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Phenotypic Evaluation of Mother Trees and their Effects on Seed Emergence and Growth Dynamics of African Locust Bean Seedlings in Nursery

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Abstract

This study was carried out in order to identify the most productive in term of seeds between African locust bean trees aged 10-29 years, 30-50 years and 51 years and older. It aims also to identify which one can guarantee better emergence and growth of young *P.B* seedlings in the nursery. These plants were chosen according to the availability of fruit and their accessibility. For the emergence and growth tests, a complete randomized block design with three replicates, each with three treatments was installed. The SPSS v21 software was used for statistical analysis, with a significance level of 5%.

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The results show that the dendrometry and productivity parameters are better when the plants are at least 30 years old (DBH > 44 cm). Indeed, seeds from trees aged 30 - 50 years significantly improved seed emergence by giving a rate of 70.33%±7.23. Plants growth was not significantly affected by trees age.

Keywords: growth; germination; diameter; *Parkia biglobosa*; seedlings.

1. Introduction

In Benin, around 175 forest plant species are identified and consumed through their leaves, fruits, seeds, roots, tubers and flowers [1]. Among these, african locust bean (Parkia biglobosa) and shea (Vitellaria paradoxa) are the most frequently encountered due to their economic importance [2]. Parkia biglobosa is one of these species used in agroforestry parks in south Africa of the Sahara [3]. It is a perennial legume of agroforestry systems belonging to the sub-family Mimosoideae, family Fabaceae [4]. It plays an important role in protecting against wind and water erosion [5]. It also helps restore and improve soil fertility due to its nitrogen-fixing capacity [6, 7, 8]) and contributes to microclimate improvement [9]. This species could therefore be permanently introduced into agroforestry systems to play the role of chemical fertilizers in soil fertilization [10]. Indeed, Parkia biglobosa is a forage species much appreciated by livestock and an excellent soil fertilizer [11]. These agroforestry species integrated into agroforestry systems are sources of goods and services for the survival of rural populations and their adaptation to climatic uncertainties [2]. Many parts of this species are used for human consumption, pharmacopoeia, energy wood, soil fertilization, handicrafts and are also a source of income [12]. The species constitute thus a staple diet for over 20 million people in 20 African countries [13], helping to reduce nutritional imbalances. Indeed, its products undeniably contribute to improving people's incomes [14, 15]. Moreover, the high use of african locust bean seeds is mainly due to their transformation into the traditional "MAGGI" called "afitin" in the local Beninese language. In addition, 100 g of African mustard made from these african locust bean seeds contain significant quantities of protein (36.5 mg), lipids (28.8 g), iron (378 mg) [16], vitamins B2, PP and many other nutrients [17, 18], thus guaranteeing a power of nutrient diversification. It should be noted that this species is used from root to crown for its medicinal virtues and anti-diarrheal, antimicrobial, anti-hypertensive, anti-inflammatory, analgesic, antispasmodic, antihelminthic, antimalarial properties [18]. The leaves, pods, bark and roots of P. biglobosa are said to contain alkaloids, tannins, saponins, flavonoids, steroids, phenols, glycosides [18, 19]. For this reason, savannah populations preserved the species on their farms for its many virtues [20, 11, 21]. Of the thirty-one (31) medicinal woody species most widely used in traditional Beninese medicine, it ranks fifth [22]. Despite the important role played by forest resources in general, and Parkia biglobosa in particular, in improving human living conditions in West Africa in general, and Benin in particular, there is some concern about their long-term survival, given the current rapid degradation of forest areas in the country [23]. Benin is currently one of the world's most deforested countries, with an annual loss of 50,000 ha between 2000 and 2010 [24]. As a result, we are witnessing the destruction of savannah woodland resources, which nevertheless provide goods and services to local populations [25]. Agroforestry parks are characterized by an ageing stand, leading to a drop in fruit production, with a low regeneration rate leading to a sharp decline in their distribution area [26, 27, 28, 29]. The adverse effects of climate change, the low regeneration rate [30], the aging of orchards, the spread of invasive exotic species and the disappearance of natural habitats are raising fears for the species' survival [31, 32]. The non-development of planting and maintenance techniques for the species, the use of almost all seed produced and the effect of climate change [28] are also weighing on the protection and conservation of the african locust bean. There is therefore a risk that this agro-biodiversity will disappear [33] if measures are not taken. It is for this reason that Jamnadass says "Blessed be they, Africa's endogenous fruit trees, are disappearing and if we do not invest in them now, we will lose many of them [34]. In addition, because of its slow growth, studies on the vegetative propagation potential of dwarf are needed [35]. To achieve this, research is needed to shorten the production cycle of this species, focusing mainly on grafting and cuttings [35]. To this end, for the preservation of many goods and services provided by Parkia biglobosa (Jacq.) R. Br. ex G. Don, Fabaceae, it is fundamental to know the phenotypic variability of the species through the implementation of strategies aimed at its domestication [36]. In situ preservation of the species therefore requires in-depth study of its population dynamics and the various factors involved in their renewal processes [36]. [37] assert that knowledge of a species' fruiting capacity as a function of the age and diameter of individuals is crucial in defining management methods for the populations being exploited. According to [38], the most discriminating parameters for assessing the variability of P. biglobosa trees are: tree height, seed thickness, pedicel thickness, peduncle thickness, pedicel length, peduncle length, fruit length, seed weight and pulp weight per fruit. Diversity within a species can be assessed through morphological and molecular parameters [39, 40, 21]. The great diversity is linked to geographical origin and the difference between individuals from the same population [41]. Mostly, fruit and seed organs [42] are proving to be good descriptors of P. biglobosa and could be used for routine assessment of the species' morphological variability. With this in mind, [43] suggest research into the genetic, pedological and climatic-soil characterization of seeds in order to determine, on the one hand, the different varietal groups of african locust bean seeds in use in North Benin and, on the other, the group whose african locust bean plants have high productivity. It is within this framework that the present work aims to characterize phenotypically the populations of Parkia biglobosa in North Benin and to evaluate the germination dynamics of their seeds and the growth of their seedlings, in order to contribute to its domestication with a view to its integration into the agroforestry system. Specifically, the aim is to identify the best age range for mother trees in terms of fruit production, seed emergence and growth of young african locust bean seedlings in the nursery.

2. Materials and methods

2.1. Material

2.1.1.Study environment

In order to achieve these objectives, research was carried out in two municipalities in northern Benin. The first was the municipality of Péhunco in the Atacora department, where phenotypic data were collected. The second is the municipality of Parakou in the department of Borgou: it was in this commune that the seed emergence and growth trials of african locust bean seedlings in nursery were carried out. These trials were carried out at the National Federation of Cashew Producers of Benin (FENAPAB) in the town of Parakou.

2.1.1.1. Characteristics of Péhunco municipality

Located between the upper Alibori valley to the east and the Mékrou valley to the west, in the central-eastern part of the Atacora and Donga departments, Péhunco municipality is one of thirteen (13) municipalities in these two departments. Following the administrative reform, Péhunco is one of the 9 municipalities of the Atacora department. It is bordered to the north by the municipality of Kérou, to the south by the municipality of Djougou in the Donga department, to the east by the municipalities of Sinendé and N'Dali in the Borgou department, and to the west by the municipality of Kouandé. With a surface area of 1,900 km2, it occupies 9.26% of the total surface area of the Atacora department, including 207 km2 of classified forest. Administratively, Ouassa-Péhunco comprises three (03) arrondissements (Péhunco, Gnèmasson, Tobré) and 26 villages and town districts. The municipality is located between 10°13'42" North and 2°0'7" East.

✓ Climate

Péhunco's climate is Sudano-Guinean, with a rainy season generally running from mid-April to mid-October, and a dry season from mid-October to mid-April. August is usually the wettest month, with 1,200 mm of rainfall per year. The average rainfall is 1000 mm, but fluctuates between 800 and 1200 mm [44].

✓ Soil

The soil in Péhunco is essentially biotite gneiss included in the Dahomeyan which is a layer of magmatic rock and gneiss. Apart from the classified forests, the remainder of Péhunco's surface area is made up of gravelly soils of low fertility. The low water retention capacity of these predominantly sandy soils makes them highly sensitive to rainfall deficits.

✓ Vegetation

The vegetation is generally wooded or shrubby savannah. It is mainly wooded in the classified forest along the watercourses. There is also a fairly varied but predominantly grassy herbaceous layer.

✓ Relief and hydrographic network

The municipality of Péhunco is a peneplain located on the watershed between the Niger and Atlantic basins. Together with the OTI depression, the hills and the Atacora mountain range, this peneplain forms the four (4) main relief features of the department. Péhunco's hydrographic network is made up of the Mékrou river in the district of Péhunco and Gnèmasson, and numerous torrential rivers such as the Alibori in the district of Tobré. These two rivers (Alibori and Mékrou) are tributaries of the Niger River. This hydrographic network is completed by rivers, most of which are seasonal in nature.

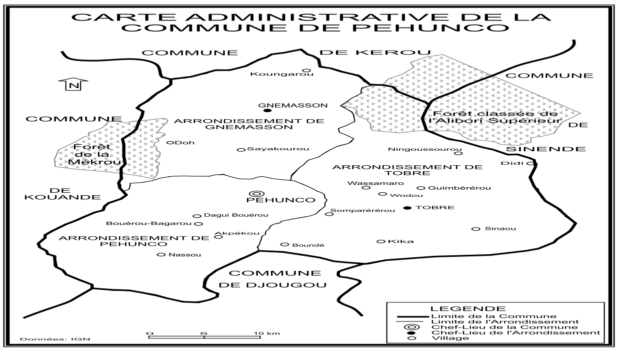


Figure 1: Administrative map of the municipality of Péhunco

Source: 2016 survey (SCDA/Péhunco)

2.1.1.2. Characteristics of the municipality of Parakou

The town of Parakou is located between 9°15' and 9°25' north latitude and between 2°30' and 2°45' east longitude, covering an area of approximately 441 km2.

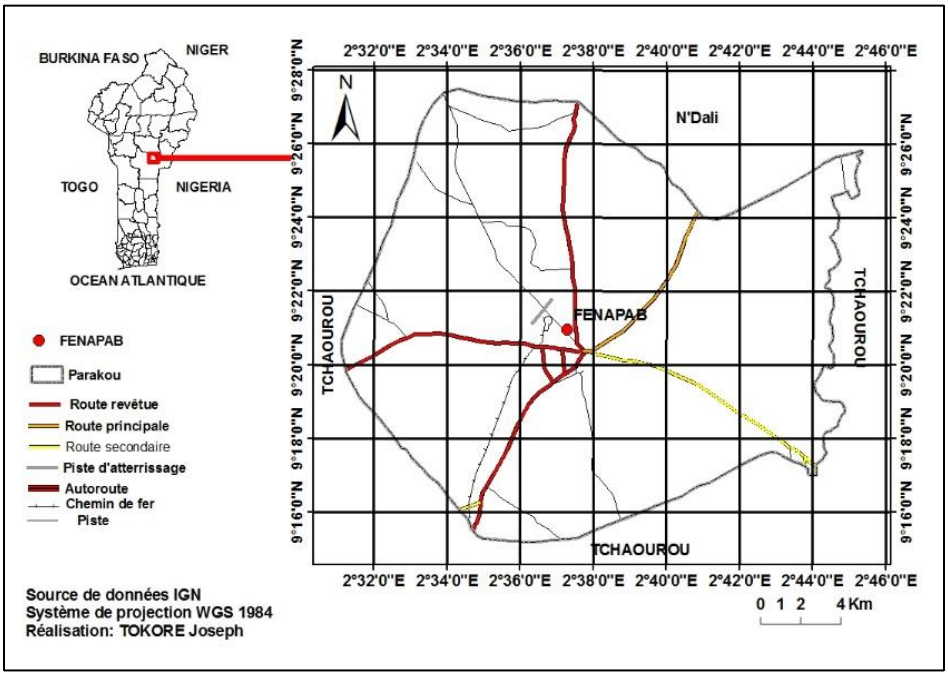


Figure 2: Geographical location of the town of Parakou

Source: TOKORE, 2020

✓ Climate

The climate in the municipality of Parakou is humid tropical (South Sudanian). It is characterized by a succession of two seasons: a dry season lasting five months from mid-October to mid-April, and a rainy season occupying the rest of the year. Average annual rainfall and temperature are 1,200 mm and 27°C respectively, with a relative humidity of 60%. The city's temperature drops during the December-January period. Maximum rainfall occurs between July, August and September [45].

✓ **Vegetation**

Parakou's vegetation cover is dominated by wooded savannah. It is characterized by the predominance of african locust bean (Parkia biglobosa) and shea (*Butyrosperum Paradoxum*). The lowlands are swampy savannah grasslands, with bamboo (*Bambusa arundinacca*) bushes. Fallow land is invaded by a wide variety of grasses and shrubs.

✓ **Soil**

The Parakou region is characterized by a predominance of light-textured, thick soils due to low levels of erosion.

2.1.1.3. Plant material and techniques

The plant material consists of seeds freshly harvested from african locust bean plants in Parkia biglobosa parks in the Ouassa- Péhunco municipality (Atacora). The technical equipment consists of a graduated ruler, a camry electronic balance with a 5 kg capacity and 0.1 accuracy, a cutter, bags and envelopes, a tape measure, a clinometer, calipers, polyethylene bags, watering cans, a coarse sieve, a laboratory thermometer, a cooking pot, data collection sheets and pen.

2.2. Method

2.2.1. Pre-sowing operations

Prior to sowing the seeds, several operations were carried out. The substrate (gully sand) was sieved using a coarse sieve to remove stones, twigs and other coarse elements that could interfere with seed emergence and root penetration. This sieving was preceded by watering the substrate. The substrate was then sterilized using the old pot method, in which a reasonable quantity of water is placed in a pot, followed by a quantity of substrate capable of absorbing the water. The pot is then hermetically sealed and the whole thing is heated under the pressure of a charcoal fire. When the temperature reaches 100°C or close to it and stabilizes, the pot is lowered and the contents inverted. The purpose of this sterilization is to neutralize disease germs and other living organisms in the substrate that could adversely affect seed emergence. After potting, which took place after the substrate had cooled, the pots were watered until the substrate was at field capacity. In addition, to ensure the quality of the seeds intended for sowing, they were subjected to a flotation test, and those that submerged to the surface were eliminated. Then, batches of seeds by age group were soaked for 24 hours in tap water, the volume of which was twice the reference volume of the seeds. After soaking, all seed lots were dried in the shade for 6 hours before sowing. It should be noted that the seeds were sown at a depth of around 2 cm in the substrate at a rate of three seeds per bag, one bag having received 4, in other words 100 seeds per plot. During sowing, the radicular part of the seed was oriented downwards to facilitate germination. Maintenance was limited to regular weeding and hoeing (once every two weeks) of the pots.

Substrate screening

Substrate sterilization

Substrate cooling before potting

Soaking seeds before sowing

Figure 3

2.2.2. *Experimental setup*

For the study of phenotypic variability in Parkia biglobosa, data collection followed the semi-reasoned sampling method. Three villages at least 30 km apart were randomly selected. In each village, 30 trees divided into three age classes (10-29 years, 30-50 years, and 51 and over) were also selected on the basis of their accessibility and the presence of fruit. This classification is based on the fact that african locust bean trees start producing between 8 and 10 years of age and only reach their maximum age from 30-50 years. Villages are considered as replicates and age groups as treatments. For each cardinal point of each village and at its center, 2 trees per age range (6 trees per point) were targeted, giving a total of ninety (90) trees for the study. For this collection, infructescence were collected from disease-free african locust bean trees at least 100 m apart. The infructescence were collected randomly from each stand, but not towards the ends of the crown to avoid edge effects. For the evaluation of these phenotypes on seed emergence and seedling growth, a complete randomized block design with three replicates, each with three treatments (age groups) or plots, was set up. These are made up of 33 pots each, giving a total of 297 pots for the experiment. The plots are spaced 50 cm apart, while the pots are glued together within these plots. Seedlings were reduced at one plant per pot after emergence. To minimize border effects, data on growth parameters were collected only on the 10 seedlings in the middle of the plot, while all pots were considered for seed emergence data. The only factor highlighted in this study was the age range or diameter at breast height (DBH) classes.

2.2.3. Data and collection method

2.2.3.1. Collection of phenotypic data from African locust bean plants in situ stands

Morphological data were collected in the municipality of Péhunco, while germination and seedling growth tests were carried out in the municipality of Parakou, at FENAPAB. Firstly, the diameter at breast height (DBH) and total height (H) of each tree were measured using a tape measure and clinometer respectively. Then, for each tree, 6 infructescence were collected in a randomized way, while avoiding harvesting towards the ends of the crown to avoid edge effects. The infructescence were collected at the medial part of the crown and at the four cardinal points of the crown in addition to their center. After descent, they were weighed before counting the number of pods per cluster and the number of seeds per pod (by simple counting). The dimensions (length and width) of these pods were also taken using a tape measure. The pods were then manually shelled by opening the valves and removing the fibrous thread running from the base to the apex, and the seeds with the adherent pulp were extracted. The seeds are then soaked in tap water for several hours to facilitate separation of the pulp from the seeds. Finally, they are washed to completely remove the pulp. The seeds were then air-dried to remove any impurities. After this drying operation, the weight of 1,000 seeds per age group was taken using an electronic scale. To determine the total height of the tree, two sightings were carried out: a first sighting (V1), at the top of the tree, evaluated as a percentage of the distance (L) from the operator to the tree, and a second sighting (V2) at the foot of the tree. To determine approximate age (A), the diameter at breast height was divided by the value of the growth rate (GR) of slow-growing species such as the P. biglobosa : $\mathbf{A=\frac{DBH}{VC}}$ **(1)** with DBH in meter (m) and VC= 1.5 [46]. The total height (H) of the tree measured is obtained by the relationship $\boldsymbol{H = \frac{(V1+V2)*L}{100}}$ **(2)** with L in meter (m).

Cranberry | Foot Cranberry | Soaking for seed pulping | Pulled seeds by age group | 1000-grain weight measurement

Figure 4

Source: TASSIKI (2022)

2.2.3.2. ***Nursery data and collection methods***

In order to assess the impact of these age ranges on the emergence and growth of seedlings in the nursery, related tests were set up. To this end, a number of data were collected from these tests:

✓ the seed emergence date from the first seed emergence;

✓ the number of germinated seeds for which the radicle has penetrated the thin layer of sand (30-day period);

✓ the diameter at the crown (DC) and the height of the plants in order to calculate their vigor (45 days after sowing);

✓ the number of leaves, their length and even number of quills. Plant height (H) was measured from the crown to the apical bud.

In order to determine the variables of emergence (latency time (TLa), velocity (VL), duration (DL) and emergence rate (TL)), seed and plant vigor, the following formulas were used:

✓ $\mathbf{TLa}\ (\boldsymbol{day}) = (\boldsymbol{JPG} - \boldsymbol{JS})$, With JPG: day of first emergence; JS: Day of sowing. This corresponds to the number of days spent without any emergence **(3);**

✓ $\mathbf{DG}\ (\boldsymbol{day}) = (\boldsymbol{DJG} - \boldsymbol{TLa})$, With DJG: the day from which the lift rate reached its peak **(4);**

✓ $\mathbf{MTG}\ (\boldsymbol{Day}) = \sum(\boldsymbol{Gi} * \boldsymbol{Ji})/\boldsymbol{Gt}$ With Gi: emergence rate on day i, Ji: number of days after sowing; Gt: total emergence rate. The higher its value, the lower the seed vigor **(5).**

✓ $(\%) = \frac{\boldsymbol{NGG}}{\boldsymbol{NTGS}} * \mathbf{100}$, (NGG: number of germinated seeds, NTGS=total number of seeds sown) **(6);**

✓ $\boldsymbol{Vi} = \frac{\boldsymbol{HP}}{\boldsymbol{DC}}$ **,** (Alexandre, 1977) with HP: plant height (cm) and DC: diameter at crown (cm) **(7).**

Vigor (Vi) is said to be good when the DC/H ratio is less than 80, and the most vigorous plant is the one with the lowest ratio.

Figure 5

Germinated seeds and methods for measuring the diameter and height of *Parkia biglobosa* seedlings

2.2.4. Statistical data processing

The data collected were purified, entered and coded using Microsoft Excel 2013 spreadsheet software. They were then processed using SPSS version 21 software, following Global Linear Models (GLM) and Generalized Linear Models (GLM) for measured and counted variables respectively. The Tukey test and poison regression were then applied for comparison of means, with a significance level of 5%. Pearson's bivariate correlation coefficients and Spearman's Rho correlation coefficients were used to highlight existing relationships between the parameters studied.

3. Results and discussion

3.2. Results

3.2.4. Effect of age classes of seed mother trees on their phenotypes related to seed production.

ANOVA shows that for morphological characteristics collected on african locust bean trees, only DBH, height, Weight Clusters and number of pods per cluster means are significantly ($p < 0.05$) influenced by DBH (diameter at breast height) classes.

Table 1: phenotypic characteristics of seed trees by diameter class

Classes de DBH (cm)	**DBH (cm)**	**H (m)**	**Bunch weight (kg)**	**Number of pods**	**NGr**	**Weight 1000 Seeds (kg)**	**LG (cm)**	**lG (cm)**
[18 ;44]	29,00± 5,86a	11,18 ±2,16 a	0,11± 0,06a	7,83± 4,76a	13,56± 4,86a	0,224±0,06 a	21,31± 4,55 a	1,97± 0,17 a
[45 ; 75]	52,87± 8,42b	15,41 ±3,13 b	0,12± 0,05a	8,06± 3,09a	16,53± 5,65 a	0,23±0,10 a	21,1± 5,76 a	2,02± 0,23 a
[76 ;160]	94,06± 21,99c	19,80 ±2,08 c	0,17± 0,07b	12,58±6,05b	15,92± 4,40 a	0,225±0,07 a	20,8± 5,67 a	2,05± 0,12 a
P.value	0,00	0,00	0,04	0,017	0,2	0,124	0,45	0,51

Within the same column, values followed by the same alphabetical letter are not significantly different at the 5% threshold (Tukey). [18 ;44] =1=1ère class=lowest class; [45 ;75] =2= 2ème class=medium class; [76 ;160] =3=3ème class=highest class, **DBH=**diameter at breast height; **HP=**total height; **NGr=**number of seeds**; LG=**pod length; **lG=**pod width.

Analysis of Table 1 shows that for all variables except pod length and number and weight of 1000 seeds, african locust bean trees in the third class have higher values than those in the first class, which have lower values. For this third class, the average DBH and total height of the trees are 94 cm and 19.8 m respectively, giving them greater vigor (21.06). This enables them to produce bunches weighing 0.17 kg, each bearing around 13 pods. Each pod contains around 16 seeds, 1000 of which weigh 0.225 g. The table also states that the seeds weigh more and are more numerous when the pods are long with medium wide. As for the first class (inferior class), the average DBH is 29 cm, the height 11.18 cm with a vigor of 38.57 (the lowest). This inferiority has a significant impact on production variables (weight and number of bunches, weight and number of pods and seeds). It is remarkable that the phenotypes of these sampled trees become better when the dendrometric parameters are high, in this case when the average DBH is greater than 44 cm. However, according to the same table, pod length decreases as tree DBH increases. This decrease is also observed for the number of seeds when DBH exceeds 75 cm. So, as DBH increases, pod length decreases and pod number increases.

3.2.5. Evaluation of the impact of the age of African locust bean mother trees on seed emergence in nursery

Table 2 shows the values of seed emergence parameters (lag time, duration, seed vigor and emergence rate) as a function of age class (DBH). Statistical analysis shows that these diameter classes have a significant influence ($p < 0.05$) only on lag time and slightly on seed emergence speed.

Table 2: Impact of mother tree age on seed emergence

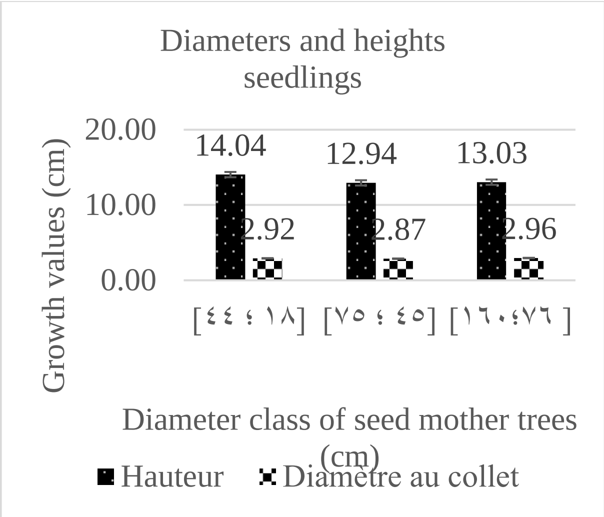
DBH classes	Latency time	Time to lift	Seed emergence speed	Lift rate
[18 ;44] =1	10,33±0 ,58a	32,33±12,7a	2,19±0,14a	56,33±4,04a
[45; 75] =2	9,00±1,0ab	25,33±1,53a	2,66±0,28ab	70,33±7,23a
[76 ;160] =3	7,67±0,58b	26,67±3,21a	2,00±0,24a	55,00±12,12a
P.value	0,047	0,725	0,050	0,118

Within the same column, values followed by the same alphabetical letter are not significantly different at the 5% threshold (Tukey). [18 ;44] =1=1ère class=lowest class; [45 ;75] =2= 2ème class=medium class; [76 ;160] =3=3ème class=highest class, DBH=diameter at breast height; HP=height of cowpea feet.

Analysis of this table shows that the first seed emergence began one week (7.67 days±0.58) after sowing and was observed in the upper class, while it was prolonged (10.33 days±0.58) in the lower class. However, emergence was faster (2.66 seeds/day±0.28) with seeds from trees in the middle class, with an emergence rate of 70.33%±7.23 (the highest). This class is followed by the lowest class in terms of emergence speed and seed emergence rate (2.19 seeds/day and a rate of 56.33%±4.04). We can therefore conclude that seeds from trees with a DBH between 44 and 76 cm germinate faster, at a higher speed, thus shortening emergence time and increasing emergence rate. It should be noted that these advantages are not obtained with seeds from trees with an average DBH below 45 cm or above 75 cm.

3.2.6. Impact of the age of African locust bean mother trees on seedling growth dynamics.

Figure 1 below shows the impact of the age of cowpea plants on the growth dynamics of seedlings. The ANOVA shows that the different age classes evaluated had no significant effect ($P>0.05$) on growth parameters. Height, leaf length and the number of pairs of pinnae varied respectively from 12.94 cm to 14.04 cm, from 11.8 cm to 13.33 cm and from 2.6 to 3.



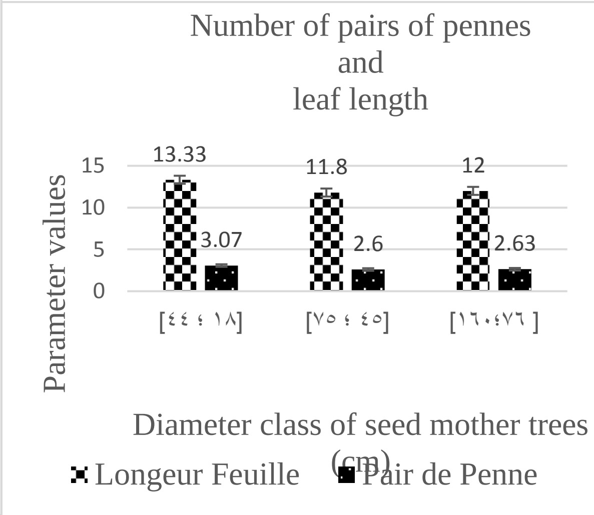


Figure 1-b **Figure 1-a**

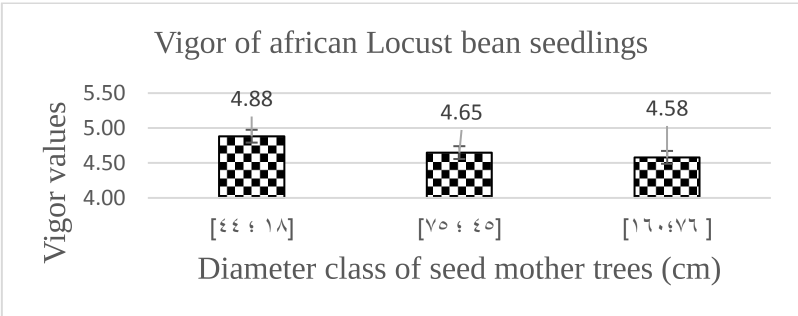


Figure 1-c

Figure 1: Impact of the ages of African locust bean mother trees on seedling growth dynamics

Despite this lack of difference between the age classes assessed for growth parameters, analysis of this plate reveals that, apart from the diameter at the crown (Plate 1-a) of the plants, for which the upper class was better, with the corollary of good plant vigor, other parameters such as height (Plate 1-a), leaf length and evenness (Plate 1-b) were better with the lower class. In fact, apart from plant vigor, the lowest values were recorded with the middle class. In general, we can conclude from these analyses that whatever the age of the African locust bean plants from which seeds are collected, the growth of seedlings in the nursery is almost uniform.

3.2.7. Intra-characteristic correlations

The correlation values between the parameters assessed are shown in Table 3. This table shows that some of these parameters are highly correlated ($P < 0.05$) with each other. Those that are positively or negatively correlated respectively explain their evolution in the same or opposite direction; that is to say an increase in one lead to an increase or decrease in the other, and vice versa.

Table 3: Intra-characteristic correlations of african locust bean seedlings in the nursery

Corrélations

	HP	DBH	Poidsgrappe	LG	IG	NGr	NbreGou	PoidsGr	Poids100Gr
HP	1,000	,857**	,371**	,092	,073	,038	,380**	,321**	,321**
DBH	,857**	1,000	,406**	,070	,018	,121	,391**	,294*	,294*
Poidsgrappe	,371**	,406**	1,000	,186*	,182**	,269**	,812**	,493**	,493**
LG	,092	,070	,186*	1,000	,385**	,670**	-,151*	-,542**	-,542**
IG	,073	,018	,182**	,385**	1,000	,264**	-,070	-,164**	-,164**
NGr	,038	,121	,269**	,670**	,264**	1,000	,018	-,524**	-,524**
NbreGou	,380**	,391**	,812**	-,151*	-,070	,018	1,000	,796**	,796**
PoidsGr	,321**	,294*	,493**	-,542**	-,164**	-,524**	,796**	1,000	1,000**
Poids100Gr	,321**	,294*	,493**	-,542**	-,164**	-,524**	,796**	1,000**	1,000

**. La corrélation est significative au niveau 0,01 (bilatéral).

*. La corrélation est significative au niveau 0,05 (bilatéral).

DBH0: diameter at breast height of seed mother trees; **LG:** pod length; **lG:** pod width; **TLa:** lag time; **VL:** emergence speed; **DL:** emergence duration; **TL:** emergence rate; **LongFP:** length of seedling leaves; **PPP:** number of seedling leaves; **DC:** diameter at seedling collar; **HP:** seedling height.

Analysis of this table shows that, on the one hand, the height and diameter of african locust bean plants are strongly and positively correlated with each other and, on the other, with cluster weight, number of pods and seed weight. As for cluster weight, it is positively correlated with the variables making up the pods (pod length and width, number and weight of seeds), which together make up the cluster itself. In fact, increasing the number of pods and seeds significantly increases and decreases seed weight respectively. Moreover, the greater the length and width of the pods, the greater the number of seeds and the lower their unit weight. It should also be noted that increasing pod length reduces pod width (and vice versa). The number of seeds is also reduced when pods are small. From the above, it can be seen that the larger the diameter of the trees, the greater the number of pods and seeds produced, and the greater the weight of the cluster. This weight is greater when the pods are long and/or wide. As the seeds pile up in the pods, small seeds are formed, reducing their unit weight. On the other hand, as the tree ages, it produces a large number of small pods.

3.3. Discussion

The results of this research have shown that trees with a DBH greater than 44 cm (trees over 30 years old) are taller and produce more fruit than trees with a smaller diameter. This good fruit production is explained by the strong positive correlations between dendrometric parameters (DBH, height) and certain production parameters (number of seeds, bunch weight, pod weight, seed weight, etc.) revealed by the results of this research. Indeed, several authors have shown that parameters relating to tree height, trunk diameter and crown diameter have a potential influence on fruiting [47]. As DBH and plant height increase, fruit and seed production also increase [48]. These authors showed that fruit production is better when DBH is greater than 40 cm. Thus, the results of the present work have shown that fruit weight (bunches) and seed weight increase with pod length. Lamien et al (2008) revealed a positive correlation between the number and average weight of fruits and Vitellaria paradoxa tree size. In addition, the results of the present study showed that seeds from DBH of P.B between 44 cm and 76 cm are more numerous and heavier, contained in long, wide pods. [51] showed that the longer and wider the Adansonia digitata pod, the greater the weight. [48] also found that seeds are more numerous in long pods than in wide ones. These authors stipulate that in the Sudano-Guinean zone, the average number of pods/clusters is 13. However, the results of research carried out in the Sudano-Guinean zone show that the average number of pods per cluster is 9, with a minimum of 2 and a maximum of 29. As for [52], they show that the number of pods/clusters varies between 6 and 15. These differences in results are thought to be due to the physico-chemical characteristics of the soils in the study environments and those of the tree populations surveyed. It should also be noted that the production parameters of Parkia Biglobosa trees vary from one sub-population to another, whereas dendrometric parameters vary very little [43]. Notwithstanding the better results obtained with older trees, results showed that when DBH is greater than 75 cm (feet over 50 years old), trees produce many less long but wide pods. This means that at a given DBH level, fruit production falls. This can be explained by the loss of sap visually observed on some older vines during fruit collection. This gum-like sap flows through the cracks in the bark of these plants and may be due to the effects of the trees' senescence phase. In Burkina Faso, [50] noted a reduction in Vitellaria paradoxa production with increasing diameter, indicating that good-producing trees are small in size.

Furthermore, the results of emergence and growth tests on seedlings resulting from these harvested seeds show that seeds from older trees, particularly those with a DBH of between 44 and 76 cm, germinate significantly faster, thus shortening emergence time while guaranteeing good emergence rates. Pods produced by older trees (DBH≥45 cm) become increasingly shorter but wider, containing seeds that germinate rapidly. These results consolidate those of [10] who worked on a limited number (6) of cowpea plants and obtained collinear results. This is therefore the optimum DBH or age range for the best physiological and phenotypic characteristics in both in situ and ex situ stands. With regard to seedling growth, which was virtually uniform whatever the age range, they showed that growth was nevertheless faster when seeds came from mother trees in the extreme classes (DBH ≤ 44 cm and DBH ≥ 76 cm). Seedlings generated by seeds from large-diameter trees being more vigorous. These results can be explained by the strong correlations between the phenotypic characteristics of the mother trees and the variables of seedling emergence and growth in the nursery. They can also be explained by the fact that the age/DBH class of mother trees and seed provenance influence seedling growth and development [26]. Thus, diameter at breast height influences the growth and development of seedlings and can be considered a discriminatory in the process of producing cowpea seedlings [10]. They also state that large-diameter cowpea trees have good fruit production and generate vigorous seedlings. [53] and [54] have also shown that the productive performance of mother trees plays a very important role in the rapid production of vigorous seedlings resistant to climate change.

4. Conclusion

This study, which assesses the effect of the age range of mother trees on their production, the quality of the seeds they produce and the effect of the latter on the emergence and growth dynamics of young *P.B* seedlings, contributes to the development of an appropriate technology for the domestication of P. biglobosa in Benin. In fact, it has enabled us to identify relationships between the tree's dendrometric parameters, mother tree production factors, seed emergence factors and nursery seedling growth factors. The results of this study are a good start towards the successful rapid production of good quality cowpea seedlings. In fact, they show that the age ranges of cowpea plants significantly affected fruit production and seed emergence in the nursery. In fact, the phenotypes of these plants relating to production (number of seeds, bunch weight, pod weight, seed weight, etc.) become better when the DBH is greater than 44 cm. However, when DBH exceeds 75 cm, pod length, number of seeds and 1000-seed weight decrease. This implies that older trees produce fewer, longer and wider pods containing seeds that germinate quickly. Furthermore, correlation analyses showed a strong positive correlation between tree dendrometric parameters, production factors, seed emergence factors and nursery seedling growth factors. The larger the diameter of the trees, the greater the number of pods and seeds produced, giving the bunches a high weight. This weight is greater when the pods are long and wide. It should be noted that it has been less common to have a cluster made up of many long pods. When the seeds pile up in the pods, this results in the formation of small seeds, reducing their weight and compromising seed emergence in the nursery. Moreover, when seed emergence rate and speed are high, the resulting seedlings have small diameters at the collar. And if emergence time is long, the seedlings grow taller, with long leaves and several pairs of pinnae. Finally, it should be noted that the speed of seed emergence is proportional to the rate of emergence. Overall, seeds from trees with a DBH of between 44 cm and 76 cm germinate more quickly with a high emergence rate, thus shortening emergence time while providing good emergence rates. With regard to the growth parameters of young african locust bean seedlings in the nursery, this study shows that whatever the age of the african locust bean plants from which the seeds are collected, the growth of the seedlings is virtually uniform. At the end of this work, it is possible to make a predictive estimate of the production potential of P. biglobosa based on dendrometric parameters, and to know from which african locust bean trees to collect seeds for the rapid, high-quality production of young African locust bean seedlings in the nursery. The best seed tree would be 30-50 years old (DBH between 44 cm and 76 cm). At this age, it produces clusters of long, wide pods filled with seeds with a high germination capacity. It is very important to note that the mother plants on which data are collected must be disease-free and at least 100 m apart. For each factor modality, 25 plants must be considered, and the fruit must be fully mature. In addition, this study could address not only the genetic aspect of the seeds, the types of soil on which these mother trees are grown, but also the size of the seeds (length) at sowing. It is imperative that all individuals, organizations or structures wishing to produce good quality african locust bean plants take into account the results of this research. As this is a slow-growing species, studies on the best substrates for improving the growth of african locust bean plants in the nursery are essential.

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5.Conflict of interest

The authors declare that they have no competing interest in this article.

6.Authors' Contributions

Alimi Tassiki and Sabi Bira Joseph Tokore Orou Mere: Study Design. Alimi TASSIKI: Data Collection. Alimi Tassiki: Data Analysis. Alimi TASSIKI: Project management. Sabi Bira Joseph Tokore Orou Mere and Michel Batamoussi Hermann: Supervision of work. Alimi Tassiki, Salami Arouna and Cécile Hounsou: Drafting of initial manuscript. Alimi Tassiki and Sabi Bira Joseph Tokore Orou Mere: Manuscript review and editing.

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