Enhancing Timber and Medicinal Plant Resources: Propagation Techniques for *Khaya senegalensis* (Desr.) A. Juss. in Tropical Regions

ABSTRACT

Human uses the resources of tropical forests, which contain great biological diversity, for food, traditional and commercial purposes, including on an international scale. Some species have been exploited for timber production. The aim of this work was to identify the best part of the shoot for regeneration of Khaya senegalensis in the two seedling sebstrates. This work will provide a database for the regeneration and domestication of forest products, with *Khaya senegalensis* as a model plant. It is one of the medicinal and timber species on which sustained attention and priority actions should be focused. The main objective of this study was to determine whether this plant, with its high health value, can be regenerated by cuttings. The set-up comprised 180 bags arranged in a random block of 90 bags for each of the seeding substrates (black earth and red earth). The results showed that regeneration by cuttings is possible in the substrates. Old cuttings showed the best viability rates, at 70% and 43.33% for black earth and red earth substrates respectively. The best regeneration percentage was observed for aged cuttings (36.66% and 20%). These results showed variability in length and collar diameter according to cutting type and substrate. Of the three types of explants tested, the old part of the stem proved better than the young and intermediate parts. However, it would be interesting to improve the rate of regeneration and rooting of cuttings by using vegetative hormones.

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Keywords : Khaya sénégalensis; Domestication; Cuttings; Forest biodiversity; Regeneration

1. INTRODUCTION

Humans have always used the resources of tropical forests, which contain a wealth of biological diversity (Sosef et al.[1]), for food, traditional and commercial purposes, including on an international scale (De Wasseige et al.[2]). Some species have been exploited for timber production (Sawyer [3]). *Khaya senegalensis* falls into this category. However, overexploitation of the species has led to its inclusion on the International Union for Conservation of Nature's red list (Adjahossou et al.[4]) as a species facing a very high risk of extinction in the wild (IUCN [5]). This species produces one of the most prized woods on African continent. It has been marketed under the name Mahogany for around two centuries. *Khaya senegalensis* is one of the medicinal and timber species that require sustained attention and priority action on account of its socio-economic importance (Kantende et al. [6]). It is a multi-purpose species and one of the largest and most majestic trees in the Sudanian region (Eyog [7]). Various organs of the species are used for their medicinal properties (Kolawole et al.[8]). Indeed, *K. senegalensis* is a tropical evergreen tree whose organs are widely used in the treatment of several diseases (Sokpon & Ouinsavi [9], Nikiema & Pasternak [10]; Adomou et al.[11]). The leaf, bark, fruit and root have highly recognized medicinal, food and ornamental values. Oil from the seeds is used in African cooking. Leaves and bark are used to treat stomach ache, diarrhea and constipation. These organs also treat malaria. They are a remedy for jaundice and leprosy. It eliminates intestinal parasites, and is a plant with febrifuge, antibiotic and vermifuge therapeutic properties. In addition to its medicinal importance, its wood is also heavily exploited as timber and service wood, which poses threats to the survival of this species, as it faces abusive exploitation by the rural population (Daïnou et al.[12]). This results in forest degradation and loss of biodiversity. However, to remedy this situation, the domestication of this medicinal species with high therapeutic or nutritional value is worth considering. The general objective of this work is to regenerate *K. senegalensis* by cuttings. Specifically, the aim is to determine the best part of the stem to use as a cutting for good regeneration, and to determine the seeding substrate that conditions the best regeneration of the cuttings.

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2. MATERIALS AND METHODS

2.1 Experimental site

The study took place in one of the experimental nurseries of the Université Jean Lorougnon Guédé located in the town of Daloa at 6°53 north latitude and 6°27 west longitude. The town is located in the Haut Sassandra Region in West-Central Côte d'Ivoire. It is around 141 km from Yamoussokro, the political capital, and around 400 Km from Abidjan, the economic capital (Diomandé et al. [13]). Daloa is bordered to the north by the town of Vavoua, to the south by Issia, to the west by Duekoue and to the east by Bouafle. The vegetation, which belongs to the mesophilic sector, is largely made up of dense forest, which has now disappeared to make way for various cash crops (Sangare et al.[14]). The soil is ferralitic and the climate is humid tropical, with one rainy season and two dry seasons (N'guessan et al.[15]). Dry and wet seasons alternate with temperatures ranging from 24.65°C to 27.75°C on average.

2.2 Plant material

The plant material used consists of *Khaya senegalensis* cuttings. These cuttings consist of three parts of the stem. The old part, which corresponds to the old wood directly connected to the root; the growing part, characterized by the part that generally bears the leaves; and the middle part, which corresponds to the intermediate zone between the old wood and the young part.

2.3 Methods

2.3.1 Taking and preparing cuttings

Cuttings were taken from the stems of plants showing variability in stem length and diameter. Each cutting has at least one node and is 14 cm long, 10 cm below the node and 4 cm above. Each stem was subdivided into three parts (old, young and middle). A total of 30 cuttings of each type were taken,

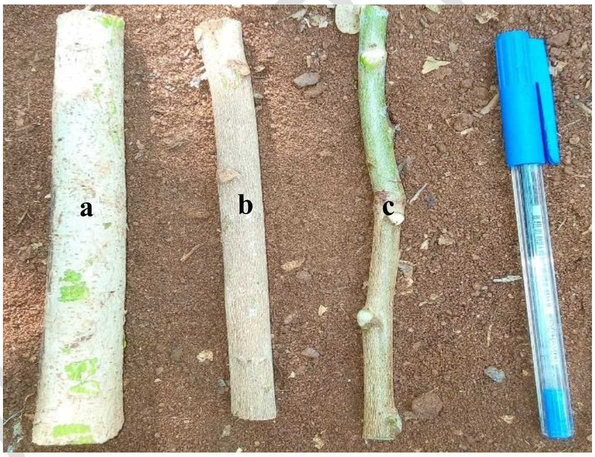

Fig1. Type of cuttings a .Older part ; b .Middle part ; c .Younger part

2.3.2 Seeding substrate

Two substrates commonly used for cuttings were tested. These were red soil taken from the Jean Lorougnon GUEDE University in Daloa, and black soil taken from a former garbage dump.

2.3.3 Experimental design

The trial was conducted in a greenhouse built from the branches of oil palms (Elaeis guineensis), with wires used to connect the branches and a transparent tarpaulin to cover the nursery. The dimensions of the greenhouse are 9.54 m long, 3.3 m wide and 2.9 m high. The set-up comprised 180 bags arranged in a block of 90 bags for each of the seeding substrates. The cuttings were planted at a depth of 5 cm in the substrate. Each substrate received a total of 90 cuttings, i.e. 30 cuttings of each type, including 30 old cuttings, 30 old cuttings and 30 young cuttings. The cuttings are watered every two days and hand weeding is carried out as soon as weeds appear in shaded areas.

2.3.4 Observed parameters

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The parameters observed are bud break rate and time, bud height measured every week, bud neck diameter, regeneration and cuttings mortality rate. For this purpose, cuttings having developed a new leafy stem are counted at the end of the experiment, while the mortality rate concerns the proportion of dead cuttings no longer capable of developing buds. At the end of the experiment, the total number of each type of dead cuttings was determined according to the substrate. Observations lasted two months from April to June 2021.

2.3.5 Statistical analysis of data

The various parameters collected were subjected to statistical analysis. Two factors (substrates and cuttings) were subjected to an analysis of variance. When a difference was observed for a parameter tested for a given factor. The ANOVA was completed by the small significant difference test (SSDT). This test highlights the best parameter(s) tested. The data collected were analyzed using STATISTICA version 7.1 software.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Bud development and regeneration of cuttings

Cutting regeneration begins with bud formation. The bud formed develops over time into a leafy stem. In the greenhouse, we were able to follow this process. The bud forms on the 7th day after cultivation in the various substrates, and the first leaves of the young stem appear on the 13th day. The leafy stem evolves over time.

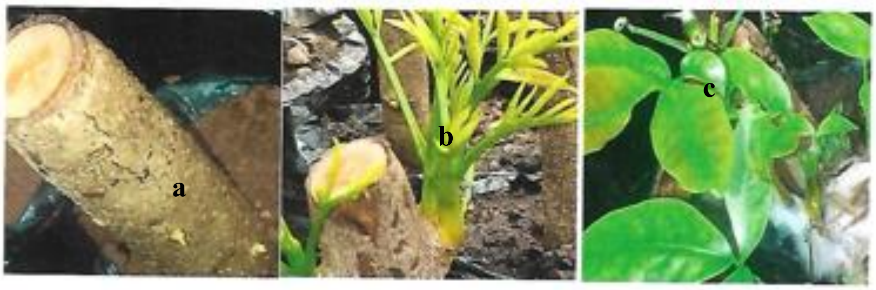

Fig 2. Bud develoment, a : Formation of axillary buds, b : Developmment of petioles and appearance of the first leaves on the stem, c : Formation of leaves around the young stem

Table 1 shows the results of the multivariate analysis of two factors studied: substrate (*P=0.046*) and cuttings used (*P<0.001*). This means that the results obtained are significantly influenced by the nature of the substrate and the type of cuttings used. Thus, in this work, results are presented according to substrate and type of cutting.

Table1. Multivariate analysis of significance using Wilk's test

	Test	Value	*F*	dl effect	*P*
ord.origin	Wilk	0.872	12.637	2	0.000
Substrates	Wilk	0.965	3.136	2	0.046
Cuttings	Wilk	0.844	7.594	4	0.000
Substrates*Cuttings	Wilk	0.940	2.701	4	0.031

3.1.2 Mortality and viability of cuttings on different types of substrate

After 40 days' observation, T1 cuttings showed the best viability rates, on substrates. T2 cuttings showed low viability rates on the substrates. T3 cuttings recorded 100% mortality, the lowest viability rate in both substrates (Table 2). No young cuttings survived on either substrate. The red earth substrate thus recorded the highest mortality rate, while the black earth substrate recorded the highest viability rate (Table 2).

Table 2. Viability and mortality rates of cuttings according to substrate type

Substrate	Red earth			Black earth		
Type of cuttings	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Viability (%)	43.33	10	0	70	16.66	0
Mortality (%)	56.66	90	100	30	27	10
Overall viability (%)	17.7			28.887		

T1 Older part ; T2 Middle part ; T3 younger part

3.1.3 Regeneration of cuttings in different types of substrate

Regeneration rates varied in the substrates. For differents substrates, red earth and black earth, the highest percentage of regeneration was observed in T1 cuttings, followed by T2 cuttings (Table 3). As for T3 cuttings, we observed a total absence of regeneration. The regeneration rates observed in Table 3 show that black earth is a better substrate for regenerating cuttings

Table 3. Regeneration rate of cuttings accorging to substrate

Substrates	Regeneration of cuttings		
	T1(%)	**T2(%)**	**T3(%)**
Red earth	20	6.67	0
Black earth	36.67	10	0

T1 : Older part ; T2 : Middle part ; T3 : younger part

3.1.4. Variation in mean stem length and collar diameter

The length and collar diameter of regrowths varied according to the type of cuttings and the nature of the substrate. No observations were made on young cuttings which did not regenerate. The results of the statistical analyses presented in Table 4 showed a significant difference in the length and collar diameter of regrowths on the cuttings. However, the nature of the substrate did not show any significant differences in the length and collar diameter of the regenerated cuttings.

Table 4. Average stem length and average collar diameter as a function of substrate

	Stem lenght (cm)			Diameter at collar (cm)		
Cuttings	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Red Eaeth	19.667^{a}±1,461	9.00^{b}±2.53	0^{c}±0.00	0.45^{a}±0.063	0.40^{a}±0.11	0^{b}±0.00
Black Earth	12.272^{a}±1,079	10.333^{a}±2.066	0^{b}±0.00	0.463^{a}±0.046	0.40^{a}±0.089	0^{b}±0.00
F	33.047			0.334		
P	*P< 0.001*			*P< 0.001*		

T1 : Older part ; T2 : Middle part ; T3 : younger part

3.2 Discussion

The results of this work showed that young cuttings had a low regeneration rate. In fact, young stems have excellent cell division qualities, but once cut, they contain fewer nutrient reserves. These portions of stem separated from the mother stem, no longer receiving reserves from elsewhere, dry out, leading to the death of the cuttings. Our results are in line with the work of Traoré [20], who reported that the inability of young Piliostigma reticulatum cuttings to regenerate was due to the fact that they did not contain sufficient nutrient reserves to allow eventual emergence. On the other hand, according to Hartmann et al [17], these young cuttings were subjected to desiccation and death. In addition, the same

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authors revealed that higher ambient temperatures could lead to bud break before root initiation, and increase water loss through transpiration. This will very often lead to cuttings drying out and dying.

As far as cuttings are concerned, the older part of the *Khaya senegalensis* stem was the best part for regenerating cuttings (Auneerudy and Pinglo [21]). Taking cuttings from the aged part of the *K. senegalensis* stem gave satisfactory results, since by the sixtieth day of the trial, some cuttings had produced root buds and others true roots for shoot survival and development. Regeneration of old cuttings therefore took place over a long period. Indeed, the regeneration capacity of aged cuttings could be explained by their ability to retain the nutrients required for bud formation and development over a long period. However, some cuttings can also develop leafy stems, but without a root system. Similar results were obtained with *Guiera senegalensis* cuttings in Burkina Faso (Bationo [22]). This author reports that cuttings without root systems are kept alive by accumulated reserves, but gradually dry out as these reserves are depleted.

This study also demonstrated the influence of substrate in the regeneration of Khaya senegalensis cuttings. The highest mortality and lowest viability of cuttings were observed in the red soil substrate, while the black soil induced the lowest mortality and highest viability. On the one hand, this result could be explained by the fact that red earth is a very clayey soil, with the capacity to retain water (Soro[16]). This capacity leads to an excess of water, and the massive humidity in the substrate will result in rotting of the cuttings. This will lead to the death of the cuttings. On the other hand, red soil compacts easily, according to Soro [16], preventing the roots from breathing. This process will lead to asphyxiation of the roots, which could also lead to the death of the cuttings.

With regard to growth parameters, the results showed that the nature of the substrate had no statistical influence on the evolution of growth parameters. These results corroborate those obtained in the work of Silué et al[23] who showed that there was no significant difference in the growth of Khaya senegalensis seedlings tested in different soil types. However, analysis of the effect of different substrates on the regeneration qualities of cuttings revealed that the black earth substrate induced the best results for growth parameters in *Khaya senegalensis*. These results are similar to those of Silué et al [23] and Onana [24], who observed better values for growth parameters in *Khaya senegalensis* and *Pericopsis elata* respectively on typical substrates. The experimental period and conditions under which the trials were carried out may also explain the overall results obtained.

4. Conclusion

The main objective of this study was to determine the potential of *K. sénégalensis*, a plant with a high health value, to be regenerated by cuttings. Following experiments with different types of cuttings (old, mature and young) on different substrates (black earth and red earth), the results showed that the type of substrate did not influence the regeneration rate, but rather the mortality rate. Of the three types of explants tested, the aged part or old part proved to be the better part of the stem than the young and intermediate parts. Although there was no significant difference between the substrate and the growth parameters, the black soil showed the best conditions for viability and regeneration by cuttings of *K. senegalensis*. It would therefore be interesting to improve the regeneration rate and rooting of cuttings through the use of vegetative hormones. In addition, a genotype effect test could be carried out to propose in-vitro culture for recalcitrant genotypes.

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