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A comparative assessment of propagation methods for *Lannea schweinfurthii* a critical threatened multipurpose tree species in Tanzanian Rangelands

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Abstract
Seed, stem cutting with Indole-3-butyric acid (IBA) hormone, and media for air layering were compared in propagating *L. schweinfurthii.* 250 seeds were sun -dried under tree shade and each 10 sown in petri dishes for the next 5 consecutive days. Each set of 50 seeds was soaked in cold water for 1 day, then thoroughly washed early the 2nd day and unsoaked sun dried under tree shade for 2 days before sowing 10 each in petri dishes randomly with five replicates and watered daily. Germination percentage (GP) and Rate of germination (RG) were computed on 21st day. Using 280 stem cuttings of 7.5 cm length, IBA concentrations 0, 50, 75, and 150 mg/L were investigated by dipping (5 seconds) and soaking (12 hrs) in 10 media under CRD with 3 factorial arrangement. 10 random branches per 10 trees each where air layered with forest soil, rice husks, and saw dust. Sun drying for 2 and 3 days had the highest GP and RG of 64%, 1.24 day-1 and 44%, 0.32 day -1 respectively. However, water soaking for 1 day had higher GP and RG of 92% and 4.62 day-1 respectively. Stem cuttings did not root or shoot in 10 media despite using IBA. Sawdust had the highest root percentage, collar diameter, leaves, and root length of 70.83%, 2.567 cm, 75.01±3.3, and 16.6±1.3 respectively. Conclusively, water soaking L. schweinfurthii seeds for 1 day promote more effective seed growth than sun drying. Air layering using sawdust proved to be the fastest method of propagating *L. schweinfurthii*.

Keywords: Tanzania, *Lannea schweinfurthii,* seeds, *stem cutting,* air layering

Introduction

The availability of animal feeds in most tropical and subtropical countries depends on natural weather conditions (Mnenwa and Maliti, 2010 [28]; Randell *et al*., 2022 [36]). Currently, these areas experience long dry seasons due to climate change effects, resulting in pasture scarcity (Joseph 2022) [16]. Woodward and Coppock (1995) [46] found that local browse tree species could survive in critical drought conditions. The trees provide grazing animals with nutritious feed and sustain them until the next growing season, as well as treating livestock diseases (Oloo *et al*., 2013) [33]. In addition, they are known to have high nutritive values (Selemani, 2020) [41] and contain significant high amounts of protein, vitamins, and minerals that grasses lack in the dry season (Ahanger, *et al*., 2016) [2]. In a tropical country like Tanzania, numerous local browse tree species have also been used to feed ruminant livestock (Maleko and Koipapi 2015) [26]. *Lannea schweinfurthii*, however, has proven its multipurpose benefits as a suitable browse species, and was highly ranked in a study conducted by Krog *et al*. (2006) [22] and Mtengeti and Mhelela (2006) [30].

Lannea schweinfurthii (Mumbu in Swahili) is medium-sized tree that is widespread in Africa from Somalia to Southern Africa, commonly found in wooded grassland, dry forest, and river valleys (Figure 1). The tree is usually 3-5 m high, irregularly branched, with rounded crowns and spreading branchlets. Its bark is grey-brown in color and smooth, with flaking when older. Often densely crowded at the ends of branches, with few leaflets usually 3-5, oval, large terminal leaflet to 9 cm, tips blunt, and a grooved leaf stalk. The flowers are small and cream-colored, borne on hanging spikes up to 20 cm tall. Moreover, *L. schweinfurthii* is found to have both sexes with fruits that are oblong 1-2 cm, red-brown in color, fleshy and edible (Katende *et al*., 1995) [19].

Lannea schweinfurthii has high CP content that range between 12.6 % and 15.0 % with in vitro Dry matter digestibility of 61.3% (Mtengeti and Mhelela, 2006) [30]. A plant that is preferred by both bulls and breeding herds by providing suitable shade and feed (Mtengeti and Mhelela, 2006) [30]. Moreover, this species, can modify soil condition (adding N and P content) that facilitate growth of pasture and favorable grass structure beneath and thus attract grazing ungulates (Treydte *et al*., 2007) [47]. On the other hand, plant provides building poles and firewood (Mtengeti and Mhelela 2006[30]; Oloo *et al*, 2013) [33]. Also, a remedy for variety of diseases, malaria (Mollel *et al*., 2019) [29], neurological disorders (Adewusi and Streetlamp, 2011) [1], enhance memory and used as a sedative (Van Way and Gericke, 2000) [48] cures stomachache, anemia, and diarrhea (Ribeiro *et al*., 2010) [39]. The multiple use of *L. schweinfurthii* has increased its demand and thus require more conservation efforts for its existence. Its low seed viability and thick mesocarp makes propagation via seed less effective (Katende *et al*., 1995) [19]. Seeds are prepared most by sun drying under shade, but the time duration is still also unknown. Conversely, Badano and De Oca (2022) [8] demonstrated how this preparation technique resulted in shrinkage of embryos, which decreased seed survival, germination, and seedling establishment. Still, a gap exists in water soaking seed preparation as an alternative to sun drying under the shade. In agriculture, the method is widely used in growing crops such as maize, beans, *Magonia pubescens* and pitaya. Soaking seeds in water before planting might help remove fluid mesocarp of *L. schweinfurthii* seeds, according to Zhao *et al*. (2005) [50] also found to enhance fast imbibition and increase seed germination percentage and rate. However, studies have delved into the alternative use of stem cutting as a method of propagating numerous fodder trees with similar seed attributes. The stem cutting method, revealed by Hartmann (1975) [14], is a vegetative propagation technique using plant organs (stems) to reproduce plants of a similar genus. The method provide the production of clones that are duplicates of the parent plants both phenotypically and genotypically. This mode of propagation is also simple, practical, and affordable in agro-pastoral communities and other communities. Though *L. schweinfurthii* can traditionally be propagated via stem cuttings without any manipulation, better performance can however be obtained when rooting hormones are used. This is because they stimulate root and shoot initiation like in many other related studies. Indole-3-butyric acid (IBA) is the most authentic rooting hormone (Kester *et al*., 1990) [20]. Nevertheless, there are other options such as naphthalene acetic acid (NAA) and Auxin. There are indications that these hormones may also be harmful to young cuttings of particular species (Tien *et al*., 2020) [45]. In this regard, IBA is still probably the most suitable hormone for general use due to its non-toxicity to plants at all concentrations (Kamila and Panda, 2019) [17]. Air layering drives the formation of roots that are well-adapted to soils, so it is a better method than all other methods of vegetative propagation (Corredoira *et al*., 2019) [11]. A branching air layer has a more balanced root system than a cutting, and develops rapidly when transplanted (Singh *et al*., 2021) [42]. In woody and non-woody plants alike, the season is extremely important for layering: light, moisture, and optimum temperature are necessary for rooting on layers (Tomar, 2016) [46]. Considering the severe threats to *L. schweinfurthii's* existence, this study also explore the possibility of propagating the tree by air layering during the rainy season (November to April), using different growing media.

Therefore, the first study aim was to determine the current sun drying time for *L. schweinfurthii* seeds under tree shade while comparing it with soaking them in water before planting. Stem cuttings, combined with IBA hormone and growth media for air layering, were examined as alternatives to propagating *L. schweinfurthii*. These findings contribute to the rapid increase in tree abundance by providing farmers, institutions, agencies, and experts with methods that yield better results, are affordable, and practical. This will, in turn, provide more quantity and quality feed for better animals' performance and production all seasons in rangeland areas of Tanzania.

Figure 1. Countries in which *Lannea schweinfurthii* has been recorded in south, central and east Africa (Maroyi , 2019)

Fig 1

Methodology

Study area

Research materials were collected from the Sokoine University of Agriculture (SUA) botanical garden (37o 39'9" East, 6o 50'20" South) and experiments were conducted at the Horticulture unit (37o 39'47" E, 6o 50'48" S) (Figure 2). These areas receive annual rainfall of 600-900 mm and temperatures from 25oC to 30oC. The areas have rainfall bimodal pattern, less rainfall occeurs from November to December. while Longrains from March and end in May or June. During the rainy season, recieves annual average rainfall of about 800 mm and 81% Relative humidity while the monthly minimum and maximum temperatures are 14.8ºc and 32.4ºc respectively.y (SUA Meteorological station 2021).

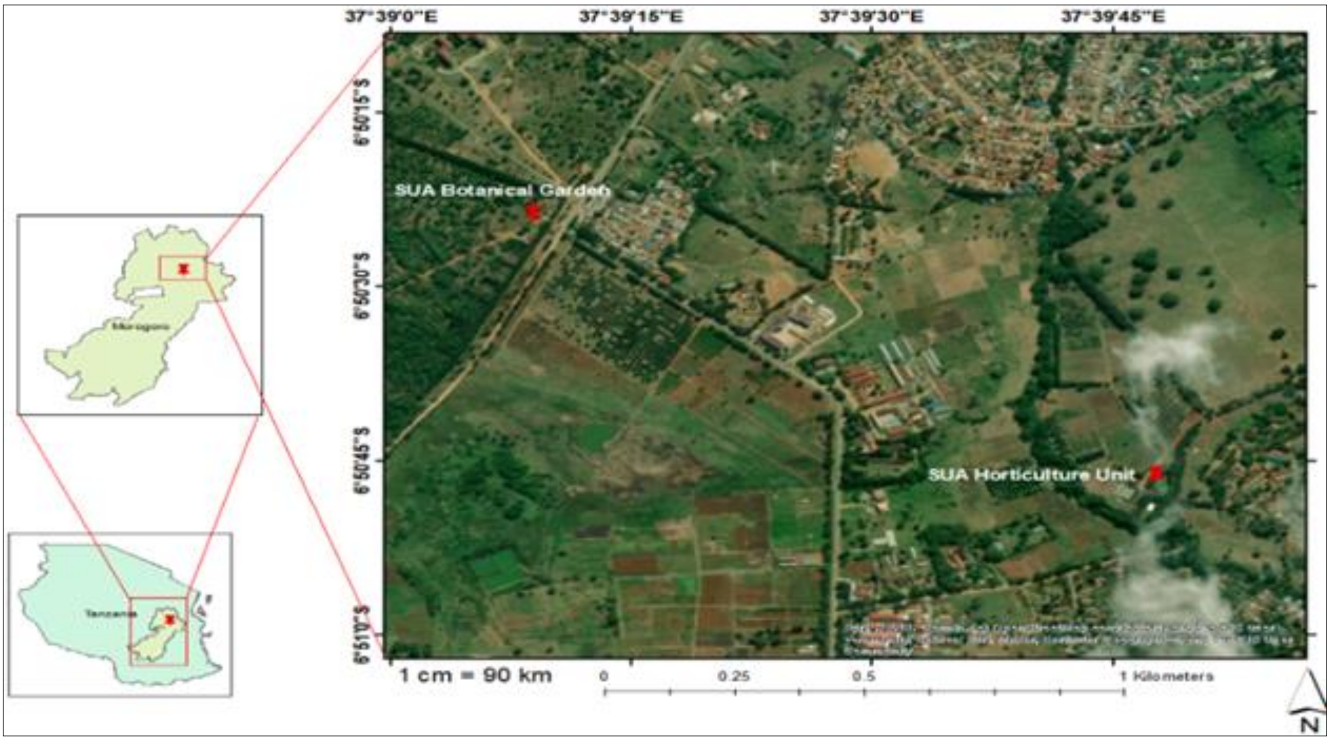

Fig 2: The map showing SUA botanical garden and Horticulture units, Morogoro region, Tanzania

Propagation by seeds

A total of 450 mature *L. schweinfurthii* tree seeds were collected from the SUA botanical garden and placed immediately in plastic bags then transferred to SUA's horticulture unit. The seeds were peeled the same day and 250 healthy seeds were placed under the shade of the tree. On the following 5 consecutive days, 50 seeds were taken daily from the shade and 10 sown in each petri dishes with moistened filter paper. Watering of these seeds was performed every day, and data on germinated seeds was taken on the 21st day of the experiment. The 100 remaining healthy peeled seeds were tested by soaking half of them in a plastic container filled with cold water for 24 hrs. In order to remove the fluid mesocarp covering seed coat, the soaked seeds were washed rigorously with water the following morning. The other 50 unsoaked seeds were sun dried under tree shade for 2 days. However, the unsoaked seeds were removed from the shade early on the 3rd day. In the seed experiment, 10 seeds in each preparation method were sown in 5 replicates onto moistened filter paper in petri dishes under a completely randomized design. Seed watering was done daily, and germination counts were taken on the 21st day. The percentage of seed germinated and rate were calculated as described by Muzzo *et al.* (2018) [31]

1. Rate of germination (RG): estimated by firstly calculating Mean Germination Time (MGT) =

   $$MGT = \Sigma (N \times D)/n.$$

Where N is the number of seeds which in D-day grow, n is the total number of seeds grown and D is the number of days from the date of germination. The reversing of MGT at the end of this period RG was obtained

2. $$\text{Germination percentage (GP)} = \frac{\text{Total number of seed germinated}}{\text{Total number of seed sown}} \times 100$$

Propagation by stem cuttings

Stem cutting preparation

The *Lannea schweinfurthii* stem cuttings were obtained from Sokoine botanical garden located at the University farm from young/ succulent terminal stems of parent plants with 7.5 cm length and lateral buds (Akwatulira *et al*., 2011) [3] and collected early in the mornings (Teklehaimanot *et al*. 2004) [44]. Cutting vegetative materials with a sharp knife reduces injury to the parent plant. Trimming the leaves down to 2–3 inches was also done during sample collection. The base of the sample cuttings was squared by using scissors to avoid one-sided rooting (Akwatulira *et al*., 2011) [3]. The cuttings were always wrapped in a moistened sack and transported to the experimental site (Horticulture unit).

Sample size of stem cuttings

The cuttings sample size was calibrates using below formula

$$N = \frac{t^2 \text{ x } cv^2}{d^2}$$

Where, N = sample size, t^2 = t-value at 5% (1.96), cv^2 = coefficient of variation (0.427) and d^2 = tolerable deviation of sample mean (0.05). Thus, N= 280 stem cuttings.

Effect IBA concentration on rooting and shooting of the *L. schweinfurthii* cuttings at different seasons.

The IBA powder was dissolved in ethanol, then diluted using distilled water to make concentration levels of 0, 75, and 150 mg/L (Teklehaimanot *et al*., 2004) [44]. The rooting media composed of Forest soil (F) + Breeding Sand soil (S) + compost manure (C) + DAP (P), (FSCP), (34.5%, 20.6%, 20.7%, 20.7% and 3.5%) was prepared, where forest soil was obtained at 15 cm deep. The media were sprayed with pesticides to protect them from termites. The cuttings were immediately immersed in distilled water before being dipped into different IBA concentration levels to their basal ends (2-3 cm) for 5 s (Akwatulira *et al*., 2011) [3] before being stuck randomly into the pots with media at 2.5 cm depth and labeled. The remaining powder was tapped off the cuttings, and these cuttings were then randomly placed into the pots. The pots were placed on plastic trays to prevent termite and weed infestations. A thick polythene sheet covered the wood frames inside the propagation chamber, maintaining 80 to 90% humidity and preventing water loss (Akwatulira *et al*., 2011) [3]. To retain moisture in the media until the cuttings rooted, the cuttings were watered twice a week (Akwatulira *et al*., 2011) [3]. The experiment was carried out in September, November, January, and March. September is described as a dry period where there are high levels of food stored in the plant after active photosynthesis during the major wet period. November is the middle of a short rain period where there is more stored food that may support propagation via stem cutting. In Morogoro, January represents the midpoint between the short and long rains, when plants are mostly unable to grow due to a lack of essential nutrients. The beginning of March marks the start of the long rainy season, when the plants have already flowered and produced fruit. The experiment was under complete randomized design with 4 × 3 × 3 factorial arrangement of three factors i.e., 4 months: September, November, January and March, 3 levels of rooting hormone; 0, 75 and 150 mg/L, 3 periods of observation; 30 days, 60 days and 90 days.

Effect of quick dipping and soaking of stem cuttings into IBA on rooting and shooting of the *L. schweinfurthii* cuttings

The concentration of 50 mg/L of IBA hormone was prepared by dissolving IBA powder in 50% ethanol. The prepared stem cuttings were dipped first in distilled water before being soaked into IBA concentration to their basal ends (2-3 cm) for 12 hours (Teklehaimanot *et al.,* 2004) [44] while others were quick dipped for 5 seconds (Reinten *et al.,* 2002) [38] and dried for 10 minutes before being placed into the planting pots at 2.5 cm depth randomly. After the remaining powder was tapped off the cuttings, it was allocated into plastic trays that prevented weed and termite invasion (Akwatulira *et al* 2011) [3]. The propagation chamber was covered with a thick polythene sheet to maintain humidity at 80 to 90 % and prevent water loss. Watering of cuttings was done daily to retain moisture in the media until the cuttings rooted (Akwatulira *et al*., 2011) [3]. The experiment was also carried out in September, November, January, and March. The experimental design was a complete randomized design with a 4×3×2 factorial arrangement of three factors i.e.; 4 months: September, November, January and March, 3 observation periods of 30 days, 60 days and 90 days, 2 IBA application methods; Quick dipping and soaking.

The effect of growing media on the root and shoot formation of *L. schweinfurthii* cuttings.

Initially, the 50 mg/L IBA concentration level was prepared and 0 mg/L was used as a control. Rice husk (R), saw dust (D), Rice husk + Saw dust (RS), (50:50), Saw dust + Sand soil (DS), (50:50), Rice husk + Sand soil (RS), (50:50) and Forest soil + Breeding Sand soil + compost manure (C) + DAP (P), (FSCP), (34.5%, 20.6%, 20.7%, 20.7% and 3.5%) as the control was prepared as the medium for this experiment in their respective ratios indicated. Rice husks and saw dust were transported to the Horticulture unit in dry sacks from the milling and timber factory around Morogoro town. These materials were presoaked in water for 4 days before being used. Prepared cuttings were first soaked in distilled water at their basal end before being quick dipped in 50 mg/L of IBA hormone and 0 mg/L for 5 seconds (Reinten *et al.*, 2002) [38] and dried for 10 minutes before being placed into the pots with medium at 2.5 cm depth randomly and labeled. Cuttings were first tapped off the powder, then randomly placed into pots. They were then randomly placed into plastic trays that protect against termites and weeds. They were then covered by thick polythene sheets that maintain average 85% humidity that prevent water loss in the growing chamber (Akwatulira *et al*., 2011) [3]. The cuttings were watered often to prevent moisture loss to the medium, which affects root and shoot formation. The experiment was set under complete randomized design with a 6 × 3 × 2 factorial arrangement of three factors, i.e., 10 media. Rice husk (R), saw dust (D), Rice husk + Saw dust (RS), (50:50), Saw dust + Sand soil (DS), (50:50), Rice husks + Sand soil (RS), (50:50) and Forest soil + Breeding Sand soil + compost manure (C) + DAP (P), 3 Observations; 20 days, 40 days and 60 days, 2 levels of rooting hormone; 0 and 50 mg/L.

Propagation by air layering

Determination of the most appropriate rooting media for air layering for *Lannea schweinfurthii* branches.

Six random branches located within the lower canopy of the 10 trees making a60 total branches were selected for air layering. This was done for each media to be used, i.e., forest soil, rice husks and saw dust. On each branch, lateral twigs of apical bud within 25-50 cm were removed and 1-1.5 cm ring of bark girdled at 40 cm from the branch apex (Browse 1992) [10]. The branches diameter where air layering is to be performed should range from 6 to 10 mm (Teklehaimanot *et al*. 2004) [44]. A middle stem segment of 20 cm length, basal to, was selected as the layering site. The layered sites were covered in moist rooting media, excess water squeezed out and wrapped with 1200 cm2 (40 × 30 cm) black polyethylene sheet with the ends tied by plastic braces. This type of material maintains a dark, warm and humid environment, while allowing gas exchange (Browse 1992) [10]. The study was conducted in mid-June to September of which Mwang'ingo *et al*. (2010) [32] pointed to be the dormant phase (dry season) in Tanzania had better rooting compared to rainy seasons (December to February).

Seeds, leaves and branches for *L. schweinfurthii*

L. schweinfurthii tree

Fig 3

Data collection and analysis

Collection of data was done three times at an interval of 30 days respectively from the starting of each experiment, i.e. 30 days, 60 days and 90 days. The number of cuttings alive (shooted callused, rooted), total number and mean length of shoots and root on the cuttings, total number of roots produced, total root and shoot biomass produced, number of leaves sprouted and branches was recorded in each experiment in step cutting experiment. In air layering, number, and percentage branches rooted, Collar diameter, number of leaves and Root length were recorded. Then Analysis of Variance (ANOVA) was carried by SAS software using GLM to obtain mean, for number and length of roots and shoots; and the interactions of stem cuttings and IBA concentration levels and months of planting. The significant differences in callusing, rooting and shooting success of different stem cuttings was determined by Chi square test.

Results and discussion

Seed germination

The results for germination percentage (GP) and rate of germination (RG) of *L. schweinfurthii* seeds prepared by sun drying under tree shade on different days are presented in Figure 3. The GP and GR for *L. schweinfurthii* species varied significantly ($P<0.05$) when sun dried under shade on different days before sowing. The results are contrary to those reported by Rawat *et al*. (2015) [37] investigated a similar genus of *Lannea coromandelica* seeds which did not germinate under sun drying. Other sundried fodder tree seeds, however showed the highest GP of 92% for *Leucaena leucocephala* (Rusdy, 2017) [40] and 86% for *Samanea sama* (Staples and Elevitch, 2006) [43]. Interestingly, the study found that *L. schweinfurthii* seeds sun dried under tree shade for D2 and D3 had the highest GP and RG, both 64%, 1.24 day-1 and 44%, 0.32 day-1. However, D1, D4 and D5 had the lowest GP and RG values of 20%, 28% and 12%, respectively, and 0.2 day-1, 1.12 day-1, 0.6 day-1. Elsewhere, Banful *et al*. (2011) [9] showed air-dried or sun-dried *Annona squamosa* seeds under shade for three days increased germination to 75% by 26 days, compared with 64% within 21days in the current study. The method enhances germination improvement which accords with Koramov *et al*. (2020) [21] that also highlighted the possibility of increasing seed longevity, germination rates and plant vigor.

There was continuous RG under shade in the present study, however, with 0.69 per day. The GP and RG for seeds prepared by soaking in water and unsoaking are presented in Figure 4. There was a significant difference ($p<0.05$) between soaking and unsoaking preparation methods in the GP and RG of *L. schweinfurthii* seeds. The highest GP and RG were observed on soaked seeds, 92% and 4.62 day-1, respectively. Similar findings were reported by Missanjo *et al*. (2013) [27], but in seeds of *Albizia lebbeck* fodder tree soaked in cold water. However, their study exhibited higher GP of 67.5% in hot water treatment than in cold water. Azad *et al*. (2012) [6] disclosed that hot water soaking softens the thick seed coats, allowing water to permeate the coats and the seeds to absorb water and imbibe. Likoswe *et al*. (2008) [24] showed that soaking seeds in hot water leaches out chemical inhibitors and breaks chemical seed dormancy. Despite using cold water in the study, an intriguing observation was that the seeds continued to germinate after 21 trial days, whereas unsoaked, they were all dead, as in Azad *et al*. (2012) [6] using hot water. Moreover, the time for *L. schweinfurthii* seeds to germinate by the study method is less than those reported 60 days (Van Wyk and Gericke, 2000) [48] and 45 days (Magwede et al., 2019) [25].

Propagation of stem cuttings

The influence of IBA hormone and 10 growing media on root and shoot formation of *L. schweinfurthii* stem cuttings was evaluated under a polythene made growth chamber. However, *L. schweinfurthii* stem cuttings did not root and shoot in any trials. Conversely, Prabakaran *et al* (2017) [35]observed rooting and shooting formation of similar genus of *Lannea coromandelica* (Houtt.) using appropriate media and quick dipping (5 seconds) in IBA as per the current study. The IBA hormone levels (0, 10, 20, 30, 40, and 50 mg/l) were different from those in the present study. The semi-hard wood cuttings of *Lannea coromandelica* exhibited more rooting and shooting, while the cuttings of the young/succulent terminal stems of *L. schweinfurthii* showed poor performance in the current study. Dhixya (2014) [12] reported the use of hard wood cuttings to propagate *Dalbergia sissoo*, with better results. In the study carried out by Picerno et al. (2006) [34] on *Lannea microcarpa*, the use of semi woody cuttings was recommended, which is a similar genus with *L. schweinfurthii* yielded better results. Although these woody and semi-woody cuttings are not reported to support ecological restoration (Zahawi, 2005) [49].

Propagation by air layering

The results for the number of branches rooted, root length, root percentage, collar diameter and the number of leaves formed after air layering with media of forest soil, sawdust, and rice husks are presented in Figure 5. The growth indices varied significantly ($p<0.05$) in layered branches with forest soil, sawdust, and rice husks. Similar results were reported by Asaah (2012) [5] on *Dacryodes edulis* trees. Layered *L. schweinfurthii* branches were high rooted in sawdust with 70.83% and least rooted in rice husks with 8.33%. Jose *et al*. (2015) [15] also observed high rooting success using sawdust in Indian studies when researching *Drypetes malabarica* plants with multiple benefits similar to *L. schweinfurthii*. During the study observations, sawdust demonstrated the ability to retain water for longer periods than other air layered media. This may contribute to its ability to provide water and nutrients for more growth. Conversely, the survival rate in their study was 100% but 75% in the present study. The collar diameter was the highest in sawdust (2.567 cm), and slight differences were found with forest soil by 1.54 cm and rice husks by 0.986 cm. The number of leaves formed in forest soil, sawdust, and rice husks were 42.0±1.2 cm, 75.01±3.3 cm and 26.01±5.4 cm respectively. However, root length formation in sawdust (16.6 cm) was almost twice that of rice husks and 4.5 cm more than in forest soil. These findings are in opposition to those reported by Ali *et al*. (2016) [4] evaluated similar media on air layering Litchi tree fruits, and found sawdust had the lowest root formation in comparison to forest and rice husk. Nonetheless, Kanmegne *et al*. (2022) [18] pointed out that, *Canarium schweinfurthii* had high root formation, leaves, and survival when air layered with Sawdust substrate and application of 5 g/l IBA was recommended. Thus, adding rooting hormones such as IBA could result in greater success for *L. schweinfurthii*.

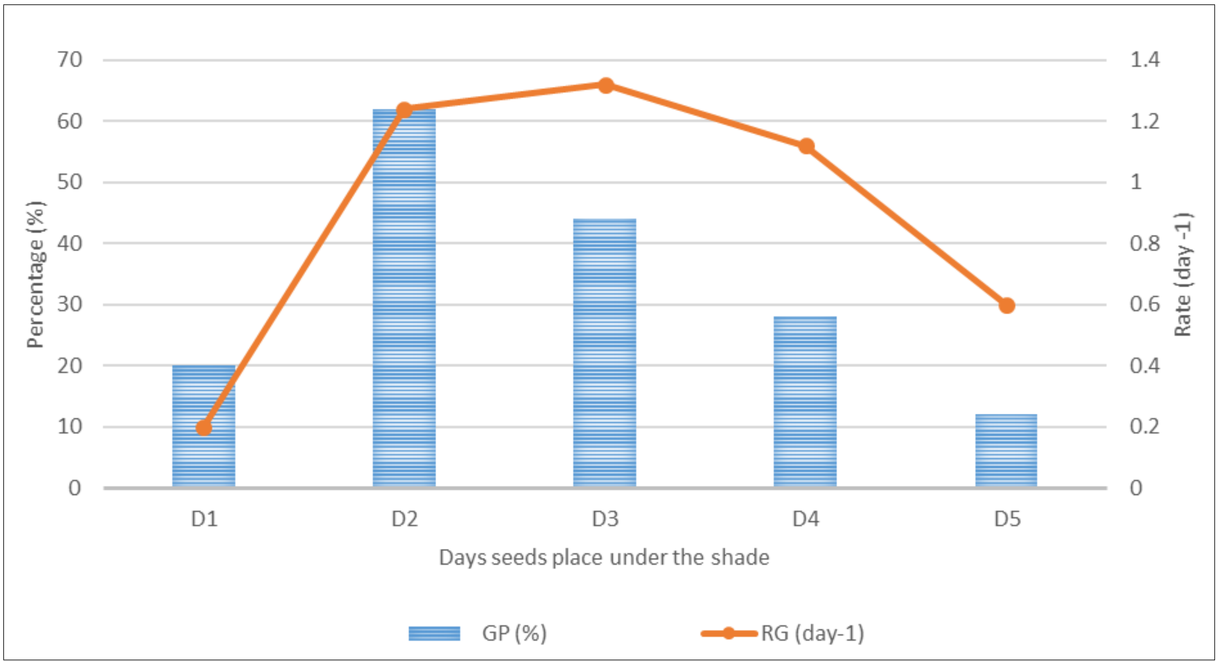

Fig 4: Rate of germination (RG) and Germination percentage (GP) of *L. schweinfurthii* seeds prepared by sun drying under tree shade in different days

Table 1: Column with same value followed by different values are significantly different at P < 0.05. GP= Germination Percent; RG = Rate of germination

Treatment	GP (%)	RG (day-1)
Unsoaked	64	1.44
soaked	92	4.62
P value	0.0001	0.2158

Table 2: Values in the same column followed by different values are significantly different at P < 0.05. Lannea sp. growth parameters under forest soil, saw dust and rice husks.

Sample	Branches rooted	% Branches rooted	Collar diameter (cm)	No. of leaves	Root length (cm)
Forest soil	10	20.83%	1.023 ± 0.341	42.0±1.2	12.1±2.6
Saw dust	34	70.83%	2.567 ± 0.883	75.01±3.3	16.6±1.3
Rice husks	4	8.33%	0.986 ± 0.626	26.01±5.4	8.6±4.3

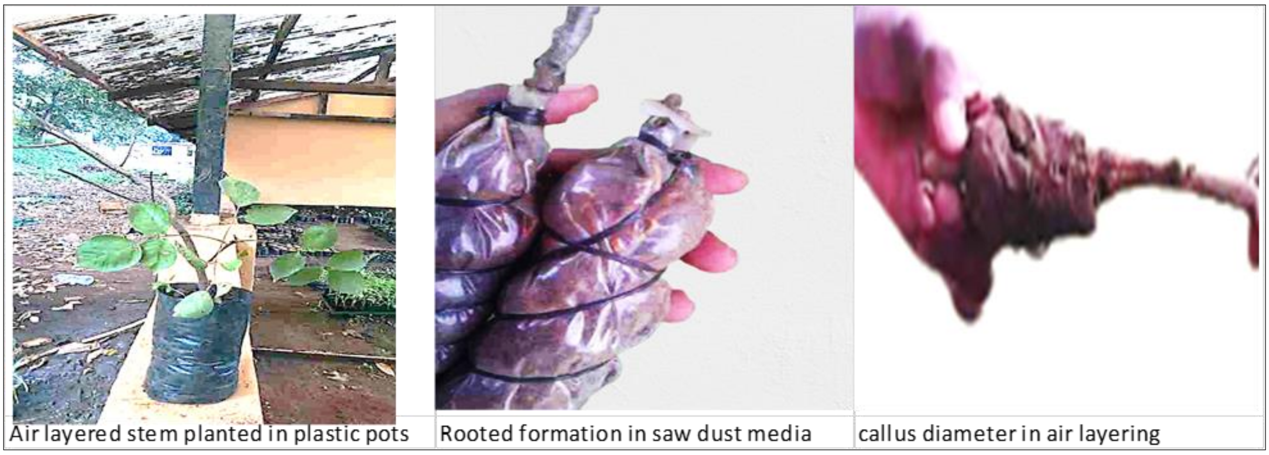

Fig 5

Conclusion

Multiple uses of *L. schweinfurthii* have increased its demand and hence its existence requires more conservation efforts. Efficacious, affordable, and practical propagation methods were tested for rapid increase in tree abundance in Tanzania rangelands. Sun drying *L. schweinfurthii* seeds for 2 days under tree shade improves germination percentage and rate. Compared with sun drying under shade, water soaking for 1 day in cold water had the highest germination and germination rate. Stem cuttings did not root or shoot in 10 media despite using IBA. An initial study is recommended to determine the appropriate cuttings, i.e., young, semi woody and woody that yield better growth results in different seasons. Air layering using sawdust proved to be the fastest method of propagating *L. schweinfurthii*.

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References

1. Adewusi EA, Steenkamp V. In vitro screening for acetylcholinesterase inhibition and antioxidant activity of medicinal plants from southern Africa. Asian Pacific Journal of Tropical Medicine, 2011, 829-35.
2. Ahanger MA, Moad-Talab N, Abd-Allah EF, Ahmad, P, Hajiboland R. Plant growth under drought stress: significance of mineral nutrients. In “Water stress and crop plants: a sustainable approach.” Ed. Ahmad P. Wiley Blackwell, 2016, 649-668.
3. Akwatulira F, Gwali S, Bosco J, Okullo L, Ssegawa, p, Tumwebaze S *et al*. Influence of rooting media and indole-3-butyric acid (IBA) concentration on rooting and shoot formation of Warburgia ugandensis stem cuttings African Journal of Plant Science,2011:5(8):421-429.
4. Ali S, Khan AS, Nawaz A, Anjum M A, Naz S, Ejaz, S *et al*. Aloe vera gel coating delays postharvest browning and maintains quality of harvested litchi fruit. Postharvest Biology and Technology, 2019, 157. 110960.
5. Asaah EK, Tchoundjeu Z, Van Damme P. Beyond vegetative propagation of indigenous fruit trees: case of Dacryodes edulis (G. Don) HJ Lam and Allanblackia floribunda Oliv. Afrika Focus,2012:25(1);61-72.
6. Azad MS, Biswas RK, Matin MA. “Seed germination of Albizia procera (Roxb.) Benth. in Bangladesh: a basis for seed source variation and pre-sowing treatment effect,” Forestry Studies in China,2012:14(2): 124-1130.
7. Van Wyk BE, Gericke N. People's Plants: A Guide to Useful Plants of Southern Africa, Briza Publications, Pretoria, South Africa, 2000.
8. Badano EI, de Oca EJS-M. Seed fate, seedling establishment and the role of propagule size in forest regeneration under climate change conditions. For Ecol Manag 503:119776, 2022.
9. Banful B, Adjei PY, Achiaa NK. Effect of Seed Drying on Germination Behavior and Seedling Growth of Sweetsop (Annona squamosa). Nong Ye Ke Xue Yu Ji Shu, 2011, 5(4).
10. Browse PM. Plant propagation. 2nd ed. Mitchell Beazley Publishers Ltd, 1992, 192.
11. Corredoira E, Merkle SA, Martinez MT, Toribio M, Canhoto JM, Correia SI *et al*. Non-zygotic embryogenesis in hardwood species. Crit. Rev. Plant Sci,2019:38:29-97. https://doi.org/10.1080/07352689.2018.1551122
12. Dhixya Deve KR. Studies on genetic variation, wood and molecular characterization of Dalbergia sissoo roxb. Genetic resources. Ph.D. Thesis, Tami
13. Forest & Landscape Working Papers 16, Danish Center for forest landscaping and planning, KVL, 2014.
14. Hartmann H, Kester D, Plant Propagation: Principles and Practices. New Jersey: Prentice-Hall Inc, 1975, 469-474. Retrieved on 2 May 2015 fromhttp://www.cropsreview.com/vegetative-propagation.html
15. Jose PA, Sumod M. Enrichment planting and ex situ conservation of Drypetes malabarica and Hydnocarpus macrocarpa-two endemic and endangered trees of Southern Western Ghats. C. Buvaneswaran *et al*, 2015, 270-274.
16. Joseph LS. Factors that accelerate vulnerability to climate change impact among the agro-pastoralists in Arumeru, Tanzania. . East Afr. J. Educ. Soc. Sci., 3 (2), 2022, 37-47.
17. Kamila PK, Panda PC. Large-scale vegetative propagation of Lasiococca comberi through air layering. J. Trop. Sci,2019:31:37-42.

18. Kanmegne G, Atchioutchoua RS, Noumbo GRT. Combining air-layering and stem cutting techniques to optimize the production of quality planting materials for agroforestry tree species: a case study of Canarium schweinfurthii Engl.(Burseraceae). Forests, Trees and Livelihood, 2022:31(3):170-183.
19. Katende AB, Birnie A, Tengnäs BO. Useful trees and shrubs for Uganda: identification, propagation, and management for agricultural and pastoral communities (No. 10). Nairobi, Kenya: Regional Soil Conservation Unit, 1995.
20. Kester DE, Hartmann TH, Davier FT. Plant propagation: Principles and Practices. 5th edition. Prentice Hall, Singapore, 1990, 647.
21. Komarov A, Naida N, Nugis E. Dynamic model of seed germination on the example of a genus Dracocephalum L. based on logistic function, 2021.
22. Krog M, Falcão MP, Olsen CS. Medicinal plant markets and trade in Maputo, Mozambique, 2006.
23. Lema MA, Majule AE. Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: the case of Manyoni District in Singida Region, Tanzania. J. Environ. Sci. Technolm,2009:3:206-218.
24. Likoswe MG, Njoloma JP, Mwase WF, Chilima CZ. “Effect of seed collection times and pretreatment methods on germination of Terminalia sericea Burch. ex DC,” African Journal of Biotechnology,2008:7(16):2840-2846.
25. Magwede K, Ramovha LI, Mabogo ḒE, Van Wyk AE, van Wyk BE. Traditional uses of the remarkable root bark hairs of Lannea schweinfurthii var. stuhlmannii (Anacardiaceae) by the Vhaven̩da, South Africa. South African Journal of Botany,2019:122:529-534.
26. Maleko DD, Koipapi ML. Opportunities and constraints for overcoming dry season livestock feed shortages in communal semiarid rangelands of Northern Tanzania: A case of Longido District. Livestock Research for Rural Development, 2015, 27:70.
27. Missanj E, Maya C, Kapira D, Banda H, Kamanga-Thole G. Effect of seed size and pretreatment methods on germination of Albizia lebbeck. International Scholarly Research Notices, 2013.
28. Mnenwa, Maliti. x A Comparative Analysis of Poverty Incidence in Farming Systems of Tanzania Special paper 10/4. REPOA, Dar-es-Salaam, 2013.
29. Mollel NP, Otieno JN, Sitoni DK. Medicinal plants traded in Arusha city, Tanzania. J. Med. Plants Stud,2022:10:175-1820.
30. Mtengeti E, Mhelela A. Screening of potential indigenous browse species in semi-arid central Tanzania: A case of Gairo division- Livestock Research for Rural Development, 2006, 18(9).
31. Muzzo BI, Mwilawa AJ, Maleko DD, Mtengeti EJ. Allelopathic effect of Chromolaena odorata aqueous leaf extracts on seed germination and seedling growth of selected crop and pasture species in Tanzania. Int. J. Botany Stud, 2018:3:41-8.
32. Mwang’ingo PLP, Kibodya G, Mng’ong’o AR. Oil yield and quality variation between sexes in Osyris lanceolata (African sandalwood) and its value as a fodder plant in Tanzania. Southern Forests: A Journal of Forest Science, 2010:72:69-74.
33. Oloo TW, Brett R, Young TP. Seasonal variation in the feeding ecology of black rhinoceros (Diceros bicornis) in Laikipia, Kenya. African Journal of Ecology,1994:32:142-157.
34. Picerno P, Mencherini T, Loggia RD, Meloni M, Sanogo R, Aquino RP. An extract of Lannea microcarpa: composition, activity and evaluation of cutaneous irritation in cell cultures and reconstituted human epidermis. Journal of pharmacy and pharmacology, 2006:58(7):981-988.
35. Prabakaran, P, Kanna SU, Parthiban KT, Rajendran P, Mahendran S. Macropropagation of Lannea coromandelica (Houtt.) Merr. clones. Electronic Journal of Plant Breeding,2017:8(3):764-771.
36. Randell H, Gray C, Elizabeth HS Climatic conditions and household food security: Evidence from Tanzania. Food Policy, 2022:112:0306-919.
37. Rawat RBS, Singh SK, Singh R. Propagation of Sal (Shorea Robusta) Associates in Tarai Region of Uttarakhand Through Improved Nursery Practices. Advances in Tree Seed Science and Silviculture, 2015, 200.
38. Reinten E, Gertze S, Arends L. Propagation methods. Cultivating fynbos for quality cut flower production. ARC Training Course Manual, Elsenburg, South Africa, 2002, 50-70.
39. Ribeiro A, Romeiras MM, Tavares J, Faria MT. Ethnobotanical survey in Canhane village, district of Massingir, Mozambique: medicinal plants and traditional knowledge. J Ethnobiol Ethnomed, 2010, 6:33.
40. Rusdy M. Enhancement of seedling emergence and early growth of Leucaena leucocephala by hot water, mechanical and acid scarification pre-treatments. International Journal of Applied Environmental Sciences,2017:12(5),857-863.
41. Selemani IS. Indigenous knowledge and rangelands’ biodiversity conservation in Tanzania: success and failure. Biodiversity and Conservation, 2020:29:3863-3876.
42. Singh S, Mishra DS, Singh AK. Tamarind (Tamarindus indica L.). In Tropical Fruit Crops Theory to Practical Chapter: 16; Jaya Publishing House: Delhi, India, 2021, 610-631.
43. Staples GW, Elevitch CR. Samanea saman (rain tree). Species profile for Pacific Island agroforestry, 2006.
44. Teklehaimanot Z, Mwang'ingo P, Mugasha A, Ruffo C. Influence of the origin of stem cutting, season of collection and auxin application on the vegetative propagation of African Sandalwood (Osyrislanceolata) in Tanzania, 2004. http://dx.doi.org/10.1080/20702620.2004.10431770
45. Tien L, Chac L, Oanh L, Ly P, Sau H, Hung N *et al*. Effect of auxins (IAA, IBA and NAA) on clonal propagation of Solanum procumbens stem cuttings. Plant Cell Biotechnol. Mol. Biol,2020:21:113-120.
46. Tomar A. Impact of seasonal changes on air layering and rooting hormone in Spondias pinnata (J. Koenig ex L. f.) Kurz. Trop. Plant Res,2016:3(1):131-135.
47. Treydte A, Heitko¨ nig I, Prins H, Ludwig F. Trees improve grass quality for herbivores in African savannas. Perspect Plant Ecol Evol System,2016:8:197-205.

48. Van Wyk B-E, Gericke N. People’s plants: a guide to useful plants of southern Africa. Pretoria: Briza Publications, 2000.
49. Ahawi R. Establishment and growth of living fence species: an overlooked tool for the restoration of degraded areas in the tropics. Restoration Ecology,2005:13:92-102.
50. Zhao CX, Wang XY, HB Li, F He. Preliminary study on germination characteristics of Hylocereus undatus seed. Seed 24: 37–40. (In Chinese), 2005.