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## **TANZANIA JOURNAL OF FORESTRY AND NATURE CONSERVATION**

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In 2000, the then Faculty of Forestry and Nature Conservation (now college of Forestry, Wildlife and Tourism) of the Sokoine University of Agriculture (SUA) in Morogoro, Tanzania, inaugurated the *Tanzania Journal of Forestry and Nature Conservation*. This development was taken in order to elevate the former publication of the then Faculty of Forestry, *Faculty of Forestry Records*, to a status of an International Journal. The last issue of the *Faculty of Forestry Records* was volume 72 and this Journal took over beginning with volume 73.

### **Scope**

The *Tanzania Journal of Forestry and Nature Conservation* accommodates the current diverse and multidisciplinary approaches towards ecosystem conservation at national and global levels. The journal is published biannually and accepts research and review papers covering technological, physical, biological, social and economic aspects of management and conservation of tropical flora and fauna.

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## **ABOUT THE COLLEGE OF FORESTRY, WILDLIFE AND TOURISM**

The College of Forestry, Wildlife and Tourism of SUA attained its present status in July 2017. It started in 1973 as a Division of Forestry in the Faculty of Agriculture of the University of Dar es Salaam. Thereafter, it was elevated to a Faculty of Forestry in 1984 when SUA was established. SUA is located 3 km from the centre of Morogoro Municipality, which is 200km west of Dar es Salaam, along the Tanzania-Zambia highway.

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## Establishment potential of Elgon Olive (*Olea welwitschii* (Knobl.) Gilg & Schellenb) seedlings propagated using stem cuttings and seeds

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### ABSTRACT

Large-scale planting of *Olea welwitschii* has been hampered by availability of viable seeds. This study compared the establishment potential of seedlings propagated using stem cuttings and seeds based on their morphological quality characteristics and initial field growth performance. Five seedlings from each propagation method were subjected to destructive sampling for assessment morphological qualities based on shoot height, Root Collar Diameter (RCD), root and shoot fresh and oven-dry weight. Field experiment was laid out with three replications in complete randomized block design with 10 seedlings per replication at spacing of 3 x 3 m line plots for assessment of establishment potential based on height, RCD and survival at planting and after field establishment. Results indicated that RCD ( $p = 0.001$ ), root fresh weight ( $p = 0.0036$ ) and root dry weight ( $p = 0.0279$ ) of seedlings propagated from stem cuttings were significantly higher than those propagated from seeds. Three months after field establishment, seedlings propagated from stem cuttings had significantly ( $p < 0.0001$ ) higher RCD and higher survival ( $p < 0.0001$ ) than seedlings propagated using seeds. Preliminary results revealed that seedlings propagated from stem cuttings established and survived better in the field than those propagated from seeds. Thus, large-scale planting of *O. welwitschii* can

be increased by using seedlings propagated from stem cuttings although further studies are required to compare long-term field performance of seedlings propagated from stem cutting and that from seeds.

Key words: large-scale planting, establishment potential, stem cuttings, seedlings performance

### INTRODUCTION

Elgon olive (*Olea welwitschii* (Knobl.) Gilg & Schellenb) is one of high value indigenous tree species in Tanzania occurring naturally in the south-eastern slopes of Mountain Meru, Ngurudoto crater and scattered on the slopes of Mount Kilimanjaro (Mbuya *et al.* 1994; TAFORI 2003; URT 2013). Its wood is used for construction, flooring, joinery, furniture and sliced veneer. The wood is also used as firewood and for charcoal making while the bark is used in traditional medicine (Mbuya *et al.* 1994; Maundu and Tengnäs 2005; Aerts 2011). However, most of indigenous trees species in Tanzania are threatened by over-harvesting while their artificial field establishment is hampered by lack of viable seeds, poor field establishment and growth rates.

Establishment of seedlings and survival in the field is mostly a function of especially seedling root and shoot biomass characteristics (Jahansson *et al.* 2012; Corpuz *et al.* 2013). Shoot and root biomass are directly related to shoot



height, stem basal diameter, root configuration and root to shoot ratio (Wightman 1999; Mohamed 2013). In recent developments through biotechnology, juvenile stem cuttings collected from managed mother plants and rooted under optimum temperature, relative humidity and using rooting hormone and suitable media can achieve normal and well developed rooting systems as seedlings propagated by seeds (Çiçek *et al.* 2010; Hartmann *et al.* 2011).

A study by Ky-Dembele *et al.* (2010) conducted on *Khaya senegalensis* seedlings and seedlings found comparable growth patterns in the field after establishment. However, a study by Çiçek *et al.* (2010) found that seedlings propagated using cuttings of *Fraxinus angustifolia* performed better in the field after transplanting than those propagated using seeds. On the other hand, seedlings propagated using seeds of *Carapa procera* and those of *Eucalyptus globulus* of similar genetic background had higher initial growth at young ages (2 years) but at 5 years, the growth became similar with those propagated using cuttings (Gaspar *et al.* 2005; Pangou *et al.* 2011). This indicates that regardless of the propagation method used, performance of seedlings after field establishment may become similar.

Large-scale planting of *O. welwitschii* whose propagation is conventionally done using seeds has been constrained by unavailability of planting materials caused by seed dormancy, poor seed availability and viability (Maundu and Tengnäs 2005; Aerts 2011). Attempts to propagate *O. welwitschii* using juvenile stem cuttings have been successful (Maduka *et al.* 2017) but studies on field establishment potential of the seedlings propagated using stem cuttings are limited. According to Mng'omba *et al.* (2008), Chamshama *et al.* (2009), and Chamshama and Nshubemuki (2011), propagation methods for

production of planting stocks, among others, have influence on tree field survival and growth performance. Therefore, this study was initiated to compare the initial field establishment potential of *O. welwitschii* seedlings propagated using juvenile stem cuttings and seeds.

## MATERIALS AND METHODS

### Study site and planting materials establishment

Production of *O. welwitschii* planting stocks using stem cuttings and seeds was carried out at the Horticulture Section nursery of Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. Seedlings propagated using juvenile stem cuttings and seeds were established in 10 x 15 cm polythene pots with a potting mixture of top forest soil, decomposed cow dung manure and sand at the ratio of 3:1:1 by volume. Roots induction in juvenile stem cuttings was done using a rooting hormone, indole-3-butyric acid (IBA) powder at 0.6% and rooting media (Maduka *et al.* 2017). Roots in both seedlings propagated from stem cuttings and seeds were pruned once they touched the ground. The experiment to determine seedling morphological characteristics was conducted at SUA while the experiment to assess initial field establishment potential of the seedlings was carried out at the Tanzania Forestry Research Institute (TAFORI) headquarters trial site. TAFORI headquarters trial site is within Morogoro Municipality at 37°43'50"E and 6°47'21"S and has silt clay soil with the pH of 6.4. According to Morogoro Weather Station, the mean rainfall for 6 months from March to September 2015 was 51.1 mm with the highest rainfall of 144.3, 131.4 and 72.2 mm in March, April and May, respectively (Figure 1).

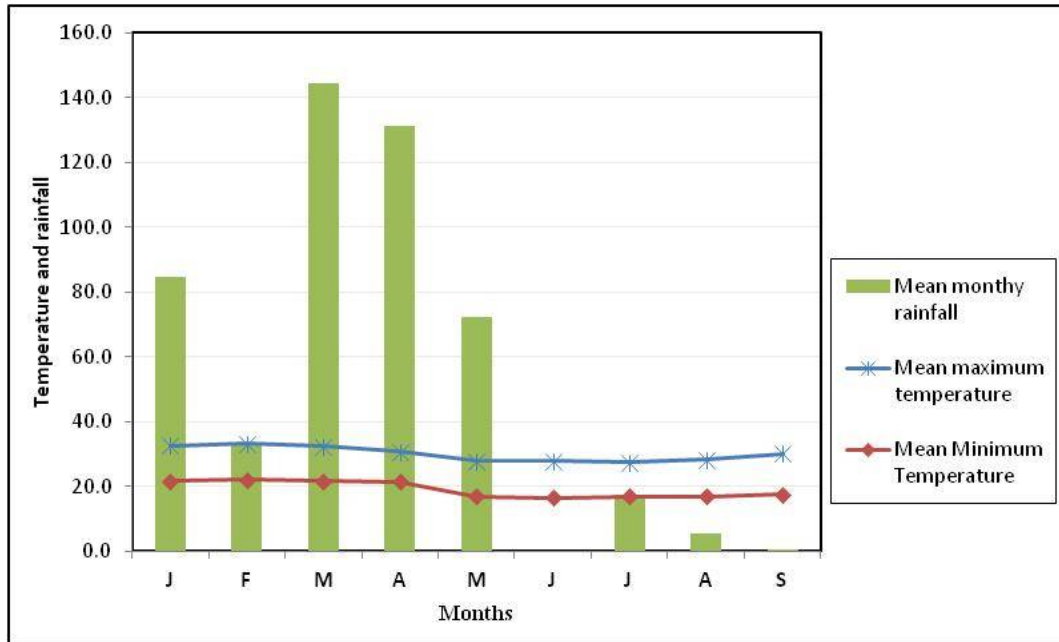


Figure 1. Rainfall and temperature for the period January to September 2015

### Experimental design and management

At the age of 15 months, prior to field establishment, five seedlings were selected from each of the two propagation methods namely stem cuttings and seeds for assessment of morphological quality characteristics through destructive sampling. Roots were cleaned of soil and then separated from shoots and packed

individually in paper bags for determination of fresh and oven-dry weight (Mohamed 2013). Root and shoot samples from each root systems of seedlings propagated using stem cuttings and seeds (Plate 1 A and B) were next oven-dried to constant weight at 65<sup>0</sup>C (Beets *et al.* 2007; Trueman *et al.* 2013).

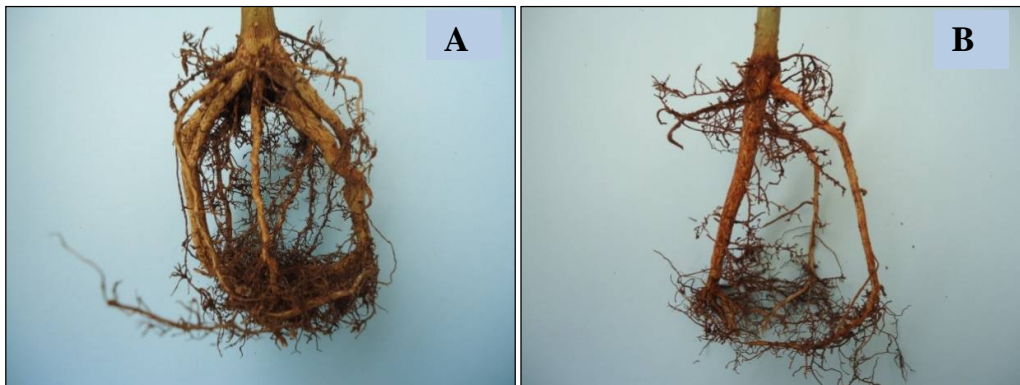


Plate 1. Rooting system of *Olea welwitschii* seedlings: stem cutting (A) and seed (B) seedlings

A field experiment was established in March 2015 after the onset of the rains using seedlings propagated from stem cuttings and seeds. The experiment was laid out with 10 seedlings per replication

replicated three times in a complete randomized block design on hand cultivated and pitted field (Plate 2 A and B) at a spacing of 3 x 3 m line plots.





Plate 2. Transplanted *O. welwitschii* seedlings: Cuttings (A) and seeds (B) seedlings

## DATA COLLECTION AND ANALYSIS

Data on fresh and dry weights of roots and shoots of seedlings were measured using a sensitive digital balance (Takoutsing *et al.* 2013). Root and shoot dry weights, and root to shoot ratios of the seedlings were calculated from oven-dry weights. Data on height and RCD of seedlings were collected at planting and three months after planting in the field. Seedling height was measured using tape measure while RCD was measured using a digital caliper. Data was also collected on the survival of the seedlings at three months from the date of planting.

Morphological and growth data were subjected to statistical analytical system (SAS) software tool (SAS Institute Inc. 2002). Comparison of treatment means was performed using two samples Student t-test at 5% significant level.

## RESULTS

### Morphological growth characteristics of *O. welwitschii* seedlings

Propagation methods had a significant effect on establishment potential of *O. welwitschii* based on root diameter, root fresh weight and root dry weight (Table 1). Seedlings propagated using stem cuttings had significantly ( $p = 0.001$ ) bigger RCD mean of 8.40 mm than those propagated using seeds which had RCD mean of 6.11 mm. Moreover, seedlings propagated using stem cuttings had significantly ( $p = 0.0036$ ) higher root fresh weight mean of 22.48 g than those propagated using seeds which had root fresh weight mean of 19.10 g. Similarly, the root dry weight mean of 18.14 g was significantly ( $p = 0.0279$ ) higher in seedlings propagated from stem cuttings than in seedlings propagated from seed with mean of 15.89 g.

**Table 1. Seedlings morphological growth characteristics**

Seedlings growth variables	Seedlings propagated from stem cuttings	Seedlings propagated from seeds	Mean difference	p-value
Height (cm)	76.00 ± 3.54	77.40 ± 7.86	- 1.4 ± 6.09	0.7299
RCD (mm)	8.70 ± 0.87	6.19 ± 0.69	2.51 ± 0.79	0.001*
Root fresh weight (g)	22.59 ± 1.31	19.25 ± 1.29	3.35 ± 1.30	0.0036*
Shoot fresh weight (g)	45.31 ± 9.00	45.66 ± 1.10	- 0.35 ± 6.41	0.9346
Root dry weight (g)	18.14 ± 1.34	15.89 ± 1.31	2.25 ± 1.33	0.0279*
Shoot dry weigh (g)	31.43 ± 6.44	26.81 ± 1.35	4.63 ± 4.65	0.1545
Root/shoot ratio	0.62 ± 0.12	0.59 ± 0.02	0.03 ± 0.08	0.6137

\* indicates significant difference based on Student t-test at a probability level of  $\leq 0.05$ .

± indicates standard deviation of the mean.



### Effect of propagation method on field establishment potential of *O. welwitschii* seedlings

Propagation methods had a significant effect on RCD of the seedlings at planting and three months after planting, and plant survival at three months after establishment (Table 2). Seedlings propagated using stem cuttings had significantly ( $p < 0.0001$ ) bigger RCD mean of 8.5 cm than those propagated from seeds which had an RCD mean of 6.3 cm at planting. Similarly, seedlings

propagated by stem cuttings had significantly ( $p < 0.0001$ ) bigger RCD mean of 9.3 cm than seedlings propagated using seeds which had RCD mean of 7.2 cm at three months after field establishment. Moreover, seedlings propagated using stem cuttings had significantly ( $p < 0.0001$ ) higher survival mean of 64% than seedlings propagated from seeds which recorded a survival mean of 45 % at three months after field establishment.

**Table 2. The effect of propagation methods on initial field growth and survival variables of *O. welwitschii* seedlings**

Period	Seedlings growth Variable	Seedlings propagated from stem cuttings	Seedlings propagated from seeds	Mean difference	p-value
At planting	Height (cm)	75.3 ± 8.1	76.0 ± 6.7	- 0.7 ± 7.5	0.7051
	RCD (mm)	8.5 ± 0.8	6.3 ± 0.6	2.18 ± 0.7	< 0.0001*
At 3 months after planting	Height (cm)	77.9 ± 7.1	77.1 ± 6.4	0.81 ± 6.8	0.7472
	RCD (mm)	9.3 ± 0.8	7.2 ± 0.6	2.05 ± 0.7	< 0.0001*
	Survival (%)	64 ± 9.2	45 ± 8.7	19.0 ± 9.0	< 0.0001*

\* indicates significant difference based on Student t-test at a probability level of  $\leq 0.05$ .

± indicates standard deviation of the mean.

## DISCUSSION

### Morphological growth characteristics of *O. welwitschii* seedlings

Seedlings of *O. welwitschii* propagated using stem cuttings in this study had a larger root system than those propagated using seeds. The root system was associated with the use of juvenile stem cuttings, rooting media and hormones in inducing rooting during propagation. Application of rooting hormones enhances formation of more roots in stem cuttings (Hartmann *et al.* 2011; Hassanein 2013; Bryant and Trueman 2015) by improving enzymatic activities and increasing starch hydrolysis and mobilization (Amri 2011; Kebede *et al.* 2013). Juvenile stem cuttings collected from young phase of tree, for instance from the seedling provide more root, root easily and behave as seedlings with upright stem (orthotropic) than from mature phase (branches and twigs) which

are difficult to root and tend to grow laterally (plagiotropic). This is because rooting and growth of woody plants stem cuttings is explained by its physiological or ontogenetic status not chronological age of the tree (Hartmann *et al.* 2002; Davis and Jacobs 2005; Hartmann *et al.* 2011). Thus, field growth performance of seedlings propagated using stem cuttings, especially for timber tree species can be improved when juvenile stem cuttings collected from primary axis of the young phase are propagated.

Larger root system in *O. welwitschii* seedlings propagated using stem cuttings represented quality of good seedling. A good seedling must have a smaller to medium shoot system and a root system characterized by dense root system with many lateral roots (Wightman 1999; Chamshama and Nshubemuki 2011). Root





system improves roots-soil contact for moisture and nutrient absorption which is an important factor for initial field survivals (Grossnickle 2005; Chamshama and Nshubemuki 2011). Larger root systems also enhance xylem hydraulic conductivity to absorb and translocate water and nutrients towards the shoot system (Martinez-Ballesta *et al.* 2010; Johansson *et al.* 2012; Mohamed 2013; Takoutsing *et al.* 2013). The high root hydraulic conductivity is further associated with improved stomatal conductance, photosynthesis, seedling survival and plant growth after transplanting (Oda *et al.* 2005).

#### **Effect of propagation methods on field establishment potential and survivals of *O. welwitschii* seedlings**

Seedlings of *O. welwitschii* propagated using stem cuttings had higher survival and slightly better growth in the field than seedlings propagated using seeds. The higher survival and better establishment of seedlings propagated using stem cuttings were due to their larger RCD. Çiçek *et al.* (2010) also reported similar trend on seedlings of *Fraxinus angustifolia* propagated using stem cuttings by having the larger RCD and height than seedlings propagated using seed at initial establishment in the field. The basal diameter was also reported to be the best single morphological indicator of hop hornbeam (*Ostrya carpinifolia* Scop) seedling quality (Ivetić *et al.* 2013). The RCD has a direct relationship with more roots and better balance of root to shoot ratio in the field (Johansson *et al.* 2012; Mohamed, 2013; Takoutsing *et al.* 2013). On other hand, tree species that are hard to root (Pangou *et al.* 2011) could have different initial field performance. For instance, seedlings of *Carapa procera* propagated from seeds and *E. globulus* of similar genetic background initially had larger basal diameter and height though after five years became similar with those of trees propagated using stem cuttings

(Gaspar *et al.* 2005; Pangou *et al.* 2011). This shows that planting stocks from both propagation techniques can be used provided they have ability to achieve higher amount of seedlings during propagation and survive efficiently in the field.

On other hand, the relatively low survival rate achieved with seedlings propagated from stem cuttings was contributed by sporadic and low rainfall experienced during the planting season which favoured early termite attack of newly transplanted seedlings. Nevertheless, in addition to using seedlings with large RCD, initial field survival can also be improved through application of termiticides and planting in land that is adequately prepared. Adequately prepared land enhances soil moisture holding capacity caused by reduced weed competition and increased water infiltration (Chamshama and Nshubemuki 2011). Basing on benefits obtained with clonal propagation, especially on mass propagation and production of true-to-type seedlings (Longman 1993; Hartmann *et al.* 2011), its application could facilitate improvement, larger-scale planting and conservation of tree species with seed germination related problems and easier to root.

#### **CONCLUSION AND RECOMMENDATION**

Seedlings propagated using stem cuttings of *O. welwitschii* before field transplanting, had good quality morphological characteristics based on root biomass and stem diameter. Preliminary results of study also revealed that *O. welwitschii* seedlings propagated from stem cuttings established and survived better than that propagated using seeds in the field. Thus, large-scale planting of *O. welwitschii* in on-farm and plantations constrained by seeds dormancy and low seeds germination rate can be increased by using seedlings propagated from stem cuttings. However, further



studies are required to compare long-term field performance of stem cuttings and seedlings propagated using seeds based on survival, stem form and wood properties.

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