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# Growth Performance of *Moringa oleifera* Planting Materials Derived from Cuttings and Seeds

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## Abstract

The worldwide interest in herbal medicine is putting intense pressure on tropical biodiversity as increasing numbers of plant species are harvested for their medicinal properties. This has led to the forest policy laying more emphasis on the need to move from reforestation of gazetted forests to afforestation of community and farm forests. However, the afforestation program depends to a large extent on the rate of germination of seeds. *Moringa oleifera* one of the key medicinal plants highly affected by germination conditions. Unfortunately, there is no published data on its seedling Eco-physiology (regeneration both natural and artificial) or the species exploitation rates in Kenya. *Moringa* seeds, when sown in the seedbed germinate readily, but after emergence, they start dying, with very few or none reaching field planting stage i.e. 30 cm. This has led to the *Moringa* population remaining low. Therefore, this study aimed to establish the difference in growth performance of *Moringa oleifera* planting materials derived from cuttings and seeds. The study was carried out at the tree nursery at University of Eldoret that is situated in Uasin Gishu County of Kenya. *Moringa oleifera* seeds and cuttings were collected from 30 phenotypically better looking healthy trees in Marigat, Baringo County. The seeds and the cuttings were planted under two different conditions (greenhouse and normal/outside) and different watering frequencies. The results show that upbringing of *Moringa oleifera* through use of seeds had better performance than use of cuttings, both in the greenhouse and outside. In addition, cuttings of all diameter classes studied planted outside did not sprout. In the greenhouse, those in diameter class 1 and those only watered twice a day had 5.8 % survival at the end of the experiment. In diameter class 2, survival ranged from 5 % to 35 % and diameter class 3, survival ranged from 5 % to 15 % at the end of the experiment. The watering frequency used did not show any significant difference in the growth and survival of the seedlings. The mean height and mean root collar diameter of the seedlings in the greenhouse and outside did not show significant differences in their growth, when subjected to similar treatments. The study recommends that *Moringa oleifera* planting material should be done in the green house as faster growth and better results are realized. In addition, propagation through seed is still the better alternative for *Moringa oleifera* species.

## Keywords

*Moringa olifera,* Propagation, Growth Performance

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## 1. Introduction

The worldwide interest in herbal medicine is putting intense pressure on tropical biodiversity as increasing numbers of plant species are harvested for their medicinal properties (Lewis, 2003). *Moringa oleifera* is one of these important but endangered medicinal trees (Khan, Dular& Solomon, 2003). This has led to the forest policy laying more emphasis on the need to move from reforestation of gazetted forests to afforestation of community and farm forests (Lund, 2006). This is important in order to meet the needs of the fast

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growing population in terms of forest products, fodder for animals and other requirements such as soil and water conservation, food, medicine, shade and improvement of soil fertility among others.

Emphasis has to be put on farms through Agroforestry practices and on community lands as woodlots, scattered trees along road reserves, schools grounds etc. The afforestation program depends to a large extent on the rate of germination of seeds, which is the most commonly used method of regeneration (Ramachandra&Thapliyal, 1995). Mature seeds of some tree species readily germinate under favorable conditions of moisture and temperature (Baskin, 2001). This results in uniform germination in large quantities, which can meet the requirements of afforestation. Other seeds do not germinate until dormancy is broken through seed pretreatment methods (Baskin& Baskin, 2004) while other seeds, like *Moringa* will germinate but not establish itself to maturity (Muhl, 2009). This could be due to low seedling vigor, unfavorable environmental conditions, such as moisture, post-emergence infestation by pests or infection by pathogens or lack of viable seeds due to poor storage (Desai, 2004). This affects reforestation in that less seedlings will be available for planting at a given planting time.

*Moringa oleifera* one of the key medicinal plants highly affected by germination/growth conditions (Muhl, 2009). It is native to India, Arabia and naturalized in Tropical Africa (Anwar, Latif, Ashraf,& Gilani, 2007). In Kenya, it's found mainly in the Northern regions including Wajir, Garissa, Taita and Moyale counties (Tsaknis, Lalas, Gergis, Dourtoglou & Spiliotis, 1999). The tree is only found in patches and does not seem to regenerate itself in those areas. This could be due to fungal infections, pests' infestation, over exploitation due to its many uses by the local people and their livestock or due to lack of an alternative tree species which could meet the needs of the people.

*Moringa* is a multipurpose tree (MPT).It is used as a vegetable, medicine, for fodder and its gum is used in textile industries (Paliwal& Sharma, 2011). The bark is used for rope and mat making, wood used for pulp and paper, and seeds yield a clear odourless oil, to the extent of 22 %- 38.5 % (Fuglie, 2005), which is an excellent salad oil. *Moringa oleifera* is not only a source of medicine for patients, but also an important source of income for local and national economies.

Even with all these uses,*Moringa* has only recently been introduced in the highlands as an Agro forestry tree species in a very limited scale; hence its population in Kenya has remained low. It is expected that with the growing confidence in natural medicines, the market for *Moringa oleifera* remedies could double or triple in the next few years. This will be a major issue since the sustainability of harvesting *Moringa* is of concern, particularly with continued selective exploitation of the species. Conservation issues associated with *Moringa* collection in Kenya are that it has very high post germination mortality (sometimes 100%) (Phiri & Mbewe, 2010).

Unfortunately, there is no published data on its seedling Eco-physiology (regeneration both natural and artificial) or the species exploitation rates in Kenya. *Moringa* seeds, when sown in the seedbed germinate readily, but after emergence, they start dying, with very few or none reaching field planting stage i.e. 30 cm (Baskin, 2001; Anwar *et al.,* 2007). This has led to the *Moringa* population remaining low. Successful afforestation requires, among others, a high percentage rate of germination in the nursery. *Moringa* is normally grown easily from seeds or cuttings. Seeds are planted 2 cm deep and germinate within 1-2 weeks. Germination rates are usually very good, as found out in India, but survival can drop to 0 % after two weeks (Price, 2000). An alternative method of propagation through cuttings (vegetative propagation) has not been tried in order to determine whether it is a better alternative to seed propagation. Therefore, this study aimed to establish the difference in growth performance of *moringa oleifera* planting materials derived from cuttings and seeds.

## 2. Materials and Methods

The study was carried out at the tree nursery at University of Eldoret that is situated in Uasin Gishu County of Kenya. The area is approximately 1950 m above sea level and has a mean annual temperature of 14 - 16°C (Maxon & Ofcansky, 2014). The area receives annual rainfall in the range of 900-1110 mm. The soil is of igneous origin and acidic (pH 4.5-5.0), with low fertility and moisture storage. It is classified as rhodic ferralsol classification and oxisols classification (Osundwa *et al.,* 2013).

*Moringa oleifera* seeds and cuttings were collected from 30 phenotypically better looking healthy trees in Marigat, Baringo County. The seeds were collected when the pods had turned brown in colour. Seeds were picked at random for sowing. The cuttings were also obtained from the 30 trees.

### 2.1. Vegetative Propagation

Coppice spouts of three diameter classes (5 mm-10 mm, 14 mm-16 mm, 17 mm-20 mm) from 30 superior trees that were just beginning to harden, were cut and kept constantly moist. The cuttings were inserted in the rooting hormone, (Anatone 3, a synthetic Auxin) which contains 33 % Alpha Naphthalene Acetic Acid (ANAA), to accelerate their rooting and placed in a polythene tube with soil. The tubes were placed under a greenhouse and normal field conditions in the nursery. Two temperatures regimes (normal condition (14-16 °C) and green house (18-20 °C) were used.Three watering regimes (twice a day, once a day, once on alternative days) were also adopted. An insecticide was used to control pests at the beginning of the experiments in the soil medium and again after clones sprouted. The treatments were replicated three times.

Six (6) cuttings were used per experimental unit. A total of 648 cuttings were used, 324 in the greenhouse and 324 under normal field conditions. For all treatments, forest soil was used in 15 cm diameter polythene tubes where each cutting was planted. Observations were done at 8 am daily and any sprouting of the cuttings was recorded. This continued for six months. Weeding was done to ensure no competition for water and nutrients was subjected to the cuttings. In the control no hormone or insecticide was used throughout the experiment. This was to try and find out whether this was the cause of the clones' death.For each treatment, the number of successfully sprouted cuttings was recorded and calculated as a percentage of the total. The best treatment was assessed on the basis of clones' survival at the end of the experiment.

### 2.2. Seed Propagation

Seeds were picked at random and two seeds sown directly on individual containers (polythene tubes 15 cm diameter), in a medium of forest soil. The sown seeds were placed in the greenhouse and others under normal field conditions, two temperature regimes (greenhouse (18-20 ° C) normal field temperature (14-16 ° C), three watering regimes (twice a day, once a day, and once on alternative days). An insecticide was also used to control any insect infestation.

Six (6) seeds per treatment were used and replicated three times. A total of 216 seeds, 108 in green house (36 for each watering regime) and 216 under normal field conditions (36 for each watering regime) were used. Daily observations were made to note commencement of germination. After the first germination was noted, the experiment was left for 14 days, before seedling heights and root collar diameters of each seedling were measured on weekly basis. This was to give all seeds time to germinate. For the polythene tubes where both seeds germinated one seedling was removed and only one seedling was left in each polythene tube. The height was measured using a meter rule where the measurement was taken from the base of the stem to the tip of the shoot. The root collar diameter was measured using a veneer calipers at the base of the stem. The mean height and mean root collar diameter for each week was calculated. This was done for all the seedlings during the experiment.

The best treatment was assessed on the basis of the growth performance of seedling in terms of seedling height and root collar diameter.

### 2.3. Data Analysis

All data were subjected to analysis of variance (ANOVA) to quantify the differences between applied treatments. Treatment means were separated using the least significance differences (LSD) at 0.05. Excel and SAS computer packages and Duncan's multiple range test was used.

## 3. Results and Discussion

### 3.1. Growth Performance Under Greenhouse Conditions

#### 3.1.1. Seedling Height

There were no significant differences in seedling height growth in the greenhouse and their controls.Height growth for all treatments showed a steady increase throughout the experiment. The 30 cm height recommended for field planting, was attained within the $11^{th}$ -$13^{th}$ week, after start of data collection i.e. $14^{th}$ -$16^{th}$ week after sowing.

The mean height growth, when comparing all the three treatments (treatment one- watering twice a day; treatment two-watering once a day; treatment three-watering once on alternative days), showed that it was highest in treatment 1 and lowest in treatment 2. The difference between the treatments was, however not significant. (Figure 1)

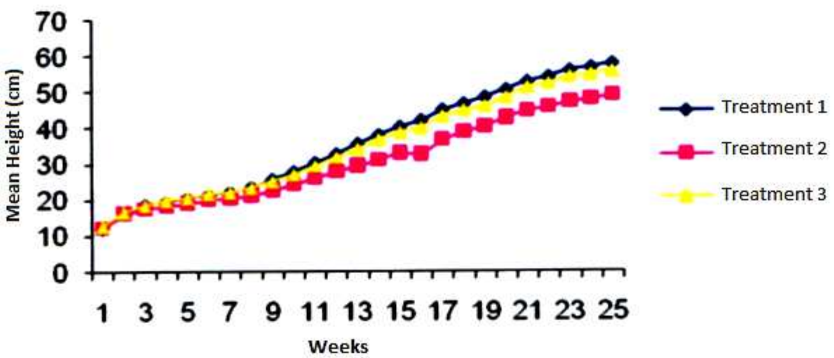


**Figure 1.** Mean Height Growth for the 3 Three Treatments.

Figure 1 seedlings planted in the greenhouse, the mean height growth was highest for treatment 1, followed by treatment 3 and then treatment 2.

Since computed value of F = 1.07 with $p$-value = 0.347 > 0.05, it is concluded that these differences were not significant at 5 % level of significance.

Using the Duncan's multiple range test to separate the means, it was found that:

- Between Treatments 1 and 2, computed P - Value = 0.1729 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.
- Between Treatments 1 and 3, computed P - Value = 0.8017 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.
- Between Treatments 2 and 3, computed P - Value = 0.2646 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.

### 3.1.2. Root Collar Diameter

Root collar diameter growth increased steadily throughout the experiment for treatment 2 and 3, but had a high increase in treatment 1 from the 23rd week, while its control continued its increase uniformly. There were however no significant difference in all the treatments and their controls. When the mean collar diameters for all treatments were compared, treatment 1 showed higher difference. This was due the high increase experienced from the 23rd week due to the high temperatures, 22-24 °C, experienced that week.

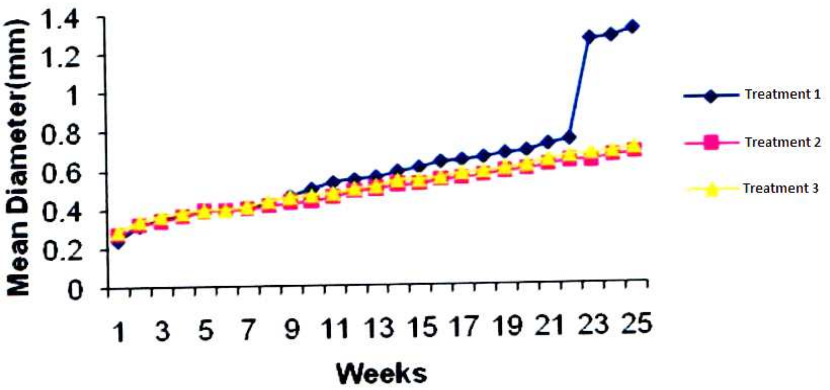


**Figure 2.** Mean Diameter Growth for the 3 Treatments.

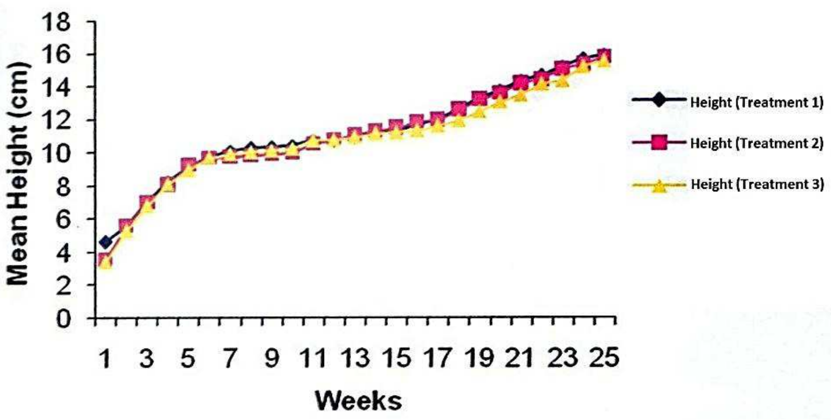


**Figure 3.** Seedling Height for the 3 Treatments under Normal Conditions.

Figure 2 seedlings planted in the greenhouse, the mean diameter growth was highest for treatment 1 and was almost the same for treatments 2 and 3.

Since computed value of F = 3.03 with P - value = 0.0546 > 0.05, it is concluded that these differences were not significant at 5 % level of significance.

Using the Duncan's multiple range test to separate the means,

- Between Treatments 1 and 2, computed P - Value = 0.0246 < 0.05, implying that there was a significant difference between the two means at 5 % level of significance.
- Between Treatments 1 and 3, computed P - Value = 0.0593 > 0.05, implying that there was no significant

difference between the two means at 5 % level of significance.

- Between Treatments 2 and 3, computed P - Value = 0.7057 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance

## 3.2. Growth Performance under Normal (Outside) Conditions

### 3.2.1. Seedling Height Growth

Seedlings planted under normal conditions (14-16°C) and watered once a day at the 25$^{th}$ week.Mean height growth for all seedlings planted outside showed a steady increase. There was no significant difference between the treatments and their controls. The seedlings did not attain the 30 cm. height at the end of the experiment for all the treatments.

When the mean height growth was compared between the three treatments (Treatment. 1- watered twice a day; Treatment 2- watered once a day; Treatment.3- watered once on alternative days) it showed that the height growth was almost the same, hence no significant difference (Figure 3).

Figure 3 seedlings planted outside the mean height growth was almost the same for all the treatments.

Since computed value of F = 0.10 with P - value = 0.9078 > 0.05, it is concluded that these differences were not significant at 5 % level of significance.

### 3.2.2. Root Collar Diameter

Root collar diameter growth for treatment 1 and its control were almost the same. For treatment 2, the control was higher, while for treatment 3 they were almost the same. There were no significant difference between the treatments and their controls. Also when all the treatments were compared, they showed no difference in their root collar diameter growth (Figure 4).

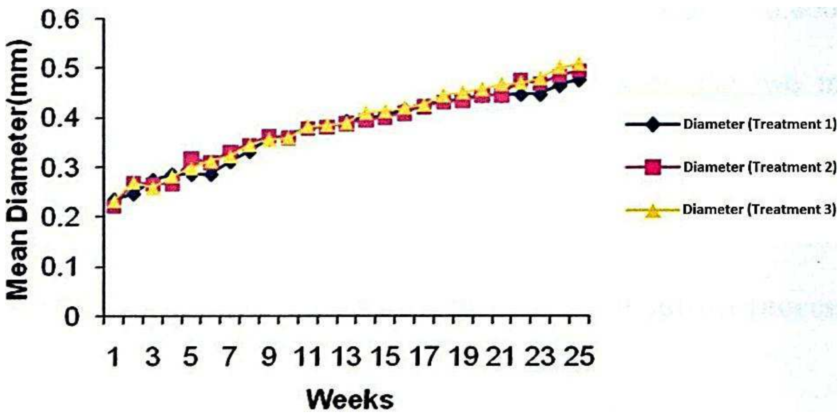


**Figure 4.** Mean Root Collar Diameter for the 3 Treatments under Normal Conditions.

Figure 4 seedlings planted outside, the mean root collar diameter growth was almost the same for all the treatments

Since computed value of F = 0.12 with P - value = 0.8892 > 0.05, it was concluded that these differences were not significant at 5 % level of significance (Appendix 28).

Using the Duncan's multiple range test to separate the means, it was found that:

- Between Treatments 1 and 2, computed P - Value = 0.8113 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.
- Between Treatments 1 and 3, computed P - Value = 0.6292 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.
- Between Treatments 2 and 3, computed P - Value = 0.8069 > 0.05, implying that there was no significant difference between the two means at 5 % level of significance.

## 3.3. Comparing Growth under Greenhouse and Outside (Normal Conditions)

### 3.3.1. Mean Height

There was significant difference between the seedlings grown in the greenhouse and those grown outside for all the treatments. Those in the greenhouse had higher mean height growth than those grown outside. Seedlings watered twice a day, the mean height growth was higher for thoseplanted in the greenhouse than those planted outside.Since computed value of F = 69.38 with *p-value* = <0.0001 < 0.05, it is concluded that this difference is highly significant at 5 % level of significance.

Seedlings watered once a day, the mean height growth was higher for thoseplanted in the greenhouse than those planted outside. Since computed value of F = 68.94 with *p-value* = <0.0001 < 0.05, it is concluded thatthis difference is highly significant at 5 % level of significance.

Seedlings watered once on alternative days, the mean height growth was higherfor those planted in the greenhouse than those planted outside. Since computed value of F = 73.26 with *p-value* = <0.0001 < 0.05, it is concluded thatthis difference is highly significant at 5 % level of significance.

### 3.3.2. Root Collar Diameter

Seedlings in the greenhouse showed higher root collar diameter growth in all the treatments as compared to those grown outside. The difference was highly significant.Seedlings watered twice a day, the mean collar diameter growth was higher for those planted in the greenhouse than those planted outside.Since computed value of F = 16.69 with *p-value* =0.0002 < 0.05, it is concluded that this difference is highly significant at 5 % level of significance.

Seedlings watered once a day, the mean collar diameter growth was higher for those planted in the greenhouse than those planted outside.Since computed value of F = 17.42 with *p-value* = 0.0001 < 0.05, it is concluded that this difference is highly significant at 5 % level of significance.

Seedlings watered once on alternative days, the mean collar diameter growth was higher for those planted in the greenhouse than those planted outside.Since computed value of F = 20.69 with *p-value* = <0.0001 < 0.05, it is concluded that this difference is highly significant at 5 % level of significance.

## 4. Discussion

### 4.1. Effect of Propagation Method

The raising of *Moringa oleifera* through seeds and cuttings showed that seeds had better performance than cuttings, both in the greenhouse and outside. In addition, cuttings of all diameter classes studied planted outside did not sprout. In the greenhouse, those in diameter class 1 and those only watered twice a day had 5.8 % survival at the end of the experiment. In diameter class 2, survival ranged from 5 % to 35 % and diameter class 3, survival ranged from 5 % to 15 % at the end of the experiment.

The low survival of cuttings in this study could be due the fact that roots did not seem to develop fast enough to start providing nutrients to the cuttings from the soil. Even those cuttings that survived did not have well developed roots at the end of the experiment. This study thus shows that seedlings from seeds were better performers than the cuttings both in the greenhouse and outside.

### 4.2. Effect of Watering Frequency

The three watering regimes used i.e. twice a day (Treatment. 1), once a day (Treatment.2) and once on alternative days (Treatment. 3), did not show any significant difference in the growth and survival of the seedlings and clones in the greenhouse or outside. Thus watering is not the cause of high mortality of *Moringa oleifera* seedlings after germination in the nurseries.

### 4.3. Growth Performance Among Seedlings

The mean height and mean root collar diameter of the seedlings in the greenhouse and outside did not show significant differences in their growth, when subjected to similar treatments. Also the growths showed no significant difference when each treatment was compared with its control. This showed that the diameter and height growths were not affected by the different watering regimes.

When height and diameter growths of seedlings in the greenhouse and outside, of each treatment were compared, they all showed significant differences. The greenhouse seedlings had higher growth than those outside. This could be associated with the difference in temperatures, thus indicating that high temperatures results in better performance for *Moringa oleifera. Moringa oleifera* is an ASAL species, and therefore it requires high temperatures to grow well.

### 4.4. Growth Performance Among Clones

Temperatures affected the growth of cuttings as no cutting (0 %) in the three diameter classes sprouted, for those cuttings planted under normal conditions (14-16 °C). Higher temperatures (18-20 °C) favoured the growth of the cuttings as those in the greenhouse sprouted, although the survival percent was low (0 % - 35 %). The diameter size also showed some effect in the growth performance. The bigger diameter cuttings continued growing for a longer time after sprouting, while those with smaller diameters either sprouted and later died or did not sprout at all.

## 5. Conclusion

*Moringa oleifera* propagation by seeds or clones is not affected by the watering frequencies as the three watering regimes used did not show any significant differences in their growth performance and survival. Raising *Moringa oleifera* through seeds had better results than using the cuttings for both temperature regimes (14-16°C, 18-20°C).Growth performance of *Moringa oleifera*, especially on height and diameter growth was better in temperatures 18-20 °C than in temperatures 14-16 °C. This was seen in the seedlings and cutting raised in the greenhouse which performed better than those under normal conditions.If cuttings are to be used in the propagation of *Moringa oleifera*, 14 mm- 16 mm diameter class cuttings would yield better results. This is due to the fact that larger diameter cuttings can continue supporting the sprouting branches before proper root development is achieved, to enable the cuttings utilizing the nutrients in the soil.

## Recommendations

The following recommendations can be made:-

- *Moringa oleifera* planting material should be done in the green house as faster growth and better results are realized.
- Propagation through seed is still the better alternative for *Moringa oleifera* species.
- More research should be done by transplanting greenhouse and outside (normal conditions) seedlings into the field, so as to assess their performance and therefore determine whether the shoot: root ratio affects their growth and survival in the field.
- Different lengths of cuttings should be tried to determine the appropriate lengths and more time needed for the cutting to fully develop their roots.

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