supports. Natural threats include wind and parasitic plant species. The equations obtained in this study were of simple linear, power, and logarithmic types, with logarithmic equations predominating. However, the best equation was linear and pertains to the sudanian zone. Simple linear equations were used by KOUYATÉ *et al*. (2006) to predict the productivity of *Detarium microcarpum* in Mali. Similarly, DOTCHAMOU *et al.* (2018) used multiple linear equations to predict the productivity of *P. biglobosa* in Benin's sudanian and sudano-guinean zones, with an R^2 value of 43.32%, slightly lower than the 52% obtained in the sudanian zone in this study. The Sudanian zone, with annual rainfall between 600 and 900 mm, falls within the favorable rainfall range for *P. biglobosa* (SINA, 2006). However, the R^2 values obtained in the sudano-sahelian zone are very low. This may be explained by factors such as tree age, plant phenology, and grazing pressure (CISSÉ, 1980; AZOCAR *et al*., 1991).

Conclusion

This study provides new insights into the fruit productivity of *Parkia biglobosa* across contrasting climatic zones. It demonstrates that fruit productivity is significantly higher in the sudanian zone than in the sudano-sahelian zone, emphasizing the determining role of climatic and pedological conditions. A novel contribution of this work is the evidence of climatic effects on fruit component allocation, with higher pulp proportions in the sudanian zone and higher pod proportions in the sudano-sahelian zone, suggesting adaptive responses to water stress. The study also identifies diameter at breast height (DBH) as the most reliable predictor of fruit productivity and proposes zone-specific allometric models, including a linear model unique to the sudanian zone. The weaker relationships observed in the sudano-sahelian zone point to the influence of non-climatic factors such as tree management and anthropogenic pressures. Overall, the findings highlight the ecological plasticity and climate resilience of *P. biglobosa* and provide valuable tools for its sustainable management and domestication.

Authors Contributions

E. S. S. designed the study, conducted the fieldwork, performed the data analyses, and drafted the first version of the manuscript

L. H. B. contributed to the scientific review of the manuscript.

A. T. provided scientific supervision of the study and contributed to the final revision of the manuscript.

References

ABENGMENENG, C. S., & DAAYENG, T. M. (2023). Regression models for key economic savanna tree species: A case study of *Parkia biglobosa* (Jacq.) R. Br. ex G. Don in the Guinea savanna ecological zone of Ghana. *International Journal of Plant & Soil Science*, **35**(22), 410-420. https://doi.org/10.9734/ijpss/2023/v35i224149

ADEMOLA, I., OYUN , M., ADEMOLA , S., OMIDIRAN , M., & TOYINBO , E. (2025). Fruits yield of <i>*Parkia biglobosa*</i> established in Wasanagare, Saki West Local Government, Oyo State, Nigeria . Journal of Research in Forestry, Wildlife and Environment, 16(4), 1–11. Retrieved from https://www.ajol.info/index.php/jrfwe/article/view/289920

AHODEGNON K. DONATIEN, GNANSOUNOU MARTIAL, BOGNINOUG. S. REINE, KANFON R. ES TELLE, CHABI BIENVENUE, AGBANGNAN DOSSA C. PASCAL, ANAGO A. EUGENIE, AHOUSSI EDWIGE, WOTTO VALENTIN and SOHOUNHLOUE C. K. DOMINIQUE, 2018. Biochemical Profile and antioxidant activity of *Parkia biglobosa* and *Tamarindus Indica* Fruits Acclimated In Benin. ISSN: 2320-5407 *Int. J. Adv. R es*. 6(11), 702-711. Article DOI: 10.21474/IJAR01/8050 DOI URL: http://dx.doi.org/10.21474/IJAR01/ 8050.

AITKEN, S. N., & WHITLOCK, M. C. (2013). Assisted gene flow to facilitate local adaptation to climate change. *Annual Review of Ecology, Evolution, and Systematics, 44*, 367–388. https://doi.org/10.1146/annurev-ecolsys-110512-135747

AMUSA, O. D., ADESOYE, A. I., & ADELODUN, A. A. (2014). Genetic diversity of *Parkia biglobosa* (Jacq.) Benth populations revealed by RAPD markers. *International Journal of Biodiversity*, 2014, Article ID 459657. https://doi.org/10.1155/2014/459657

ARBONNIER, M. (2009). Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. Editions Quae..

AVANA-TIENTCHEU M. L. A., KEOUNA S., DONGOCK NGUEMO D. et MOUGA MASDEWEL B., 2019. Structure des peuplements et potentiel de domestication de *Parkia biglobosa* dans la région de Tandjilé-Ouest (Tchad). *Int. J. Biol. Chem. Sci*. 13(1): 219-236.

AZOCAR P, LAILHACAR S, PADILLA F et ROJO H 1991. Méthode d'évaluation de la phytomasse utilisable des arbustes fourragers Atriplex repanda et Flourensia thurifera, pp. 512-514 in GASTON A, KERNICK M et LE HOUEROU H N editeurs. « IVe Congrès international des terres de parcours », Montpellier, 592 p.

BONDE L., GANAME M., OUEDRAOGO O., NACOULMA B. M., THIOMBIANO A. and BOUSSIM J. I., 2017. Allometric models to estimate foliage biomass of *Tamarindus indica* in Burkina Faso. *Southern Forests* :1-8. ISSN 2070-2620 EISSN 2070-2639 http://dx.doi.org/10.2989/20702620.2017.1292451

CISSÉ MI, 1980. The browse production for some trees of the Sahel: relationships between maximum foliage biomass and various physical parameters. In : Le Houérou, editor. Browse in Africa. Addis Ababa : International Livestock Center for Africa: 203-208 http://www.ilri.org/infoserv/webpub/fulldocs/browse_in_ africa/Chapter19.htm#TopOfPage.

COULIBALY SEYDOU OUOLOUHO, OUATTARA ABOU, OUATTARA KARAMOKO, COULIBALY ADAMA (2017). Effets antihypertensifs des extraits aqueux et éthanolique des graines fermentées de *Parkia biglobosa* (mimosaceae) chez les rats. *European Scientific Journal* . Vol.13, No.36, 162-176

DAO ABOUBACAR SIDIKI, PARKOUDA CHARLES, TRAOR&E MA ESTHER, AIM&EE WDB GUISSOU, BARBARA VINCETI, C&ELINE TERMOTE, MATTIA MANICA AND BASSOL&E IMAEL HENRI NESTOR (2021). "Comparison of chemical composition of fruit pulp of *Parkia biglobosa* (Jacq.) Benth from differents ecoregions." *African Journal of Food Science* 15, no. 1: 26-32.

DIATTA E. A., DIENG S. D, NIANG-DIOP F., GOUDIABY A. et SAMBOU B. (2020). Importance socio-économique de *Parkia biglobosa* (Jacq) R. Br. Ex G. Don (néré) dans le système agroforestier en Basse Casamance, Sénégal. *Afrique SCIENCE* 17(4) 1 - 17 1 ISSN 1813-548X, http://www.afriquescience.net

DOTCHAMOU T. O. F., ATINDOGBE G., HOUMENOU C., et FONTON N. H., 2018. Modélisation de la productivité fruitière de *Parkia biglobosa* en zone soudanienne et zone soudano-guinéenne du Bénin. *Afrique SCIENCE* 14(3) 399 – 410. ISSN 1813-548X, http://www.afriquescience.net

FACHOLA, B. O., GBESSO, G. H. F., LOUGBEGNON, O. T., & AGOSSOU, N. (2019). Paramètres dendrométriques et structuraux de *Parkia biglobosa* (Jacq.) R. Br. ex G. Don et de *Daniellia oliveri* (Rolfe) Hutch. & Dalziel dans les phytodistricts Pobè et Plateau au Bénin. *International Journal of Biological and Chemical Sciences*, 13(2), 652–661. https://doi.org/10.4314/ijbcs.v13i2.7

FAO, FIDA, OMS, PAM et UNICEF. (2018). L'état de la sécurité alimentaire et de la nutrition dans le monde 2018 : Renforcer la résilience face aux changements climatiques pour la sécurité alimentaire et la nutrition. Rome : FAO.

GIBBS, H.K., BROWN, S., NILES, J.O. & FOLEY, J.A. 2007. Monitoring and estimating tropical forest carbon stocks : making REDD a reality. *Environmental Research Letters* . p. 13.

GLEW, R.S., VANDERJAGT, D.J., CHUANG, LT., MILLSON M. and GLEW R. H., 2005. Nutrient Content of Four Edible Wild Plants from West Africa. *Plant Foods Hum Nutr* 60, 187–193. https://doi.org/10.1007/s11130-005-8616-0.

GUISSOU T., BABANA A. H., SANON K. B., BA A. M., 2016. Effects of arbuscular mycorrhizae on growth and mineral nutrition of greenhouse propagated fruit trees from diverse geographic provenances. *Biotechnol. Agron. Soc. Environ.* 20(3), 417-426

GUISSOU, A. W. D. B., PARKOUDA, C., SAVADOGO, A., TRAORÉ, Y., & TRAORÉ, A. S. (2020). Variability of nutrients in *Parkia biglobosa* kernels from different geographical regions in Burkina Faso. *African Journal of Food Science, 14*(6), 134–145. https://doi.org/10.5897/AJFS2020.1947

HENRY, M., PICARD, N., TROTTA, C., MANLAY, R.J., VALENTINI, R., BERNOUX, M. & SAINT-ANDRÉ, L. 2011. Estimating tree biomass of sub-saharan African forests: a review of available allometric equations. *Silva Fennica* 45(3B): 477–569. https://doi.org/10.14214/sf.38

HOUMEY V.K., SARR O., BAKHOUM A., DIATTA S., AKPO L. E., 2012. Estimation de la production fourragère d'un ligneux sahélien, *Maerua Crassifolia Forsk. Journal of Applied Biosciences* 59: 4349–4357 ISSN 1997–5902

HOUNDONOUGBO, J.S.H., KASSA, B., MENSAH, S., SALAKO, V.K., GLÈLÈ, K.R. and ASSOGBADJO, A.E. (2020). A Global Systematic Review on conservation and domestication of *Parkia biglobosa* (Jacq.) R. Br. ex G. Don, an indigenous fruit tree species in Sub-sahara african traditional parklands: current knowledge and future directions. Genetic resources and crop evolution, 67, 1051-1066.https://doi.org/10.1007/s10722-020-00892-w

HUC R., 2011. Les réponses des arbres aux contraintes climatiques : aspects écophysiologiques-. Forêt Méditerranéenne, XXXII (2), pp.167-172. hal-03556049

KOUYATE A. M., VAN DAMME P. & DIAWARA H. 2006. Évaluation de la production en fruits de *Detarium microcarpum* Guill. & Perr. au Mali. Note technique. Fruits 61 : 1-13

LAMIEN N., BAMBA A., 2008. Valorisation des Produits Forestiers Non Ligneux au Burkina Faso: Etat des lieux et perspectives. Programme d'Amélioration des Revenus et de Sécurité alimentaire (ARSA) : Composante « Exploitation rentable des Produits Forestiers Non Ligneux (PFNL) », 155p

LAMIEN N., SOME A. N., OUEDRAOGO J. S. , ILBOUDO B. , OUEDRAOGO C., SOMDA I., 2008. Potentiel productif de quelques essences fruitières locales au Burkina Faso. *Science et technique*, Sciences naturelles et agronomie. Vol. 30, n° 1. P 61-73

LAMIEN, N. (2006) Fructification du Karité (*Vitellaria paradoxa* C.F. Gaertn., Sapotaceae) : Facteurs de déperdition, Amélioration et Prévision des rendements à Bondoukuy, ouest Ouest Burkina Faso. Thèse de Doctorat, Université de Ouagadougou, Ouagadougou, 125 p,

LEßMEISTER A., SCHUMANN K., LYKKE AM, HEUBACH K., THIOMBIANO A., HAHN K., 2015. Substitution of the most important and declining wild food species in southeastern Burkina Faso. *Flora et Vegetatio Sudano-Sambesica* 18, 11-20

LOGOSSA, Y. B., BOUVET, J.-M., OUMOROU, M., & HARDY, O. J. (2018). Phylogeography of African locust bean (*Parkia biglobosa*) reveals genetic divergence and spatially structured populations. *BMC Evolutionary Biology*, **18**, 22. https://doi.org/10.1186/s12862-018-1136-2

LOMPO, D., B. VINCETI, H. KONRAD, J. DUMINIL, and T. GEBUREK. 2020. Fine-scale spatial genetic structure, mating, and gene dispersal patterns in *Parkia biglobosa* populations with different levels of habitat fragmentation. *American Journal of Botany* 107(7): 1041–1053. https://doi.org/10.1002/ajb2.1504

MUSARA C, ALADEJANA E.B., MUDYIWA S. M. and KARAVINA C., 2020. *Parkia biglobosa* (Mimosaceae): Botany, Uses, Phytochemical Properties and Pharmacological Potential. *Journal of Pharmacy and Nutrition Sciences*, Vol. 10, No. 3. pp 101-115

NICOTRA, A. B., ATKIN, O. K., BONSER, S. P., DAVIDSON, A. M., FINNEGAN, E. J., MATHESIUS, U., … VAN KLEUNEN, M. (2010). Plant phenotypic plasticity in a changing climate. *Trends in Plant Science, 15*(12), 684–692. https://doi.org/10.1016/j.tplants.2010.09.008

ODETOLA, A. A., AKINLOYE, O., EGUNJOBI, C., ADEKUNLE, W. A., & AYOOLA, A. O. (2006). Possible antidiabetic and antihyperlipidaemic effect of fermented *Parkia biglobosa* (JACQ) extract in alloxan-induced diabetic rats. *Clinical and Experimental Pharmacology and Physiology*, 33(9), 808-812

OUEDRAOGO A.S., 1995., *Parkia biglobosa* (Leguminosae) en Afrique de l'Ouest : Biosystématique *et* Amélioration, these. 2405p

OUEDRAOGO, M. (2012). *Impact des changements climatiques sur les revenus agricoles au Burkina Faso. Journal of Agriculture and Environment for International Development*, 106(1), 3-21.

OUEDRAOGO, M., RAEBILD, A., NIKIEMA, A., & KJÆR, E. D. (2012). Evidence for important genetic differentiation between provenances of *Parkia biglobosa* in West Africa. *Agroforestry Systems, 85*(2), 241–255. https://doi.org/10.1007/s10457-011-9453-1

OUOBA, L. I. I., DIAWARA, B., CHRISTENSEN, T., MIKKELSEN, J. D., & JAKOBSEN, M. (2006). Degradation of polysaccharides and non-digestible oligosaccharides by *Bacillus subtilis* and *Bacillus pumilus* isolated from Soumbala, a fermented African locust bean

(*Parkia biglobosa*) food condiment. *European Food Research and Technology*, 224(6), 689-694.

OUOBA, L. I., CANTOR, M. D., DIAWARA, B., TRAORÉ, A. S., & JAKOBSEN, M. (2003). Degradation of African locust bean oil by *Bacillus subtilis* and *Bacillus pumilus* isolated from soumbala, a fermented African locust bean condiment. *Journal of Applied Microbiology*, 95(4), 868-873.

PADAKALE E., ATAKPAMA1 W., DOURMA M., DIMOBE K., WALA K., KUDZO A. GUELLY and AKPAGANA K., 2015. Woody Species Diversity and Structure of *Parkia biglobosa* Jacq. Dong Parklands in the sudanian zone of Togo (West Africa). *Annual Research & Review in Biology 6(2):* 103-114

PARKOUDA C., DUFRECHOU M., VINCETI B., LE MEURLAY D., LANCON VERDIER V., PICOUET P., 2021. Physicochemical characteristics and nutritional potential of *Parkia biglobosa* ecotypes fruit pulps from Burkina Faso. *Science et technique,* Sciences Naturelles et Appliquées Vol. 40, n° 1. P 166-176.

PARKOUDA, C., DAO, A. S., OUOBA, L. I. I., & TRAORÉ, A. S. (2021). Physicochemical characteristics and nutritional potential of *Parkia biglobosa* fruit pulps from different agro-ecological zones of Burkina Faso. *Journal of Food Research, 10*(1), 56–68. https://doi.org/10.5539/jfr.v10n1p56

PROTA. 2006. *Parkia biglobosa* (Jacq.) R.Br. ex G.Don. In G. H. SCHMELZER and A. GURIB-FAKIM, eds. *Plant Resources of Tropical Africa*. Wageningen: PROTA Foundation. Accessed September 29, 2025. https://uses.plantnet-project.org/en/*Parkia_biglobosa*_(PROTA)

ROUVILLE CECILE, 1984. Les cérémonies d'initiation du bur. In: *Journal des africanistes*, tome 54, fascicule 2. pp. 75-98; doi : https://doi.org/10.3406/jafr.1984.2069

SACANDE, M., & CLETHERO, C. C. (2007). *Parkia biglobosa* (Jacq.) G. Don. Seed Leaflet, (124).

SINA S., 2006. Reproduction et Diversité Génétique chez *Parkia biglobosa* (Jacq.) G. Don. PhD thesis Wageningen en University, Wageningen the Netherlands, 118p.

SOURABIE S., ZERBO P., YONLI D. & BOUSSIM J. I., 2021. Effets herbicides d’extraits aqueux de *Parkia biglobosa* (Jacq.) R.BR.ex

G.Don. et *Tephrosia purpurea* (l.) pers. sur quatre adventices des céréales au sud-ouest du Burkina Faso. *Annales des sciences agronomiques*, Vol 25-1 : 17--28, ISSN 1659 – 5009

TEKLEHAIMANOT, Z., LANEK, J., & TOMLINSON, H. F. (1998). Provenance variation in morphology and leaflet anatomy of *Parkia biglobosa* and its relation to drought tolerance. *Trees, 13*(2), 96–102. https://doi.org/10.1007/s004680050194

TERMOTE, C., OYESIKU-BLAKEMORE, J., & VAN DAMME, P. (2022). Nutritional composition of *Parkia biglobosa* pulp and seeds: A systematic review. *Journal of Food Composition and Analysis, 103*, 104193. https://doi.org/10.1016/j.jfca.2021.104193

THIOMBIANO DNE, LAMIEN N, DIBONG DS, BOUSSIM IJ, BELEM B., 2012. Le rôle des espèces ligneuses dans la gestion de la soudure alimentaire au Burkina Faso. *Sécheresse* 23:23 :86-93

TIMMER, L.A., KESSLER, J.J. & SLINGERLAND, M. Pruning of néré trees "*Parkia biglobosa* Jacq. Benth" (1996) on the farmlands of Burkina Faso, West Africa. *Agroforest Syst* 33, 87–98. https://doi.org/10.1007/BF00122891

VISSCHER, P. M., HILL, W. G., & WRAY, N. R. (2008). Heritability in the genomics era - concepts and misconceptions. *Nature Reviews Genetics*, 9(4), 255-266. https://doi.org/10.1038/nrg2322