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Effect of different growth media on sprouting and early growth of cutting-propagated *Cordiaafricana* (Lam.)

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***Abstract*—** *Cordiaafricana(Lam.)is an economically and ecologically important component tree species of the Bamenda Highlands Forest which is under threat from over-exploitation. There is a need to develop high quality planting stock for increased availability and sustainability of the species. A study was carried out at the National Forestry Development Agency (ANAFOR) in Bamenda, North West of Cameroon, to evaluate the effect ofgrowth medium on sprouting and growth of vegetatively propagated C.africana(Lam.). Hardwood cuttings from lower branches of trees were grown in sand, sawdust, and a 1:1 sand: sawdust mixture in a non-mist propagator for three months. Data on percentage sprouting, days to sprouting, number of shoots, shoot height, stem diameter, stem volume, number of leaves, leaf length, leaf width, and leaf area were subjected to analysis of variance(ANOVA) and Scheffé's multiple means comparison test at 5% level of probability. While sawdust significantly reduced values of all the plant traits, no significant differences were detected between sand and the sand: sawdust mixture. The results show that sand and 1:1 sawdust: sand are suitable alternatives for propagation of C. africana(Lam.)from branch cuttings.*

Keywords—Cordiaafricana(Lam.), morphology, non-mist propagator, sprouting, substrate.

I. INTRODUCTION

Cordiaafricana (Lam.) (synomyms:*C. abyssinica*,*C. holstii*,*C. ubanghensis*,*C. sebestena*, *Varroniaabyssinica*, *Calyptracordiaabyssinica*) is a tree of the family Boraginaceae (FAO, 2007). It is commonly known as Sudan teak, East African cordia or large-leavedcordia (Wiersema and León 2016). It occurs at elevations of 550 to 2700 m, butgrows best between 1700 and 2300 m (FAO, 2007). The tree attains a height and diameter of up 30 m and90 cm, respectively (Obeng, 2010).This multipurpose early successional tree is an important component of the Western Highlands forest of Cameroon. It is a highly valued timber species. The moderately hard nature of its durable wood makes it good for construction and production of high quality furniture and household materials (Alemayehu et al., 2016). It is the preferred material for artisanal woodcarving, an important income generating activity for indigenous peoples of the Western and North West Regions of Cameroon. In addition, *C. africana*(Lam.) is a good source of medicine (Teklay, 2013), food, fodder, fuel wood, bee forage(Alemayehu et al., 2016).The tree is also known to improve soil fertility and water conservation (Raga and Denu 2017).In Cameroon, populations and habitats of *C. africana*(Lam.) are under threat of deforestation, fragmentation and exploitation driven by human population growth and agricultural activities. Considering the importance of this tree species, there is a need to ensure its continuous propagation and conservation.

Propagation of *C.africana*(Lam.) can be achieved by sexual and asexual means. However,the seeds displayslow and uneven germination(Maunduet al., 2005), making vegetative propagation useful alternative for its regeneration. The latter technique has the ability to shorten the long production cycle of a tree (Rana and Sood 2012) like *C. africana* (Lam.), and offset the imbalance that exists between the demand for and declining supply of its timber, timber products, and benefits.Also given that the exact copy of a mother plant is produced in vegetative propagation, the method provides a practical means by which desirable traits of the tree can be preserved (Santoso and Parwata 2014) which may otherwise get lost or diluted during sexual propagation.

Stem cuttingis the most common of vegetative propagation methods which iswidely used for woody plants due to low cost (Waziri et al., 2015) and the ease (Dawa et al., 2017) with which it is performed(Alikhani et al., 2011).Success of

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cutting propagation is affected by many endogenous and exogenous factors including ortetage (Ambebe et al., 2017), growth medium (Ashiono et al., 2017), type of cutting (Washa, 2014), plant hormones (Bhardwaj et al., 2017), plant species, health of source plant, size of cutting,and environmental conditions(Kramer and Kozlowski 2014). Furthermore, the responsesof cuttings to some of these variables are dependent onthe plant species (Hassanein, 2013). With the exception of ortet age (Ambebe et al., 2017), the effects of these factors on the propagation of cuttings of *C. africana*(Lam.) have not been investigated. The knowledge gaphas made it difficult to develop reliable silvi cultural technique for regeneration of the species.

A variety of growth media are used in the production of woody plants; in developing countries, however, they are mainly sawdust, sand, soil, manure and mixtures of these in various proportions. Essentially, a growth medium should provide the basic necessities for the establishment and early growth of cuttings (Shah et al., 2006). Furthermore, early growth parameters are good predictors of plant performance in the long term. For instance, initial height is to reflect subsequent height and overall growth (Schmidt-Vogt, 1981; South et al., 2005) even after 40 years (Poykko, 1981) in the field. Consequently, the successful conservation of *C. africana*(Lam.) will to a large extent depend on the identification of a suitable growth medium for its propagation. In this study, branch cuttings of *C. africana* (Lam.) were grown in three of the commonly used growth media with the objective to determine the most suitable for the establishment and early growth of the species.

II. MATERIALSAND METHODS

2.1 Site of cuttings collection

Material for vegetative propagation was collected from Big Babanki (latitude 6.12° N, longitude 10.25° E; altitude: 1177 m above sea level). The village is located north of Bamenda (latitude 5.95° N, longitude 10.14° E; altitude: 1258 m above sea level), the capital of the North West Region of Cameroon. Thearea is characterized by a rainy and a dry season, with extreme seasonal variations in monthly rainfall (Weather Spark, 2018).In 2017 when the experiment was conducted, the least amount of rain(6.5 mm) was recorded in January whereas the rainiest month was September with 719.9 mm (World Weather Online, 2018). The minimum monthly temperature in the course of the year was 16° C and the maximum was33° C. In the month of July 2017 when the cuttings were collected, the mean temperature and rainfall were 23° C and 448.1 mm, respectively (World Weather Online, 2018).

2.2 Experimental design

Treatments comprised of river sand, sawdust, and a sand: sawdust (1:1 v/v) mixture in three replications. Fifteen mature trees were selected from disturbed forest patches in Big Babankito be donors of planting material. Nine hardwood cuttings were randomly harvested from vigorous branches at the lower quadrant of the canopy of each tree. The cuttings from all the trees were put together, maintained in humid condition by sealing in an air-tight polythene bag and transported to the North West regional headquarter of ANAFOR in Bamenda. The study was conducted in a non-mistpropagator (Leakey,1990)made up of three chambers. Each chamber was subdivided into three subunits in which the three growth media were randomly assigned. A hole was prepared in the growth media for each cutting using a wooden dipper to save the base of the cutting from injury during planting. The cuttings were severed to a length of 12 cm with about the same diameter and set to a depth of 2 cm. There were fifteen cuttings in each subunit, making a total of 135 cuttings for the trial. Irrigation was done by providing water through PVC tubes that went through the layer of growth media into an underlying water table made up of successive layers of fine sand, stones, and gravel. Each of the tubes had a marking which indicated the water status of the propagator and from which could be determined when irrigation should be done. During irrigation, the water was allowed to fill up the water table up to the level of the gravel layer so that the growth medium was kept moist. The propagator was situated in a shade house roofed with alternating rows of transparent plastic and corrugated iron roofing sheets. The experiment started on July 1and ended on September 29, 2017.

2.3 Data collection

The cuttings were monitored for flushing daily. Flushing was considered to occur for a growth medium treatment in a chamber when 50% of the cuttings had done so. Number of days to flushing for the growth medium was then taken to be the average for the three chambers. Percent sprouting was calculated using the following formula:

$$\text{Percent sprouting} = \frac{\text{Number of cuttings sprouted}}{\text{Number of cuttings planted}} \times 100$$

At the end of the experiment, five cuttings were randomly chosen from each chamber and growth medium, and the number of shoots per cutting was recorded. Height (H)and stem diameter (D)of the dominant shoot were measured with a ruler and caliper, respectively, and stem volume (D^2H)(Aphalo and Rikala 2003)was computed. The number of leaves, and the length and width of the most widely expanded leaf per plant were determined. In the measurement of leaf dimensions, leaf length (LL) was considered to be the axis from the upper edge of the leaf to

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the lowest point while leaf width (LW) was taken as the widest region across the lamina perpendicular to the length. Leaf area (LA) was calculated using the following equation of Mosissa and Toru (2016):

LA = LL×LW×LACF

where LACF is Leaf Area Correction Factor with the value 0.67.

2.4 Data analysis

All the data were subjected to analysis of variance (ANOVA) untransformed after examining them for normality of distribution and homogeneity of variance. Separation of means for significant effects of treatments was conducted with Scheffe's F-test. All the analyses were performed using Data Desk 6.01 at $\alpha = 0.05$.

III. RESULTS

There was a significant effect of growth medium on all the parameters investigated (Table 1). Sawdust significantly reduced percent sprouting, number of shoots (Table 2); plant height, stem diameter, stem volume (Table 3); leaf length, leaf width, and leaf area (Table 4). Additionally, number of days to sprouting was highest in this growth medium (Table 2). In contrast, no significant differences were detected between sand and the 1:1 sand:sawdust mixture for any of the traits (Tables 2 – 4).In general, there was no significant effect of replication or replication-related interaction on any parameter (Table 1).

IV. DISCUSSION

The results of the present study show that growth medium is an important factor influencing the propagation of *C. africana* (Lam.) via branch cuttings. In addition, they corroborate the conclusion of Khayyat et al. (2007) that type of medium is an important determinant of the quality of rooted cuttings. The finding that the overall performance of the cuttings was least in sawdust is supported by the results of other studies. For instance, Ofodile et al. (2013) recorded the highest number of days to flushing and the lowest number of leaves of *Gongromenalatifolia* stem cuttings on sawdust in an experiment that involved three other growth media (sharp sand, topsoil, sharp sand/topsil/sawdust).Adverse effects of sawdust on sprouting (%) of *Massulariaacuminata* (Usman and Akinyele 2015), leaf length of *Ficusbinnendijkii* (Shah et al., 2006), leaf area of *Irvingiawombolu* (Dolor, 2011), plant height of *Helianthus annuus* (Yerima et al., 2015), diameter and biomass of *Eucalyptus saligna* (Ashiono et al., 2017), and rooting of *Ricinodendronheudelotti*(Tchinda et al., 2013) have also been reported. On the other hand, beneficial effects of either sand alone or in combination with sawdust on sprouting of *Warburgiaugandensis* (Akwatulira et al., 2011) and *M. acuminata* (Usman and Akinyele 2015), time to foliage production and number of leaves of *G. latifolia* (Ofodile et al., 2013), and stem length and number of leaves of *Ficushawaii* (Hassanein, 2013) asobserved in previous studies are consistent with the current dataon*C. africana*.

The variability in response are likely related to differences in physical properties of the growth media (Khayyat et al., 2007) upon which the supply of air and water to the growing plant depends (Baiyeri, 2005). Water can present a major barrier to the diffusion of oxygen so that excess water may result in anoxia at the base of the cutting (Loach, 1986).Sawdust exhibited a lower need for irrigation than sand or sand:sawdust throughout the experimental period suggesting that it retained most of the water that was supplied to it. The potential for this growth medium to retain large amounts of water at the expense of plant growth and survival has been demonstrated by Ofodile et al. (2013) and Caspa et al. (2014). In contrast, the rapid growth in the other two treatments demonstrates the potential of sand as a growth medium when used alone or when mixed with other materials. It seems probable that sand has the properties of an appropriate growth medium as one with an optimal volume of gas-filed pore space and an oxygen diffusion rate that allows proper respiration to maintain root uptake of belowground resources (Fonteno and Nelson 1990).High aeration in a growth medium is of particular importantin promoting metabolic activities and enhancing root initiation (Yeboah and Amoah 2009).In line with the work of Waziri et al. (2015),the positive impact of the sand-based media on sprouting, number of leaves, plant height, diameter, and leaf size observed in this study was likely due to easy translocation of water and nutrients to the aboveground parts of the cuttings aided by the higher potential for root growth and function. This assertion is, however, speculative because a slow rooting capacity of *C. Africana* cuttings made it difficult to collect meaningful data on root traits within the three months duration of this study.

V. CONCLUSION

In this study, growth characteristics of *Cordiaafricana* (Lam.)differed according to the growth media. Sand and sand: sawdust mixture in the ratio of 1:1 resulted in earlier sprouting of cuttings and greater growth of plants than sawdust, an indication that the sand-based media are suitable alternatives for raising plants from hardwood cuttings. Given that abiotic and biotic factors often interact with each other to produce effects that may or may not be additive(van Heerden and Yanai 1995), it will be necessary to investigate the combined effects of growth media and

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other factors such as cutting length and environmental conditions to optimize the growth performance of *C. africana* (Lam.).

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Table.1: Summary of the analysis of variance (ANOVA) for the effect of growth medium (GM) on sprouting and growth of hardwood cuttings of Cordiaafricana(Lam.).

	Treatment		
Response	GM	Rpn	GM × Rpn
% Sprouting	0.0052*	0.9893ns	0.9888ns
Days to sprouting	0.0004*	0.5189ns	0.6976ns
Number of shoots	0.0077*	0.6322ns	0.7720ns
Height	0.0020*	0.7563ns	0.8475ns
Stem diameter	0.0099*	0.3867ns	0.8320ns
Stem volume	0.0154*	0.6677ns	0.6000ns
Number of leaves	0.0006*	0.9570ns	0.9693ns
Leaf length	0.0010*	0.7199ns	0.9429ns
Leaf width	0.0038*	0.4867ns	0.8589ns
Leaf area	0.0035*	0.5792ns	0.8215ns

Rpn = Replication, * = $p < 0.05$, ns = non-significant

Table.2: Effect of growth medium on sprouting (mean ± SE) of cutting-propagated Cordiaafricana(Lam.). The hardwood cuttings were taken from the lower branches of trees and grown in a non-mist propagator for three months.

Growth medium	Sprouting (%)	Days to sprouting	Number of shoots
Sand	86.67 ± 6.01[a]	7.67 ± 0.37[a]	2.84 ± 0.22[a]
Sawdust	74.44 ± 5.56[b]	15.00 ± 0.41[b]	1.71 ± 0.15[b]
Sand:Sawdust	91.11 ± 4.55[a]	8.22 ± 0.70[a]	2.93 ± 0.27[a]

Means with the same alphabet are not significantly different from each other.

Table.3: Effect of growth medium on shootmorphological traits (mean ± SE) of cutting-propagated Cordiaafricana(Lam.).The hardwood cuttings were taken from the lower branches of trees and grown in a non-mist propagator for three months.

Growth medium	Height (cm)	Stem diameter (mm)	Stem volume (cm^3)	Number of leaves
Sand	8.05 ± 0.42[a]	6.80 ± 0.03[a]	4.75 ±0.56[a]	8.27 ± 0.55[a]
Sawdust	5.71 ± 0.37[b]	5.60 ± 0.03[b]	2.27 ± 0.27[b]	5.51 ± 0.39[b]
Sand:Sawdust	8.63 ± 0.40[a]	7.09 ± 0.03[a]	5.45 ± 0.67[a]	8.20 ± 0.46[a]

Means with the same alphabet are not significantly different from each other.

Table.4: Effect of growth medium on leaf traits (mean ± SE) of cutting-propagated Cordiaafricana(Lam.). The hardwood cuttings were taken from the lower branches of trees and grown in a non-mist propagator for three months.

Growth medium	Leaf length(cm)	Leaf width (cm)	Leaf area(cm^2)
Sand	8.07 ± 0.33[a]	5.85 ± 0.32[a]	40.05 ± 2.78[a]
Sawdust	6.35 ± 0.35[b]	5.44 ± 0.33[b]	26.47 ± 2.27[b]
Sand:Sawdust	8.51 ± 0.31[a]	7.37 ± 0.29[a]	44.64 ± 2.93[a]

Means with the same alphabet are not significantly different from each other.