Article submitted on: 30/12/2022
Revised form accepted on: 16/06/2023
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Revue Nature et Technologie
http://www.univ-chlef.dz/revuenatec

ISSN: 1112-9778 – EISSN: 2437-0312

Air layering of three agroforestry species in the Guinean savannah highlands of Adamawa in Cameroon

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Abstract

Ximenia americana, *Vitex doniana* and *Lophira lanceolata* are species prized by the populations of the Guinean savannah highlands of Cameroon. They are unfortunately still in the wild where they are subjected to various pressures. From the perspective of the conservation and enhancement of local biodiversity, their domestication appears necessary. The objective of the work is to study the vegetative propagation by air layering of these fruit trees. The experimental device used is a split-split-plot with three repetitions. Species represents the main treatment; the substrates constitute the secondary treatment while the covering of the layers with aluminum foil represents the tertiary treatment. The experimental unit was 30 layers. The rooting rate of layers varies significantly (0.000<0.001) from 48.88±1.89% in *Ximenia americana* to 81.38±2.08% in *Lophira lanceolata.* Sphagnum was the best substrate with 69.63±1.38% against 61.66±1.54% for the black soil-sawdust mixture. The analysis of variance reveals a significant difference for the substrates (0.0025<0.01). Covering the layers with aluminum foil presented a rate of 69.44±2.15% while the uncovered layers presented 61.85±1.54%, the analysis of variance shows a significant difference (0,0031<0.01). *Lophira lanceolata* exhibited the best air layering ability; the rooted layers were weaned and acclimatized for two months before being transferred to the field. During this process 19% and 52% respectively of the layers of *Vitex doniana* and *Ximenia americana* flowered. This inexpensive technique is an essential step in the process of their domestication.

Keywords: *Vitex doniana*, *Lophira lanceolata*, *Ximenia americana*, air layering, acclimatization, domestication, Guinean savannah highlands.

1. Introduction

The tropical world in general and sub-Saharan Africa in particular is facing rapid population growth. This situation is at the origin of the considerable pressures observed on natural resources [1]. These anthropogenic pressures (harvesting of firewood, overgrazing, bush fires, etc.) have greatly contributed to the degradation of forest cover [2]. These pressures result in the disappearance at a worrying rate of natural forest areas, the corollary of which is the scarcity of non-timber forest products [3]. Wild fruit trees play an important role in improving the living conditions of populations. They have a certain food and economic potential [4]. In developing countries, farmers mostly depend on non-timber forest products [5, 4]. These products make it possible to maintain household food security and substantially improve the standard of living of families. Seeds of *V. doniana* exhibit integumentary dormancy [6]. Regeneration in the natural conditions of the Guinean savannah highlands of *L. lanceolata*, *V. doniana* and *X. americana* is difficult because of bush fires and cattle browsing. The wood of the three species is used in the production of charcoal and the manufacture of handicraft. The fruits of these species are edible. Despite the importance of these indigenous fruit trees in the daily diet of farmers, they still live in the wild and therefore are subject to various pressures. It seems appropriate to domesticate them and introduce them into existing agroforestry systems so that farmers can continue to derive greater benefit from them. To achieve these objectives of domestication and reintroduction of these woody species of socio-economic interest, it is necessary to use multiplication techniques adapted to the context [7]. Asexual propagation by air layering is a possible alternative that is insufficiently exploited in the Guinean savannah highlands of Cameroon. This technique of asexual propagation has real comparative advantages and in particular the possibility of theoretically producing in an unlimited way, true genetic copies of the initial mother plant presenting the same assets in similar environmental conditions: the organoleptic quality of the fruit, the size of the fruit, the thickness of the bark, the density of the foliage, etc., are all characteristics valued by the local populations. Moreover, depending on the techniques used, these clones produced often benefit from much greater vigor and a much shorter time to fruition than plants of the same species from seedlings [7, 8]. The objective of this work was to study the vegetative propagation by air layering of three fruit trees providing non-timber forest products, in order to integrate them into existing peasant farming systems.

2. Materials and Methods

2.1. Description of the study site

The investigations were carried out in the Guinean savannah highlands of Bini-Dang (LN: 7°24'; LE: 13°32'; Alt: 1079 m) (Figure 1). The climate is of the Sudano-Guinean type with two seasons including a rainy season from April to October and a dry season from November to March. The monthly average precipitation is 105.75mm, the monthly average temperature is 22.32°C, the monthly relative humidity is 66.95% and the monthly evaporation is 164.47mm. Two main winds blow in the region, notably the monsoon during the rainy season from the south and the harmattan from the north, which is responsible for the drought. The vegetation is diverse. It is composed, among other things, of meadows, grassy savannahs, shrubby and woody savannahs. This shrubby and/or woody savannah is marked by the predominance of *Daniellia oliveri* and *Lophira lanceolata*. The density of these species has fallen sharply under the influence of various anthropogenic actions [9]. The local population is made up of herders (Bororo and Peulh) and farmers (Mboum, Dii and Gbaya). Agriculture and breeding occupy a prominent place in the region.

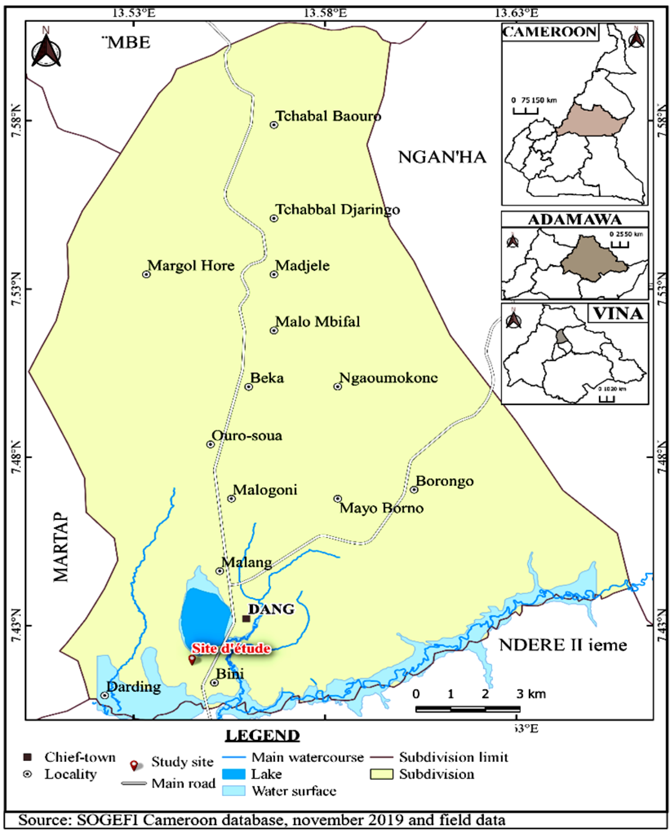


Figure 1: Location map of the study site

2.2. Methodology

The laying of the ducts took place at the beginning of the rainy season (May) and the monitoring of the field test lasted 7 months. Using a sharp knife, rings were made on the orthotropic branches 2.36 to 5.14 cm in diameter. Girdling the branch consisted of removing the bark over a length of 6 to 7 cm [10]. Then the cambium was well scraped and the bast well removed in order to stop the flow of descending elaborate sap. The bead of the substrate is held around the incised area using a transparent polyethylene film and firmly tied at the ends with a string. Half of the sheaths of each substrate were covered with aluminum foil which was well tied at the ends to protect the layer from excessive temperatures in the event of direct sunlight.

Each sheath laid bears the following inscriptions allowing the type of layer to be easily identified: date; name of the species; nature of the substrate and sheath number. The experimental protocol involved two types of substrates (the black soil-sawdust mixture in which the sawdust is previously decomposed in the respective proportions of 1/3 and 2/3 and the sphagnum). The follow-up of the test was done once a month and the watering of the sleeves was done using a 10ml syringe. Rooted layers were weaned seven months after sleeve placement and then transferred to the nursery for acclimatization. Acclimatization consisted of putting them in 12 cm×20 cm pots with topsoil and then they were introduced into the rehabilitation propagator for 6 weeks; they were taken out to spend 2 weeks under the propagation shed before being transferred definitively to the fields.

The experimental device used was a split-split-plot with three repetitions. The species constitute the main treatment; the substrates represent the secondary treatment while the covering of the sheath with aluminum foil constitutes the tertiary treatment. The experimental unit consists of 30 layers. A total of 1080 layers (30×3×3×2×2) are laid for the three species.

2.3. Data collection and analysis

The data collected related to the number of rooted layers. Data analysis is about variance. The separation of significant means was done using the Duncan Multiple range test. The statistical program used was Statgraphics plus 5.0

3. Results

3.1. Effect of species

The rooting rate seven months after experimentation varies from 48.88% in *Ximenia americana* to 81.66% in *Lophira lanceolata*. In the three species, the rooting time for layers varies from 1 month for *Lophira lanceolata* to 2 months for *Vitex doniana* and *Ximenia americana* (Figure 2). The rooting rate is increasing for five months and stabilizes from the sixth month in the species. Species analysis of variance shows a significant difference (0.000<0.001).

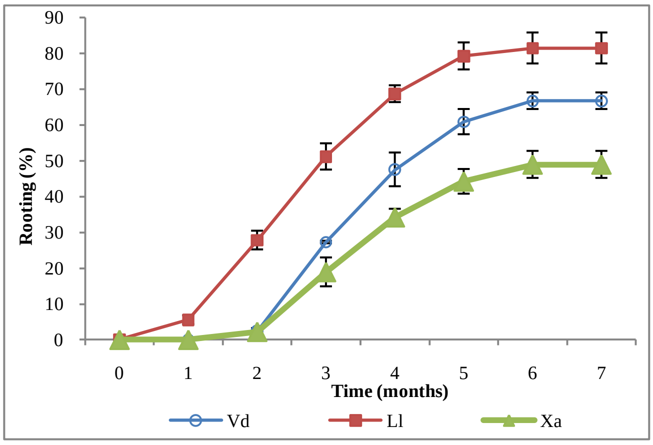
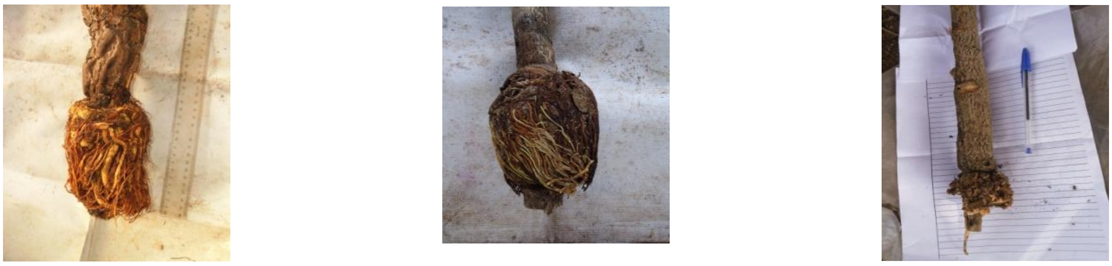


Figure 2: Variation in the rooting rate of layers in the three species as a function of time.
Legend: Vd: *Vitex doniana*; L1: Lophira *lanceolata*; Xa: *Ximenia americana*

The rooted layers of *L. lanceolata* and *V. doniana* develop a dense root network unlike those of *X. americana* (Figure 3).



L. lanceolata *V. doniana* *X. americana*

Figure 3: Rooted layers after 7 months in *L. lanceolata V. doniana* and *X. americana*

3.2. Influence of the substrate

The average rate of rooting of layers at the end of the test (7 months) after laying the sheaths varies from 61.66% for the black earth-sawdust mixture to 69.66% for the sphagnum (Figure 4). The analysis of variance indicates a significant difference between the different substrates (0.0025<0.01).

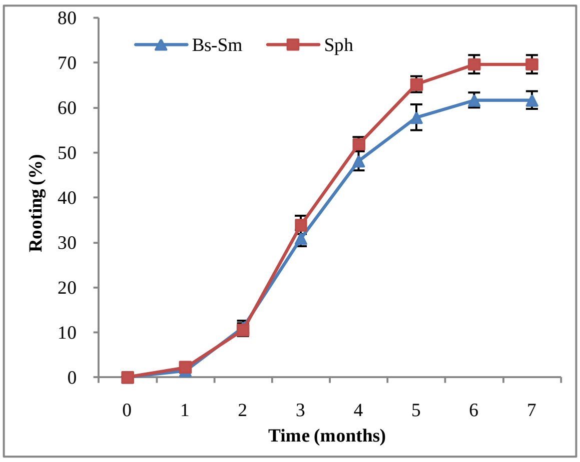


Figure 4: Variation in the rooting rate of layering in sphagnum (Sph) and the black soil-sawdust (Bs-Sm) mixture.

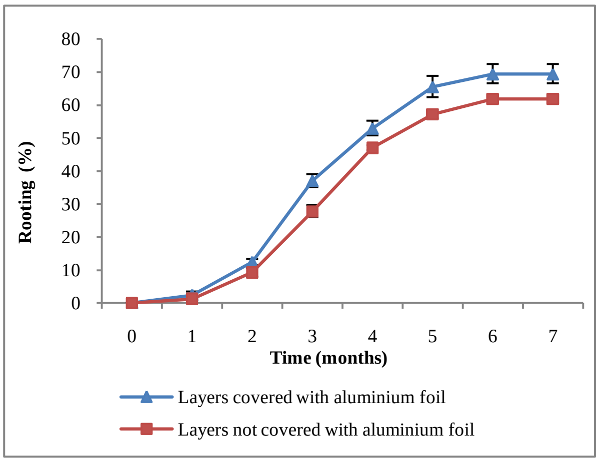


Figure 5: Variation in rooting rate depending on layer exposure mode

3.3. Influence of exposure mode

Seven months after installation, the rooting rate of layers varies from 61.85% for unprotected layers to 69.44% for those covered with aluminum foil (Figure 5). Aluminum foil has this ability to keep moisture in the sleeves. Statistical analysis shows that the sleeve exposure effect is significant (0.0031<0.01). The layers began to emit roots from the first month, mainly in the layers wrapped in aluminum foil.

The rooted layers of each species were weaned seven months after laying the sleeves and acclimatized for six weeks in the rehabilitation propagator and two weeks under the shed before being transferred definitively to the field. During this process 19% and 52% respectively of *V. doniana* and *X. americana* layers flowered (Figure 6) but did not fruit.

L. lanceolata

V. doniana

X. americana

Figure 6: Weaned and acclimatized layers of: *L. lanceolata*; *V. doniana* showing flowers; *X. americana* bearing flowers.

3.4. Species by substrate interaction

The rate of rooting of layers varies between (45.18±1.48) percent in layers of *X. americana* in the black soil-sawdust mixture to (82.22±1.98) % in *L. lanceolata* in the substrate based on sphagnum (Table 1). The analysis of variance shows that the species by substrate interaction is significant (0.0249<0.05). The rooting of layers of each species varies from one substrate to another.

Table 1
Percentage of the rooting rate of layers according to substrates and species

Substrate	*X. americana*	*L. lanceolata*	*V. doniana*	Means
Sphagnum (%)	53.52±1.61^{c}	82.22±1.98^{a}	73.88±2.13^{b}	**69.87±1.90**
Black soil-sawdust mixture (%)	45.18±1.48^{c}	80.92±1.77^{ab}	58.88±1.74^{c}	**61.66±1.66**
Means	**49.35±1.54**	**81.57±1.87**	**66.38±1.93**	**65.76±1.78**

Means followed by the same letter are statistically identical (p<0.05).

3.5. Species by exposure mode interaction

The rooting rate of unprotected *X. americana* layers is lower (43.33±1.48%) than that of *L. lanceolata* layers covered with aluminum foil (84.81±2.98%) as reported in table 2. The species by mode exposure interaction is not significant (0.1381>0.05), although the paper stimulated rooting.

Table 2
Percentage of rooting of layers according to species and mode of exposure

Mode of exposure	*X. americana*	*L. lanceolata*	*V. doniana*	Means
Layers not covered with aluminum foil (%)	43.33±1.48	78.33±2.1	64.07±1.97	**61.91±1.85**
Layers covered with aluminum foil (%)	55.37±1.61	84.81±2.98	68.70±1.69	**69.62±2.09**
Means	**49.35±1.54**	**81.57±2.54**	**66.38±1.82**	**65.76±1.97**

3.6. Substrate by exposure mode interaction

The rooting percentage fluctuates between 58.79±1.21% in layers based on the unprotected black earth-sawdust mixture and 74.69±1.96% for layers with sphagnum moss substrate and protected by paper aluminum (Table 3). Despite the variation observed, there is no significant difference for the substrate and the mode of exposure interaction (0.1893>0.05). Generally speaking, sphagnum has a high rooting rate.

Table 3
Percentage of the rooting rate of layers according to the substrates and the mode of exposure

Mode of exposure	Bs-Sm	Sph	Means
Layers not covered with aluminum foil (%)	58.76±1.21	65.06±1.67	**61.91±1.44**
Layers covered with aluminum foil (%)	64.56±1.89	74.69±1.96	**69.62±1.92**
Means	**61.66±1.55**	**69.87±1.81**	**65.76±1.68**

Bs-Sm: Black soil–Sawdust mixture; Sph: Sphagnum

3.7. Species*substrates*exposure mode interaction

The rooting rate of the layers varies from 37.77±5.38% in the black earth-sawdust mixture in *X. americana* to 57.78±2.78% for the sphagnum-based layers protected by aluminum foil (Figure 7). In general, layers treated with sphagnum moss and protected from bad weather have a high rooting rate regardless of the species. However, the species*substrate*mode of exposure interaction is not significant (0.0937>0.05).

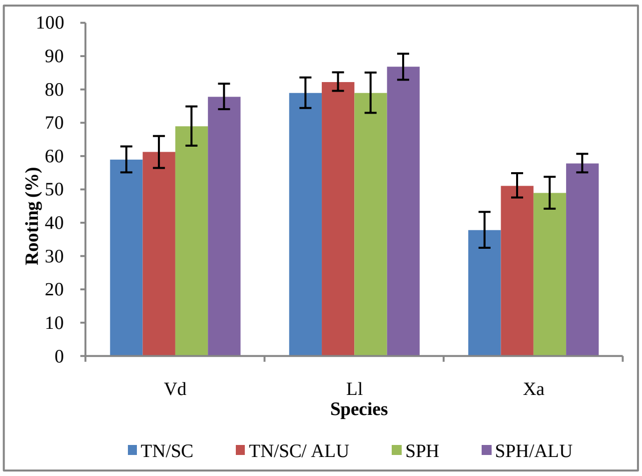


Figure 7: Rooting rate of layering according to treatment and species. Legend: *V. doniana* (Vd); *L. lanceolata* (L1); *X. americana* (Xa); Sphagnum (SPH); Sphagnum moss wrapped by aluminum foil (SPH/ALU); Black earth-sawdust (TN/SC); Earth-sawdust-wrapped by aluminum foil (TN/SC/ALU).

4. Discussion

Air layering is a low-cost vegetative propagation technique which is useful for populations in tropical areas who wish to reproduce identically a tree selected for its uses. It is an easily reproducible technique, which does not require expensive inputs, special knowledge or long training. This technique provides agroforestry and rural populations with plants that grow faster and mature earlier, which shortens the return on investment [11]. In Central and West Africa, air layering is used for the domestication of many agroforestry species of socio-economic interest [12]. Air layering of these species shows that it is possible to mass produce plants at a lower cost, within a relatively short period of 9 months. This result confirms that reported by [7, 13] and [14] who showed that air layering allows the production of plants in a short time, while keeping all the genotypic characteristics of the mother plant. Numerous air layering trials have yielded considerable results; this is the case for *Prunus azorica* which presented 100% rooting [15], *Balanites aegyptiaca* with a success rate of 95% [16] and *Coula edulis* with a rooting percentage of 48% [17]. Previous work which focused on the propagation by air layering of these three species made it possible to highlight the diameter and the rigidity of the branches which were the subject of air layering; the results obtained in this study presented rooting rates of 13.5% for *Ximenia americana*, 55.85% for *Lophira lanceolata* and 16.44% for *Vitex doniana* [18]. The laying of the sleeves for the present study took place at the beginning of the rainy season. Several authors like [9, 13, 14] show that the period of installation of the sleeves would have a significant effect on the rhizogenesis in certain species. Air layering of *Balanites aegyptiaca* in Cameroon was carried out in October (end of the rainy season and beginning of the dry season) with a success rate of 95% [16]. According to [13] the dry season is not the favorable period for carrying out air layering, it would inhibit the development of the rooting of layers. Several factors endogenous and exogenous to the species could influence the rooting of layers; this is how [19] claim that the difference in behavior may be related to the physiological state of the tree when the sleeve was placed. Layers covered with aluminum foil in *Anacardium occidentale* yielded a rooting rate of 99.44±1.66% [20].

The present study revealed that the use of sphagnum moss and the covering of sleeves with aluminum foil significantly affect the rooting of layers. These results confirm those of [21, 22] who showed that sphagnum is the best rooting substrate for layers respectively in *Vitellaria paradoxa* and *Fagraea auriculatum*. Air layering studies performed on *Berlinia grandiflora* have shown sphagnum to be the best rooting substrate in this species [23], which could be explained by the fact that sphagnum has this ability to maintain humidity in the substrate.

The layers were weaned after seven months and acclimatized for two months then transferred to the field to study their behavior in order to measure the time required to reach reproductive maturity. The production of a dense root bundle of the layers guaranteed the success of their transplanting in the field. The work of [22, 23] showed that the first weaning of *Dacryodes edulis* layers occurs five months after the sleeves have been placed. While [24] on the same species showed that weaning was carried out 3 months after laying the sleeves on the 10-year-old clones.

5. Conclusion

The three agroforestry species that were studied showed an aptitude for air layering. Sphagnum was found to be the best rooting substrate for all three species. Covering the sleeves with aluminum foil stimulated the rooting of layering. Air layering of these species shows that it is possible to massively produce seedlings of these species at a lower cost, in a relatively short time. This multiplication technique presented a promising result in the three species, which opens up interesting prospects for the domestication of the species. The introduction of these species into existing agroforestry systems of plants from air layering is therefore possible. The rooting rate of each species could be improved insofar as additional studies are carried out on the influence of the season, the position of the layer in the tuft, the position of the layer on the branch but also on other propagation techniques such as suckering, cuttings and grafting.

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