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Seed Germination and Early Growth of *Moringa oleifera* Seedlings

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Abstract

Currently, much attention is being focused to identifying suitable tree species that can provide large biomass that can be used for bioenergy. Short rotation tree species have been recognized as one of the main bioenergy resources. Seed germination and early growth potentials of *Moringa oleifera* seedlings were investigated under five potting media. Germination was monitored for 35 days while early growth characteristics were monitored for 16 weeks. Germination commenced on the 6th day after sowing and was completed between 11th and 12th day, indicating a uniform and quick germination of the seeds. Germination percentage varied between 58 and 76%. The effect of potting media on germination was significant, with seeds sown in river sand giving a significantly lower germination than those sown in other media. At the end of the 16th week of growth, average number of leaves produced varied between 793 and 1657 (maximum: 4000). This high number of leaves, which implies large photosynthetic area for Moringa seedlings were probably responsible for rapid total height and diameter growth of the seedlings. Mean total height ranged from 72 and 100.9 cm (maximum: 145 cm) while mean collar diameter varied from 0.67 to 0.89 cm (maximum: 1.49 cm) during the four months growth period. The effects of potting media on total height, collar diameter and number of leaves were not statistically significant indicating the ability of Moringa seedlings to grow in a wide range of site conditions.

Keywords: *Moringa oleifera, Germination, Early growth, Potting mixture, Bioenergy*

Introduction

Recently, concerns regarding the environmental consequences of high dependence on fossil fuels have been growing (Bhattacharya, *et al.*, 2003; Raison, 2006). Carbon-dioxide (CO_2) emission from mainly fossil fuel and coal is projected to increase from 26 Gt in 2004 to 40 Gt in 2030 (IEA, 2006). Environmental degradation, coupled with the persistent energy crisis has stimulated an increased interest in raising alternative, renewable, fast growing and high yielding short rotation energy plantations (Onyekwelu, 2011). The use of fast growing energy tree species has been identified as a promising option for reducing the high dependence on fossil fuels and consequently mitigating its effect on the climate (Onyekwelu, 2011). Bioenergy is the most widely used renewable energy source, representing nearly a billion tons of oil equivalent consumption levels comparable to natural gas, coal and electricity (IEA, 2002). Biomass has been used for energy since the early days of humanity. Today, over 2.5 billion people depend on bioenergy for their household energy (IEA, 2006). Bioenergy is experiencing a surge in interest due to the recognition of its current and future potential contribution to modern fuel, its availability, renewability, versatility and sustainability; its global and local environmental benefits, the existing and potential development and entrepreneurial opportunities (Onyekwelu and Akindele, 2006). It is expected to become one of the key energy resources in the future. In 2007, bioenergy contributed about 10% of the 470 EJ world primary energy demand (FAO, 2008).

The inability of many people in developing countries, especially the rural dwellers, to afford fossil fuels and the failure of energy infrastructures, such as electricity, has increased their dependency on bioenergy (Onyekwelu and Akindele, 2006). In Africa, for example, between 75 and 95% of energy needs of most rural households have biomass as the primary energy source. A significant number of small-scale rural and urban industries in Africa such as tea, tobacco, cassava production, brick and tile industries, alcoholic beverage production, wood processing, fish smoking, bakeries, etc, rely on bioenergy (Onyekwelu, 2011). Currently, much attention is being focused on identifying suitable tree species that can provide high-energy outputs as well as developing appropriate biomass conversion technologies. Biomass productivity depends on factors such as species and their growth rates, soil quality, climate, silvicultural practice, spacing etc (Onyekwelu, 2011). Short rotation tree species have been recognized as one of the main sources of bioenergy, with the potentials of being the largest source in future (IEA, 1988; Sajjakulnukit and Verapong, 2003). With seed oil content of between 35 and 47%, *Moringa oleifera* or drumstick is among the tree species with great bioenergy potentials. NWFP-Digest (2008) reported that Moringa is capable of producing up to 2000 litres of oil per hectare. *M. oleifera* tree is a fast-growing deciduous, medium-sized tropical evergreen tree species that grows up to 12 m in height at maturity.

To produce the quantity of oil that will satisfy the ever increasing demand for bioenergy from Moringa, its plantations with high seed yielding potential must be established. Currently, information on the germination and early growth (i.e. silviculture) of *Moringa oleifera* is scanty. Since virtually no known study has been carried out in this respect, it is essential to undertake a research that will investigate the seed germination potentials and early growth of *Moringa oleifera*. This will be a basic research that will provide necessary information needed to enhance the establishment of large scale plantation of the species for large scale bioenergy (biodiesel) production.

Methodology

Moringa oleifera dry pods were collected from randomly selected trees at Molete in Ibadan, Nigeria, situated between latitude of 7º 22´ and 9º 17´ N and longitude of 1º 2´ and 2º 44´ E. The seeds were removed from the fruit pods by hand and the seeds subsequently cleaned. The extracted seeds were sun-dried for about a day. Five different potting media were used namely: forest topsoil, river sand, sawdust, topsoil + river sand mixture and topsoil + sawdust mixture. The topsoil and river sand were sieved using 2 mm sieve to remove stones, roots and other materials that may obstruct the emergence of plumule upon seed germination. Also unwanted materials that may obstruct seed germination were removed from the sawdust. Polypots were filled with the already prepared potting media. Each treatment (i.e. potting medium) had 10 polypots with the seeds of the species sown in them and replicated five times. There were a total of 50 seeds under each treatment and 250 seeds for the experiment. The polypots were watered twice daily (morning and evening) throughout the duration of the experiment. Germination counts were taken daily beginning from the first day of germination and monitored for 30 days.

Ten healthy seedlings of fairly uniform size were selected from each treatment for the evaluation of early growth characteristics. Measurement of early growth characteristics such as survival (%), collar diameter (cm), total height (cm) and number of leaves were recorded every week from the 30^{th} day after sowing. This phase of the experiment lasted for four months, giving a total of 16 weeks of measurements. During this period, seedlings were watered daily (i.e. morning and evening). Weeding of polypots was done only when necessary.

The experiment was arranged in a Completely Randomized Design (CRD). Five treatments were involved, which were the various potting media. The data from germination and early growth characteristics were subjected to one-way Analysis of Variance (ANOVA) to determine the degree of variation between the treatments. Since germination data were in percentages, they were transformed using Arcsine percentage transformation prior to ANOVA, which was necessary to conform the data to general assumptions of ANOVA. Treatments found to differ significantly were separated using Fisher's Least Significant Difference (LSD).

Results

Seed germination commenced on the 6^{th} day after sowing (DAS) and was completed between the 11^{th} and 12^{th} day (Figure 1). Except for the seeds sown in river sand, germination of *Moringa oleifera* seeds was generally high in all potting media. Except for sawdust, germination (range: 24% and 34%) on the 6^{th} day (i.e. the first day of germination) was high. The poorest germination on the first day of germination was obtained from sawdust, with only 6% of the seeds germinating. There was extremely high increase in seed germination by the 7th day after sowing. For example, seed germination increased from 26 to 60%, 24 to 58% and 34 to 60% between the 6th and 7th day for seeds sown in topsoil + sawdust, topsoil + river sand and topsoil, respectively (Figure 1).

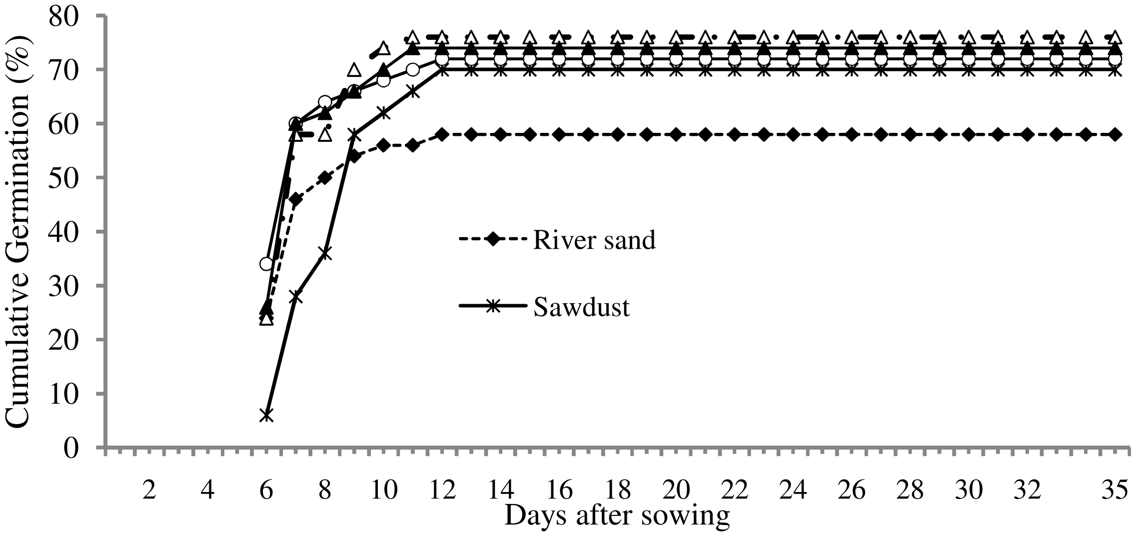

Figure 1: Cumulative germination (%) of *Moringa oleifera* seeds under different potting media

Except for seeds sown in sawdust where substantial germination was obtained by the 8th DAS, the rate of seed germination had slowed down by the 8th DAS for seeds sown in other sowing media. While germination was completed by the 11th DAS for seeds sown in topsoil + sawdust and topsoil + river sand, it was completed by the 12th DAS for seeds sown in other sowing media. At the end of the 35th day of germination experiment, the lowest and highest cumulative germination was 58% and 76%, respectively for seeds sown in river sand and topsoil + river sand, respectively (Figure 1). The results of ANOVA revealed a significant effect of potting media on the germination of Moringa seeds (Table 1). The results of mean separation showed that germination of seeds sown in river sand was significantly lower than those of other sowing media which were not significantly different from each other (Table 1).

The results of early growth characteristics revealed that Moringa seedlings have fast growth rates. For example, Moringa seedling in this study attained a maximum total height of 145 cm during the 4 months observation period. Figure 2 shows that the seedling attained an average total height of between 72 and 100.9 cm in the various potting media during the 4 months of growth. Generally, forest topsoil and river sand gave the highest height growth, although these were not significantly higher than the height growth under the other potting media (Table 1).

Table 1: Results of Analysis of Variance for the effect of potting media on seed germination and early growth rate of *Moringa oleifera* seedlings.

	River sand	Sawdust	Topsoil	Topsoil + River sand	Topsoil + sawdust
Seed germination (%)	58.0a	70.0b	72.0b	76.0b	74.0b
Total height (cm)	100.9a	85a	96.8a	78.4a	71.8a
Collar Diameter (cm)	0.89a	0.75a	0.81a	0.74a	0.67a
Leaf count	1478a	882a	1657a	805a	793a

Collar diameter growth of *Moringa* seedling was also high, attaining the maximum collar diameter of 1.49 cm in four months. At the end of the four months of growth observation, mean collar diameter varied from 0.67 to 0.89 cm (Table 1). Like height growth, the best seedling collar diameter growth was obtained under river sand and forest top soil (Figure 3). However, the effect potting media on collar diameter growth of the seedlings was found not to be statistically significant (Table 1).

Moringa seedlings produced a large number of leaves. Results indicate that a single seedling could produce as many as 4000 leaves by the fourth month of growth. Average number of leaves produced by the end of the fourth months of growth ranged between 793 and 1657 (Table 1). There was a sharp increase in the number of leaves produced after the twelfth week of growth, especially for seedlings planted in river sand and topsoil (Figure 4). The results of ANOVA revealed a non-significant effect of potting media on the number of leaf production (Table 1).

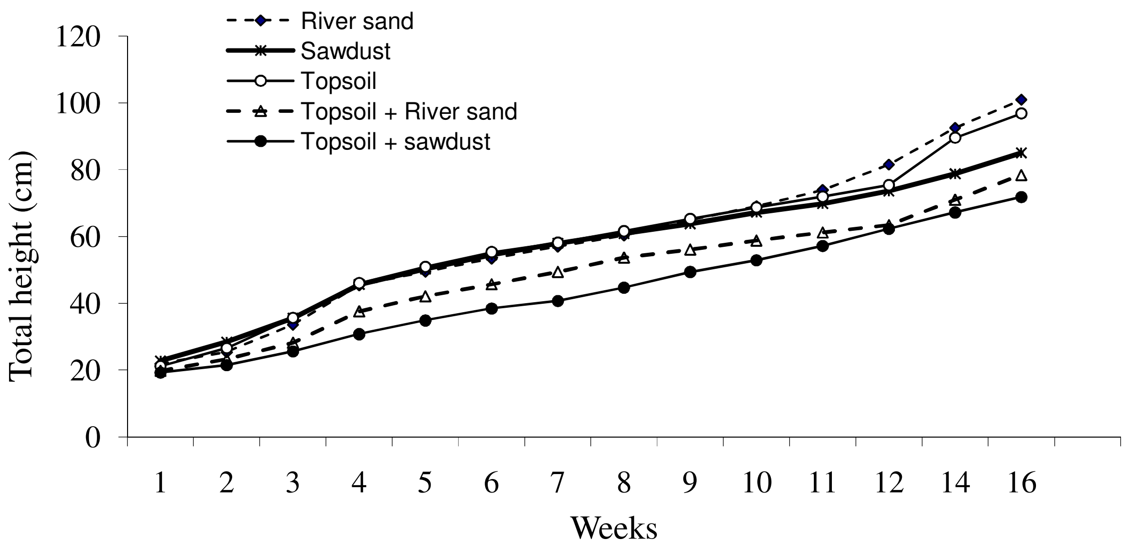

Figure 2: Mean total height growth of *Moringa oleifera* seedling under different potting media

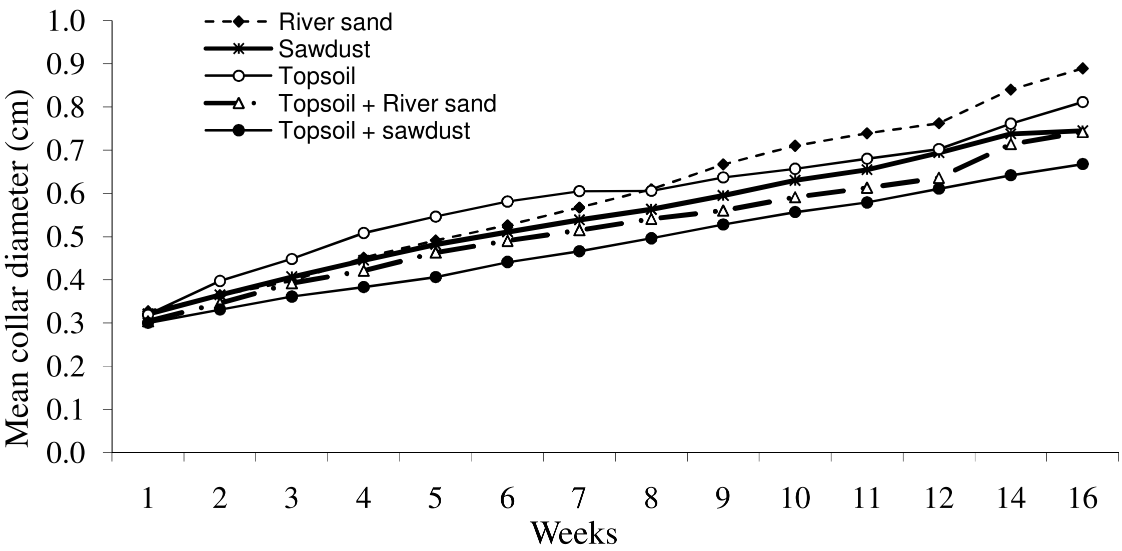

Figure 3: Mean collar diameter growth of *Moringa oleifera* seedling under different potting media

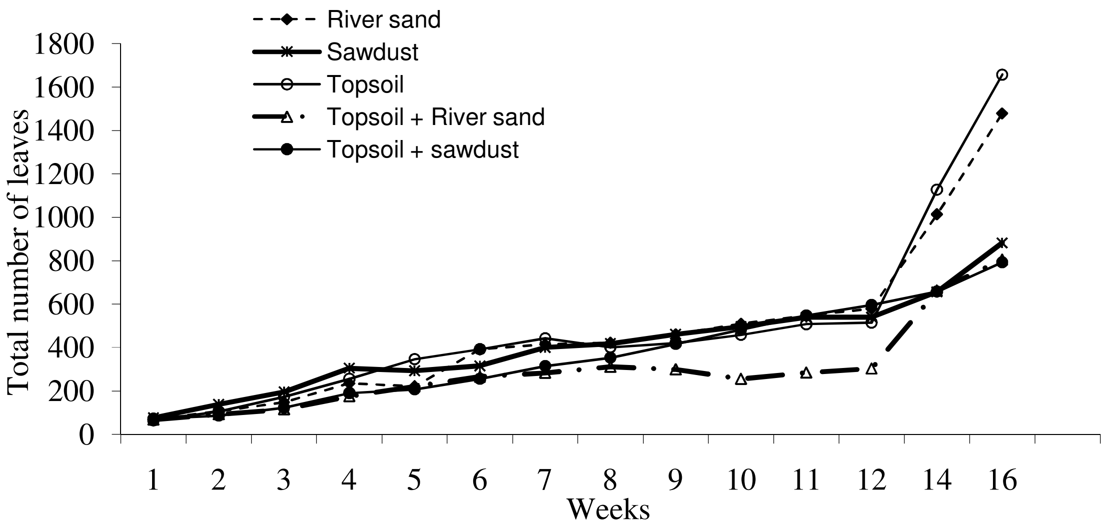

Figure 4: Mean number of leaf production of *Moringa oleifera* seedling under different potting media

Discussion

In short rotation bioenergy plantations, maximal profits by achieving maximum production from a site within a short period of time and at minimal costs are aimed at. This will entail appropriate silviculture, optimising genotype and/or adequate cultural management. Numerous species have been and are being tested for bioenergy potentials, among which *Moringa oleifera* is prominent. Generally, the choice of a species for bioenergy production depends on the ease of propagation from seeds and cuttings, ease of establishment, ability to tolerate a wide variety of climatic and site conditions, fast growth throughout rotation, high biomass production, simple and easy silviculture, ability to grow in monoculture, short rotation, etc (McKendry, 2002; Laureysens *et al*., 2004; Onyekwelu, 2011). The current surge in interest in bioenerrgy necessitates a good understanding of the silviculture of bioenergy tree species so that maximum production can be obtained.

Moringa oleifera is easily established through seed or cutting. The seeds are sown either directly or in containers, without any pre-treatment and germinates between 7 and 30 days after sowing. Moringa seeds have high germination capacity, with the seeds germinating regularly within a short time period. Our result shows that germination percentage of Moringa seeds ranged from 58 to 76%. The germination percentage recorded in this study is within the range recorded for some forest seed species (Agbogidi *et al.,* 2007 for *Dacryodes edulis*; Ojeifo *et al*., 2007 for *Dacryodes edulis*) but generally higher than what was reported for other forest seeds species (Aduradola *et al*., 2005 for *Chrysophyllum albidum*; Onyekwelu and Fayose, 2007 for *Chrysopyllum albidum*). There was indication that Moringa seeds can germinate easily, which was evidenced by the high and early germination of the seeds in this study. Results also indicated that most of the seeds germinated uniformly within a short period of time (between 6th and 12th day after sowing). The significant effect of potting media on Moringa seed germination in this study is in agreement with the report of Agbogidi *et al*. (2007), who observed significant effect of potting media on the germination of *Dacryodes edulis* seeds.

Moringa oleifera is a tree species with very fast growth rate as indicated by the results of the current study, which revealed that the seedling could attain high total height and collar diameter of 145 and 1.49 cm respectively in just four months of growth. Within the fourth months growth period, average total height growth ranged from 72 and 100.9 cm while average collar diameter growth varied from 0.67 to 0.89 cm. Assuming this growth is maintained throughout the year, this could amount to mean annual height and diameter growth of 2.88 – 4.36 m and 2.68 – 3.56 cm, respectively. This value is higher than what has been reported for the seedlings of some tropical tree species. Agbogidi *et al*. (2007) reported total height and collar diameter range of 15.0 – 19.6 cm and 0.8 – 1.5 cm, respectively for *Dacryodes edulis* seedlings after 10 weeks of growth. Ojeifo *et al*. (2007) and Ekeke *et al*. (2006) reported mean *Dacryodes edulis* seedling height growth of 22.4 cm and 32.85 cm after 6 and 12 weeks, respectively, which are much lower than that of *M. oleifera* in this study. The seedlings of the species grow faster than those of fast growing *Gmelina arborea*, which has been reported to attain an average annual height of between 1.5 and 2.5m during the first year of growth (Onyekwelu and Stimm, 2002).

The rapid early growth of Moringa seedlings could be associated with the high number of leaves produced. The species has the ability of producing up to 4000 (average 793 to 1657) leaves during early growth periods. This high number of leaves implies large cumulative photosynthetic area, which translates to fast growth. *Moringa oleifera* seedlings have considerable higher number of leaves compared to the seedlings of other tree species, which could possibly explain the much higher growth performance of Moringa seedlings. Agbogidi *et al*. (2007) reported a much lower number of leaves (between 5 and 10) for *Dacryodes edulis* seedlings. Similarly, Ojeifo *et al*. (2007) reported between 6 and 8 numbers of leaves after 6 weeks of growth for *Dacryodes edulis* seedlings.

Potting media did not have any significant effect on seed germination and early growth rate of Moringa seedlings. Thus, irrespective of potting media or their mixture, early growth of the seedlings was statistically similar. This result may be a confirmation that Moringa adapts well to a wide range of soil types, though the best growth is obtained in a well-drained loam to clay loam soil. However slightly better but non-significant growth results (especially from week 10) where obtained when the seedlings were planted in forest topsoil and river sand (Figures 2 & 3). This results contrasts with that of Agbogidi *et al*. (2007), who reported a significant effect of potting media on seed germination and early growth of *Dacryodes* *edulis* seedlings. The non-significant effect of potting media on germination and early growth rate of Moringa seedlings could be attributed to the ability of the species to grow in wide variety of sites and environmental conditions.

Conclusion

Moringa oleifera seeds have high germination capacity, with the seeds germinating regularly within a short time and completed within two weeks of sowing. The seed germinated easily and did not need pre-treatment prior to germination. Moringa seedlings have fast growth rates. Depending on potting medium, the seedling could attain mean total height of 72 and 100.9 cm (maximum of 145 cm) and mean collar diameter of 0.67 to 0.89 cm (maximum of 1.49 cm) with four months of growth. There was no significant effect of potting media on early growth of the seedling. The rapid early growth rate of Moringa seedlings could be attributed to its high number of leaves. The species has the ability of producing up to 4000 (average 793 to 1657) leaves during early growth periods. This high number of leaves implies large cumulative photosynthetic area, which translates to fast growth. The non-significant effect of potting media on early growth of Moringa seedlings could be a confirmation that Moringa adapts well to a wide range of soil types.

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