

Effects of Cuttings Length and Substrate on Cutting Parameters for the Domestication of *Stereospermum kunthianum* in the Sudano-Guinean Zone of Chad

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Abstract

The aim of this work was to develop the possibilities of domesticating *Stereospermum kunthianum*. Cuttings based on the length of the cuttings and the types of substrates were used to achieve this objective. The lengths $L_1 = 10$ cm (BL_1), $L_2 = 15$ cm (BL_2) and $L_3 = 20$ cm (BL_3) and the substrates black earth, sawdust, fine sand and homogeneous mixtures (1/1) black earth/sawdust (1/1) and fine sand/sawdust (1/1) were tested. The rates of rooting and budburst of the cuttings, and the average number of roots and leaves per cutting were determined. The results show that rooting rates were higher in BL_2 (15 cm) in homogeneous mixtures and in black earth/wood sawdust ($67.4 \pm 0.10\%$). The rate of budburst was high in the homogeneous mixture of fine sand and wood shavings for BL_3 ($29.61 \pm 0.09\%$). The average number of roots formed was high in the homogeneous black earth/wood shavings mixture (16.03 ± 2.16). The highest average number of leaves formed was in the black earth substrate (11.09 ± 0.56). The fine sand substrate recorded the highest mortality rate ($20.02 \pm 2.61\%$) with BL_1 . The BL_2 cutting length and the equi-volumic mixtures of substrates improve the possibility of domesticating *Stereospermum kunthianum*.

Keywords

Phytomedicines, Domestication, Cuttings, Rooting and Budding

1. Introduction

The use of non-timber forest products (NTFPs) by local populations is significant

in Chad. The management of these products is a lucrative and socially beneficial activity, as it provides food, employment, building materials (rope and straw) and phytomedicines for the care of local populations [1]. In Chad, an estimated 70% of the populations relies on traditional plant-based medicine for primary care. This rate suggests enormous pressure on medicinal plants [2]. These needs are growing and are now a clear threat to the long-term existence of certain species, even if they can be seen at the right time at present [3] [4]. In the western Mayo Kebbi region of Chad, many of the essences are subject to pressure from alternative medicine practitioners and farmers because of their therapeutic virtues. Medicinal plant inventory work carried out in this region has classified *Securidaca longipedunculata*, *Allium sativum*, *Burkea africana* and *Stereospermum kunthianum* as those most in demand in the primary care of illnesses [5]. Reasons why plant species traditionally used by local populations for food, disease care and endangered species require special attention [3] [6] [7].

All parts of this plant are packed with therapeutic properties. This is what makes *Stereospermum kunthianum* an agroforestry species, i.e., a plant with multiple uses. The root is a powerful diuretic. It is used to treat many other ailments such as gastritis, gonorrhoea, headaches, bilharzia, hematuria, dysentery, and jaundice. The bark of the root treats snake bites. The roots combined with the leaves combat syphilis, gastritis, asthma, and headaches. The bark of the tree is hemostatic, healing, vermifuge, and treats wounds, burns, leprosy, gonorrhoea, bronchitis, pneumonia, cough, dysentery, gastritis, phagedenic ulcer, and hypertension [8] [9]. The leaves combat asthenia, wounds, and gonorrhoea. The fruits are edible and treat coughs. This plant also has properties that combat diarrhoea, dysentery, and flatulence in livestock [9] [10]. The wood is used in construction, mortar manufacturing, and toothpicks. In West Africa, the bark is used to dye lips (lipstick). Its use as firewood is often prohibited in many localities because of its magical and religious power [11].

In the Chadian pharmacopoeia, this essence is sought after for its therapeutic properties in the treatment of hypertension, wounds, leprosy, general asthenia, and poisoning [12]. Although these plants have a natural ability to regenerate, given the high demand from the population, they are unable to slow down the decline of their population in the wild on their own.

To this end, an experiment was conducted to propagate *Stereospermum kunthianum* stem segments in order to contribute to the search for new methods of propagating this species and ensure the long-term availability of specimens.

With this in mind, a trial of *Stereospermum kunthianum* stem segment cuttings was carried out in order to contribute to the search for new methods of propagating this species and guaranteeing the long-term availability of its specimen.

2. Technical Equipment for Propagation

Two propagation frames were used for this trial. Each rooting frame was 2.5 m × 1 m × 50 cm divided into 5 compartments of 1 m × 50 cm × 50 cm. Inside the

tray, a layer of gravel was placed underneath the rooting substrate. This system creates a permanently humid environment with a temperature of 27° - 31°C and adequate light for the development of cuttings. A plastic pipe about 3 cm in diameter and 20 cm long, inserted in the front corner of each compartment of the frame, is used to measure the water level in the frame on a daily basis [13]. In addition to the two frames, a plastic watering can, pruning shears, cutting hormone (AIB), sharp knife, felt and five types of substrate (black earth, fine sand, sawdust, equi-volume mixtures of substrates (20 kg) of black earth/wood sawdust and (20 kg) of fine sand/sawdust substrates) were used in this experiment. A sprayer was used to water the crop.

The cuttings were taken from adult seed trees in the wild. All the cuttings used were trimmed to the lengths to be tested, wrapped in aluminium foil and stored in a cooler to minimize water loss from the seeds. When transported to the test site, the bases of the cuttings were soaked for 5 minutes in an auxin solution called Rhizopon AA (2% indole butyric acid AIB). Once removed, the cuttings were shown in five different types of rooting substrate. The cuttings were moistened with very fine droplets of water twice a day using a sprayer. In order to protect the frames from incident light, the greenhouse was covered by a shade (Figure 1) that retains around 50% of the external illumination [14]-[16]. During this experiment, two factors were studied: the length of the cuttings and the rooting substrates.

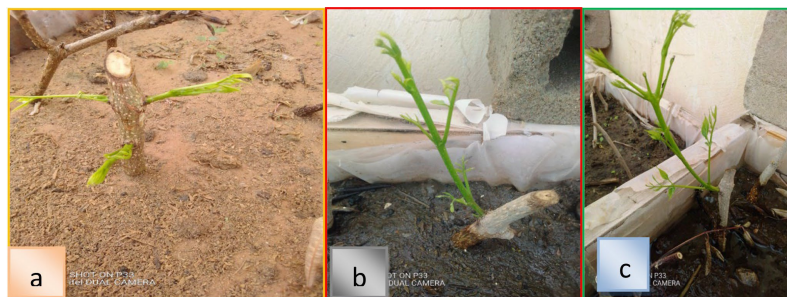


Figure 1. Ability of cuttings to form leafy axes in the distal (a), medial (b) and proximal (c) positions of the cuttings.

3. Methods

The cuttings were taken from adult seed trees in the wild. All the cuttings used were trimmed to the lengths to be tested, wrapped in aluminium foil and stored in a cooler to minimize water loss from the seeds. When transported to the test site, the bases of the cuttings were soaked for 5 minutes in an auxin solution called Rhizopon AA (2% indole butyric acid AIB). Once removed, the cuttings were shown in five different types of rooting substrate. The cuttings were moistened with very fine droplets of water twice a day using a sprayer. In order to protect the frames from incident light, the greenhouse was covered by a shade (Figure 1) that retains around 50% of the external illumination [14]-[16]. During this experiment, two factors were studied: the length of the cuttings and the

rooting substrates.

3.1. Length Testing of Cuttings

3.1.1. Pre-Treatment and Growing

The cuttings are taken and cut to the recommended dimensions: 10 cm long cuttings or BL1 cuttings class; 15 cm long cuttings or BL2 cuttings class; 20 cm long cuttings or BL3 cuttings class. The cuttings were then sown in five rooting substrates of varying nature (fine sand, black earth, sawdust, black earth/wood sawdust and fine sand/wood sawdust) contained in five compartments of the frame. The experimental unit consisted of 15 cuttings with 5 replicates, *i.e.* $15 \times 3 = 45$ cuttings in each compartment of the frame. In total, 45×5 compartments, *i.e.* 225 cuttings grown in one compartment. The experimental set-up is a randomized complete block.

Cutting parameters sought

- Rooting and budburst rates:

$$Tx = \frac{nbf}{Nt} \times 100 \quad \text{with } \mathbf{nbf}: \text{ number of cuttings that have formed leaves; } \mathbf{Nt}: \text{ total}$$

number of cuttings used

- Average number of leaves and roots formed at the end of the experiment:

$$m = \frac{nbf}{Nt} \quad \text{with } \mathbf{nbf}: \text{ number of cuttings that have formed leaves; } \mathbf{Nt}: \text{ total number}$$

of cuttings used

3.1.2. Cramer's Index

0: Indicates no effect between variables, suggesting their independence. Close to 1: Implies a strong association, with higher values denoting stronger relationships. Intermediate values: Offer a gradation of association strength, with the exact interpretation depending on your data and the context of analysis.

Cramer's V value	Significance of the effect
0.01 - 0.09	Very Small
0.10 - 0.29	Small
0.30 - 0.49	Average
0.50 - 0.69	Large
0.70 and above	Very Large

3.2. Data Collection and Analysis

Data were collected once every 3 weeks. The number of roots formed per cutting was recorded only once at the end of the experiment. The statistical analyses consisted of comparing the parameters calculated (rooting rate, bud burst rate, average number of leaves formed and average number of roots formed by seedlings). They were subjected to an analysis of variance (ANOVA) using XLSTAT 2017. Where differences existed between the different treatments, the means were separated using the Waller Duncan test at the 5% significance level.

4. Results

4.1. Effects of Substrate-Cuttings Length Interaction

4.1.1. Rooting Rate of Cuttings

Table 1 shows that the highest rooting rates were observed in homogeneous mixtures (1/1) of black earth/wood shavings ($67.4 \pm 0.10\%$) with BL₂ class cuttings (15 cm). On the other hand, the lowest rooting rate was recorded in fine sand ($17.04 \pm 0.30\%$) with BL₃ class cuttings (20 cm). Analysis of variance showed that there was a significant difference between rooting rates as a function of rooting substrate and cutting length at the 5% threshold. Rooting rates depended very strongly on the nature of the rooting substrates and the length of the cuttings (v Cramer = 0.482).

Table 1. Variation in rooting rates of cuttings according to substrate and length.

Rooting substrates	Cutting length class		
	BL ₁ = 10 cm	BL ₂ = 15 cm	BL ₃ = 20 cm
Black earth/wood sand	33.01 ± 0.10 b	67.40 ± 0.10 a	33.01 ± 0.03 b
Fine sand/wood shavings	41.06 ± 1.23 a	57.58 ± 1.14 b	42.71 ± 1.30a
Sawdust	48.70 ± 2.00a	42.03 ± 0.23 c	32.44 ± 0.10b
Fine sand	27.96 ± 0.50 b	44.89 ± 0.52 c	17.04 ± 0.30 d
Black earth	18.74 ± 0.04 c	31.91 ± 0.19 d	27.10 ± 0.11bc
P/F	0.044	0.001	0.001

a, b, c: different numbers; BL: Buttons of length L₁, L₂ and L₃; P = P-value and F = Fischer.

4.1.2. Average Root Production Per Cutting

Observation of the roots formed at the end of the experiment and after removal of the cuttings shows that the cuttings that remained alive until the end of the experiment formed roots in some cases and not in others, even though they formed leaves. **Table 2** shows that:

Table 2. Variation in the average number of roots formed per cutting as a function of substrate-length interaction.

Rooting substrates	Cutting length class		
	BL ₁ = 10 cm	BL ₂ = 15 cm	BL ₃ = 20 cm
Black earth/wood sand	13.91 ± 2.16 a	16.03 ± 2.16 a	13.54 ± 2.08 a
Fine sand/wood shavings	14.06 ± 1.83 a	15.26 ± 3.04 a	12.37 ± 1.70a
Sawdust	11.83 ± 2.02b	12.03 ± 1.24 b	12.84 ± 2.00a
Fine sand	7.96 ± 1.50 c	15.01 ± 1.5 a	9.03 ± 1.37 b
Black earth	8.74 ± 2.04 c	11.91 ± 0.96 b	9.03 ± 2.10b
P/F	0.00	0.00	0.00

a, b, c: different numbers; BL: Buttons of length L₁, L₂ and L₃; P = P-value and F = Fischer.

- The average number of roots produced by BL1 class cuttings varied from one substrate to another. The highest number was found in the homogeneous (1/1)

black earth/wood shavings mixture (13.91 ± 2.16). The lowest was recorded in the fine sand substrate (7.96 ± 1.50). Analysis of variance indicates that there was a significant difference between the means of root production by BL₁ class cuttings according to substrate ($0.00 < 5\%$). There was also a strong dependency between the interaction of substrate-length of cuttings and the improvement in the average number of roots formed by BL₁ class cuttings (v -Cramer = 0.212);

- Depending on the substrate, the BL₂ class cuttings recorded root production averages that varied according to the substrate. The highest average was recorded in the equi-volume (v/v) mixture of black earth/wood sawdust substrates (16.03 ± 2.16). The lowest was observed in the sawdust substrate (11.91 ± 0.96). At the statistical threshold of 5%, the analysis of variances shows that there was a significant difference between the means of roots formed by the bubbles according to the rooting substrate ($P = 0.00$). The dependence of the variables showed a strong link between the combination of substrates and the length of the cuttings (v -Cramer = 0.264) and the average root production. This interaction was therefore able to significantly improve root formation in BL₂ cuttings;
- In relation to the substrates, the averages of root production by the BL₃ class cuttings were variable. The highest average of roots formed was observed in the equi-volumic (v/v) mixture of black earth/wood sawdust (13.54 ± 2.08) by BL₁ cuttings, whereas the lowest was recorded in black earth (9.03 ± 1.37) with the same BL₁ cuttings. Analysis of variances at the 5% threshold shows that the difference between the means expressed by the cuttings as a function of rooting substrate is significant (0.00). The dependency between the substrate-length association and mean root production was strong (v -Cramer = 0.303). The influence of this interaction considerably boosted root formation by BL₃ class cuttings.

4.1.3. Budbreak Rate of Cuttings

Table 3 shows that budburst rates ranged from $12.41 \pm 3.33\%$ in the sawdust substrate for BL₃ class cuttings to $29.61 \pm 0.09\%$ in the homogeneous (1:1) mixture of fine sand/woodshavings substrates for BL₃ class cuttings. At the 5% probability threshold, the analysis of variances indicates that there was no significant difference between the budburst rates recorded by the cuttings in the black soil ($P = 0.0623$). However, for the same threshold, the difference was significant for all the other substrates. The dependence on substrate-length effects was weak, with Cramer's coefficient equal to 0.06.

Table 3. Variation in the budburst rate of cuttings according to length and substrate.

Rooting substrates	Cutting length class		
	BL ₁ = 10 cm	BL ₂ = 15 cm	BL ₃ = 20 cm
Black earth/wood sand	$16.10 \pm 0.36c$	$21.17 \pm 0.38c$	$19.32 \pm 4.56c$

Continued

Fine sand/wood shavings	29.61 ± 0.09a	25.58 ± 0.14a	20.36 ± 3.14b
Sawdust	17.68 ± 0.37c	21.11 ± 0.02c	12.41 ± 3.33e
Fine sand	12.41 ± 0.41d	23.42 ± 0.22b	16.24 ± 2.53d
Black earth	21.02 ± 0.22b	21.53 ± 0.04c	22.04 ± 3.12a
P/F	0.062	0.021	0.000

P: P-value; BL: length $L_1 = 10$ cm, $L_2 = 15$ cm and $L_3 = 20$ cm; Tn: black earth; Scb: sawdust and Sf: fine sand a, b, c: different numbers.

4.1.4. Average Leaf Production by Cuttings

Figure 1 illustrates the ability of cuttings to form leaves as a function of substrate. Bud formation on a cutting can be proximal (**Figure 1(a)**), intermediate or medial (**Figure 1(b)**) and distal (**Figure 1(c)**). **Table 4** shows that:

Table 4. Variation in the average number of leaves as a function of substrate and length of cuttings.

Rooting substrates	Cutting length class		
	BL ₁ = 10 cm	BL ₂ = 15 cm	BL ₃ = 20 cm
Black earth/wood sand	7.75 ± 1.62	10.42 ± 1.00 a	10.23 ± 2.04 a
Fine sand/wood shavings	6.06 ± 1.00	10.19 ± 2.52 a	9.66 ± 3.48 a
Sawdust	5.24 ± 1.44	7.47 ± 2.10 b	6.12 ± 1.45 b
Fine sand	5.62 ± 2.52	7.98 ± 1.55 b	5.63 ± 1.67 b
Black earth	7.43 ± 1.70	11.09 ± 0.56 a	6.86 ± 1.68 b
P/F	0.059	0.003	0.002

P: P-value; BL: length $L_1 = 10$ cm, $L_2 = 15$ cm and $L_3 = 20$ cm; Tn: black earth; Scb: sawdust and Sf: fine sand a, b, c: different numbers.

- BL₁ class cuttings showed leaf production averages per cutting that varied from one substrate to another. The lowest average was recorded in the sawdust substrate (5.24 ± 11.44). The best average leaf production was observed in the black earth substrate (7.43 ± 1.70). Statistical analysis of variance showed that there was no significant difference between the averages of leaves formed by the cuttings according to the substrate-length interaction at the 5% probability threshold ($p = 0.059$). The cramer coefficient was 0.56, which explains why this interaction had a weak influence on the mean of the leaves formed by the cuttings in the BL₁ class;
- BL₂ class cuttings expressed variable mean leaf numbers. The lowest average number of leaves was observed in the sawdust substrate (7.47 ± 2.1). The highest mean number of leaves was recorded in the black earth substrate (11.09 ± 0.56). The analysis of variance showed that there was a significant difference between the average number of leaves per BL₂ class cutting depending on the rooting substrate ($p = 0.003 < 0.05$). The dependency between the substrate-

length combination of the cuttings and average leaf production was moderate (v -Cramer = 0.111). This interaction improved leaf formation by BL₂ class cuttings on average;

- The BL₃ class cuttings had variable average leaf counts. The lowest average number of leaves was observed in the fine sand substrate (5.63 ± 1.67). The highest average number of leaves was observed in the homogeneous (1/1) black earth/wood shavings substrate (10.23 ± 2.04). At the 5% threshold, the difference between the mean numbers of leaves expressed by the substrate-cuttings length interaction was significant for BL₃ class cuttings. The substrate-cuttings length interaction was moderately related to leaf production by BL₃ cuttings (v -Cramer = 0.097).

4.1.5. Mortality Rate of Cuttings

The mortality rates in **Table 5** show that:

Table 5. Variation in mortality rates according to substrate and length of cuttings.

Rooting substrates	Cutting length class		
	BL ₁ = 10 cm	BL ₂ = 15 cm	BL ₃ = 20 cm
Black earth/wood sand	08.00 ± 0.10c	6.61 ± 3.30b	09.51 ± 3.13c
Fine sand/wood shavings	09.03 ± 0.09c	02.21 ± 1.02c	08.81 ± 4.01b
Sawdust	14.00 ± 1.01b	6.66 ± 4.10b	02.23 ± 2.30b
Fine sand	20.02 ± 2.61 a	11.11 ± 2.1a	11.10 ± 2.03a
Black earth	14.01 ± 0.02b	12.22 ± 1.5a	17.17 ± 5.10b
P/F	0.0011	0.010	0.003

P: P-value; BL: length L₁ = 10 cm, L₂ = 15 cm and L₃ = 20 cm; Tn: black earth; Scb: sawdust and Sf: fine sand a, b, c: different numbers.

- BL₁ class cuttings showed a variation in mortality rates depending on the substrate. Thus, the fine sand substrate recorded the highest mortality rate ($20.02 \pm 2.61\%$) and the lowest mortality rates were observed in the mixtures of black earth/wood shavings ($8.00 \pm 0.10\%$) and fine sand/wood shavings ($9.03 \pm 0.09\%$). Analyses of variance showed that there was a significant difference between the mortality rates of BL₁ class cuttings according to rooting substrate ($0.0011 < 5\%$). There was a strong correlation between the combination of substrates and lengths and the mortality rates of the cuttings. This combination therefore had a positive effect on the mortality of BL₁ class cuttings;
- The BL₂ class cuttings recorded mortality rates that varied according to the rooting substrates. These percentages ranged from $2.2 \pm 1.02\%$ in the homogeneous mixture of fine sand/wood shavings substrates to $12.22 \pm 1.5\%$ in the black earth substrate. At the 5% threshold, the difference in variances was significant ($P = 0.010$). Cramer's coefficient (0.169) indicates that there was a moderate relationship between the BL₂ class substrate-cuttings association. This interaction therefore had a moderate influence on the mortality of cut-

tings of length L_2 ;

- The BL_3 class cuttings showed mortality rates ranging from $2.23 \pm 1.30\%$ in the sawdust substrate to $17.17 \pm 5.10\%$ in the black earth substrate. Analyses of variance at the 5% probability level showed a significant difference between the mortality rates of BL_3 class cuttings depending on the rooting substrate ($P = 0.003$). Given that v -Cramer = 0.289, the link between substrates and BL_3 class cuttings was strong. This association had a considerable influence on the mortality of BL_3 class cuttings.

4.2. Effects of Substrates on the Development of Cuttings

4.2.1. Fine Sand

Figure 2 shows the formation of a pale-green axillary bud from the central wood of the stem (pith) at the apical section. The curled leaves are supported by petioles that are more robust than those of ordinary axillary buds.

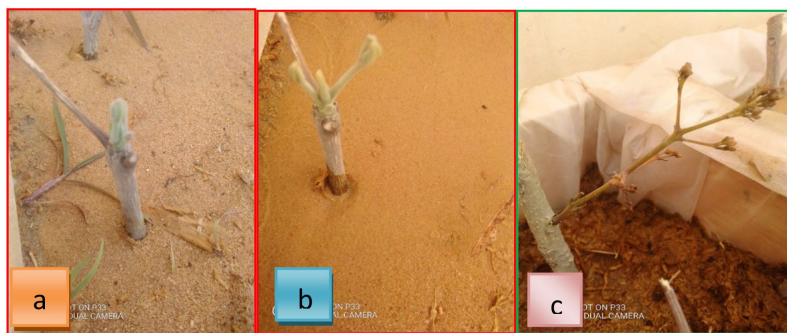


Figure 2. Bud formation on the apical section of a cutting (a and b) and of an inflorescence (c).

4.2.2. Sawdust

The success of budding of cuttings according to length in the sawdust substrate can be seen in the images in **Figure 2**. Axillary bud formation was essentially distal in cuttings of all lengths. Some cuttings formed only one or several buds (a) and others only one or several inflorescences (b).

4.2.3. Fine Sand/Wood Shavings (v/v)

The behaviour of the cuttings in the equi-volume (v/v) mixture of fine sand/wood shavings substrates varied from one cutting to another. Cuttings from the same source (same seed company) produced buds in some cases and inflorescences in others. Flower buds were the first to form (21 days after planting). However, the first bud buds were observed 24 days after planting. Flower formation did not take into account the length of the cutting and their position on the cutting was varied, *i.e.* distal, medial and proximal.

5. Discussion

The success rate of stem cuttings in *Stereospermum kunthianum* was relatively better in all rooting substrates for both long and short lengths. The best perfor-

mance was observed in the BL₂ range of cuttings ($67.40 \pm 0.10\%$) in the equi-volumic black earth/woodsilver mixture for rooting rates. This result can be explained by the maturity, water status and nutritional potential of the cuttings at the time of planting [17]. This is consistent with the results obtained by [15] for *Vitex doniana* and *Lophira lanceolata*. The success of rigid and lignified cuttings was also observed by [18] on *Piliostigma reticulatum*. The failure of young shoots to take cuttings was due to the fact that they do not contain sufficient nutrient reserves. All the substrates showed their performance in rooting stem segment cuttings as a function of length. The mixtures of substrates, black earth/wood sawdust and fine sand/wood sawdust were more favourable and showed higher rates in morphological parameters such as bud break (97%) and average number of roots formed (79%). On the other hand, the fine sand (2%) and black earth (6%) substrates were unfavourable for testing. These results are contrary to those of *Vitex doniana* obtained from [15], which showed better performance with the latter 2 substrates. The difference in percentages is thought to be due to the quantity and quality of the nutrients available in the substrates and the number of roots that each cutting was able to form to ensure its nourishment.

Stem cuttings of *S. kunthianum* harvested on the same day and from the same seedbed evolved in different ways. Some formed axillary buds, while others formed inflorescences that produced flowers. The formation of inflorescences by the cuttings could be explained by the manifestation of the genetic expression of the vegetative cycle already underway when the cuttings were harvested [19]. This result could promote the rapid spread of this species and, above all, early fruiting. And since the fruits are used as fodder and cough medicine, this cultivation method could be a source of raw material production in traditional medicine and herbivore farming [20]. Identical observations were made on *Vitex Doniana* and *Ximenia americana* cuttings by [15]. Cuttings of *Stereospermum kunthianum* can form the buds that evolve into a terminal bud from the apical section and this is what is unusual. This phenomenon can be explained by the position of the section just above a node on the cutting where the waiting meristem zone is located and where the trauma of sectioning could have triggered its functioning [21].

Average mortality rates showed that *Stereospermum kunthianum* cuttings died more in the fine sand and black soil than in the sawdust substrate and the homogeneous fine sand/woodsawdust mixture. Cuttings of length L₁ showed the highest mortality rate compared with cuttings of length L₃ and L₂. The lowest mortality rates were recorded for cuttings of lengths L₂ and L₃. Successful rooting of cuttings depends not only on substrates but also, essentially, on water content and water potential, which vary according to size, storage method and storage time [22].

6. Conclusion

This study investigated the effects of cuttings length and substrate type on vegetative regeneration of *Stereospermum kunthianum* stem segments. The results obtained show that this species is suitable for vegetative propagation. Cuttings 15

cm long sown on a mixture of black earth/wood sawdust substrates gave the best rooting rates and average number of roots for stems cuttings. Cuttings of length $L_1 = 10$ cm planted on the mixture of fine sand/wood shavings showed the best rates of cuttings budding and average number of leaves formed per cutting. Cutting lengths of 10 and 15 cm and substrate mixes are indicated for *S. kunthianum* cuttings. This method would make it possible to domesticate this species and prevent its natural population from dwindling.

Authors' Contributions

The authors of the article were all active in the production of the manuscript. BT was responsible for the testing and writing, and MH was responsible for the statistical analysis of the data. Finally, the manuscript was read by BN.

Conflicts of Interest

The authors declare that the article is not subject to any conflict of interest or competition.

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