JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2014, 3(1), 20-26 ISSN:2325–4513(PRINT) ISSN 2325 - 453X (ONLINE)

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Research Article 20

# Effect of Shade on Seed Germination and Early Seedling Growth of *Moringa Oleifera* Lam.

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(**Received:** December 15, 2013; **Accepted:** January 16, 2014)

***Abstract:*** **This study investigated the effect of shade as a moderator of light intensity and temperature on seed germination and biomass accumulation and partitioning of *Moringa oleifera* seedlings. Three levels of shade were applied: high shade, medium shade and no shade. Germination was monitored for two weeks from seed sowing and germination rate and final percentage were calculated. Four sequential harvests were carried out starting from four weeks after seed sowing. Seedling growth variables were assessed at each harvest. The results showed that shade had significant effect on germination and seedling growth variables. Medium shade resulted in fast rate of germination and high germination percentage. Also, it gave higher values for the seedling growth variables and produced erect and strong shoot than the other two treatments. These findings indicate the importance of medium shade to the germination and seedling growth of *M. oleifera* and that should be considered in the nursery conditions.**

***Index items*: *Moringa Oleifera;* Germination and seedlings growth; Shade levels.**

## I. INTRODUCTION

*Moringa oleifera* is a well-known and cultivated species of the family *Moringacae* and it is one of the world's most useful plants. It is native to the sub-Himalayan tracts of India and it has become naturalized in many locations in the tropics and is widely planted in Africa [1]. It is popularly called the "drumstick tree" for its fruits that are used by drummers and the "horseradish tree" for the flavor of its roots [2].The species is drought resistant, though in drought conditions it may lose its leaves, and it recovers when it rains [3]. It grows well under annual rainfall that ranges from 250 to 1500 mm and survives in a temperature range of 25 °C to 40 °C but has been known to tolerate temperature of 48 °C and light frost. It prefers neutral to slightly acidic soil and grows best in well-drained loam to clay-loam and it tolerates clay soils but does not grow well if waterlogged [3].The species has multiple uses that have attracted attention of researchers, development workers, and farmers. It is becoming a source of supplemented nutrition [4], where most of the world's poor people live [2]. The species is widely distributed in Sudan [5] and it was introduced originally as an ornamental. Because of its many uses, it is planted in the whole tropical belt and in Sudan concerned as "clarifier tree for turbid water" [6].

*M. oleifera* can be cultivated at the household level or in small communal nursery [6]. However, the effect of external environmental factor on seedlings growth is not fully studied under nursery conditions in Sudan, especially the effect of light intensity and temperature, which are in turn are affected by shade. In nursery practice, it is important to obtain the suitable light conditions to produce well balanced and hardened seedlings suitable for out planting. Jahn *et al*. [7] reported that germination and growth of *M. oleifera* seedlings is affected by light condition and recommended half shade for germination. Mohamad [8] mentioned that seedlings grown at 30% and 50% light intensity have tall and slim shoots with large dark green leaves and relatively poor root system. Ahmed *et al*. [9] showed that *M. oleifera* seedling under high shade produces succulent stem, but in the same time it needs some shade in early stage. Muhl*et al.* [10] indicated the importance of temperature and showed that seed germination and seedling growth of *M. oleifera* increased exponentially with an increase in temperature.

The objective of this study was to investigate effect of shade, as a moderator of light intensity and temperature, on seed germination percent and rate, seedling growth (accumulation and partitioning into root and shoot),and stem development of *M. oleifera*.

## II. MATERIALS AND METHODS

The study was conducted in a site near the nursery of the Faculty of Forestry, University of Khartoum, Sudan. The site was cleared, leveled and divided into three square units (1.5m x 1.5m each). Treatments consist of three level of shade: high, medium and without shade and they were assigned randomly to each of the three square units. To obtain the required, four pillars were erected in the four corners of each unit and then covered with green nets on the top and the four sides. One green net layer was erected on the top for medium shade (≈50% shade), double green net layer for high shade (≈80% shade) and no net on the top for without shade (≈ 0% shade).

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Aeration openings were made in each unit on the northern and southern sides. Fruits of *M. oelifera* were collected from trees grown in the study site and seeds were extracted, with an average weight of 0.232g per seed and laboratory germination was 85%. In each unit a total of 100 polythene bags (20x10cm) were filled with commonly used silt nursery soil (2.75kg). Two seeds were taken randomly from the seed lot and sawn in each polythene bag.

***Germination Count***

Germination was counted daily for two weeks and the following was calculated: days for 50% germination (the time taken to reach 50% of the final cumulative germination), germination rate (average length of time required for germination i.e. germination speed) and Germination percent (calculated as number of germinated seeds after 15 days related to total number of seeds) **[11]**.

***Seedling growth***

After germination count (two weeks from seed sowing), seedlings were singled out randomly and one seedling was left per polythene bag. Four harvests were carried out every four weeks; the first one was four weeks from seed sowing. The following variables were determined at each harvest: shoot length (cm), root length (cm), shoot dry mass (g), root dry mass (g), total dry mass (g) and root to shoot dry mass. Stem softness and resistance to cut were scored for seedlings at harvest three. Stem softness was measured by breaking the stem manually and scored it as soft or hard. Stem resistance was measured by cutting it with a razor and scored as easy, hard and very hard to cut. The data of germination and seedlings growth variables were analyzed for the three levels of shade by analysis of variance and mean separation procedures using SAS Statistical Analysis Software (2004).

## III. RESULTS AND DISCUSSION

***Effect of Shade on Germination***

Shade level had high significant effect on the studied germination variables after two weeks from date of sowing ($p \leq 0.0012$) (**Table 1**). The days for 50% germination and germination rate of the high and medium shades had significantly lower values (less time to germinate) than no shade (**Table 1**). The percentages of the medium and no shades (96% and 90%, respectively) were significantly higher than the high shade (81%).

**Table 1**

Effect of three shade levels on germination variables of *Moringa oleifera* after two weeks from seed sowing date

| Shade level | Germination variables | | |
|---|---|---|---|
| | Days for 50% Germination | Germination Rate (days) | Germination percent % |
| High shade (≈80%) | 6.05 b | 6.88 b | 81 b |
| Medium shade (≈50%) | 6.08 b | 7.05 b | 96 a |
| No shade | 8.65 a | 10.15 a | 90 a |
| P- value | 0.0001 | 0.0001 | 0.0012 |

Means with the same letter in the same column are not significantly different at P =0.05 according to Duncan's Multiple Range Test.

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***Effect of Shade on Seedling Growth***

At each of the four harvests (first one was four weeks from seed sowing and then every four weeks) seedlings growth variables were significantly affected by shade level ($p \leq 0.002$). Means of the growth variables were significantly different among the shade levels (**Figure 1, 2, 3, 4, 5 and 6**).Medium shade had significantly higher shoot dry mass, root dry mass and total plant dry mass at each harvest, while high shade had the lowest values (**Figure 1, 2 and 3**).The ratio of root dry mass to shoot dry mass also was significant among shade levels in the four harvests, where medium shade had the high ratio and high shade had the lowest in harvest 2,3 and 4(**Figure 4**). Effect of shade on shoot length and root length on each of the four harvests was highly significant (P= 0.0001).

In the first harvest, the high shade had the highest shoot length followed by the medium shade (**Figure 5**). However, in the third and fourth harvests; medium shade had significantly the highest shoot length and no shade resulted in significantly the lowest shoot length in all harvests. In harvest 3, the high shade gave succulent and tender shoot, while the medium and no shades gave erect and strong shoot (**Table 2**). Generally, the medium shade resulted in the longest root in the four harvests (**Figure 6**). High shade displayed significantly the lowest root length in all harvests. Also, the high gave small and weak root, while the medium and no shade gave tuberous and swollen roots.

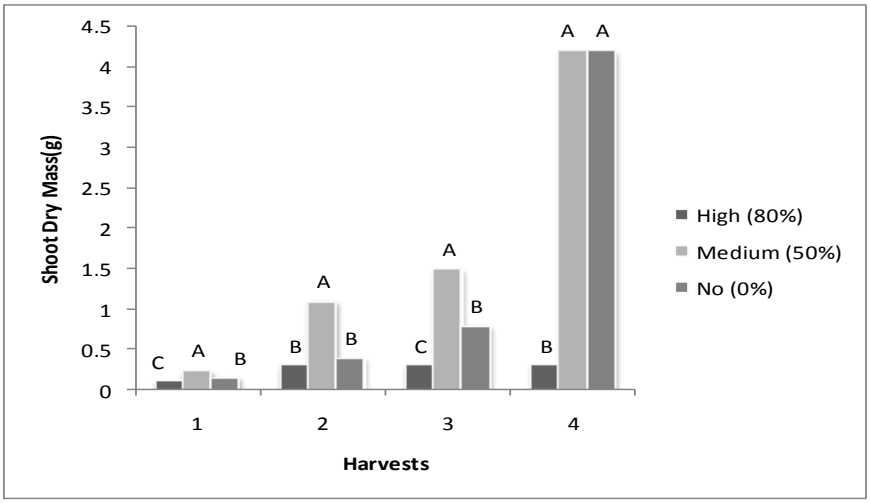


**Figure 1.** Effect of high (≈80%), medium (≈50%) and no shade on shoot dry mass of *Moringa oleifera* on four subsequent seedling harvests (every four weeks) (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test)

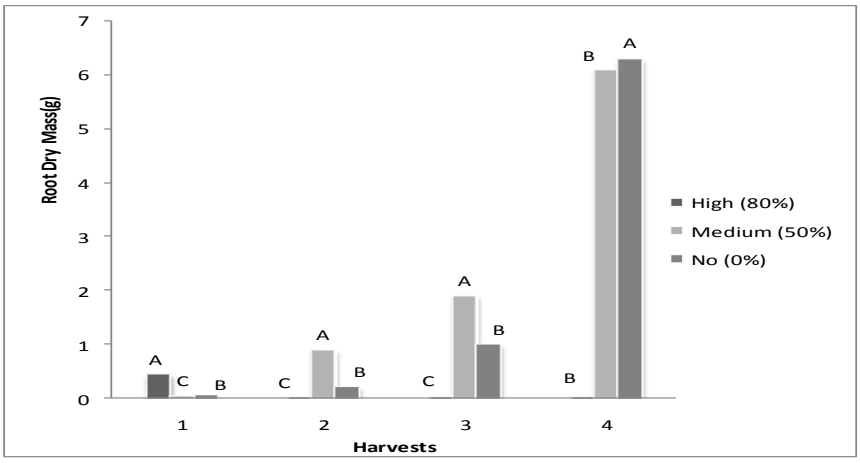


**Figure 2.** Effect of high (≈80%), medium (≈50%) and no shade on root dry mass of *Moringa oleifera* on four subsequent seedling harvests (every four weeks) (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test)

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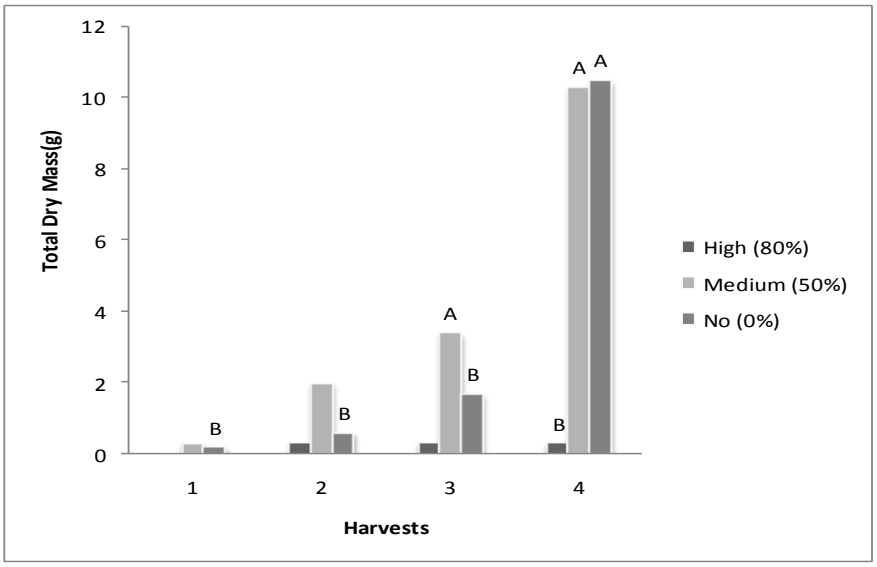


**Figure 3.** Effect of high (≈80%), medium (≈50%) and no shade on total plant dry mass of *Moringa oleifera* on four subsequent seedling harvests (every four weeks) (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test)

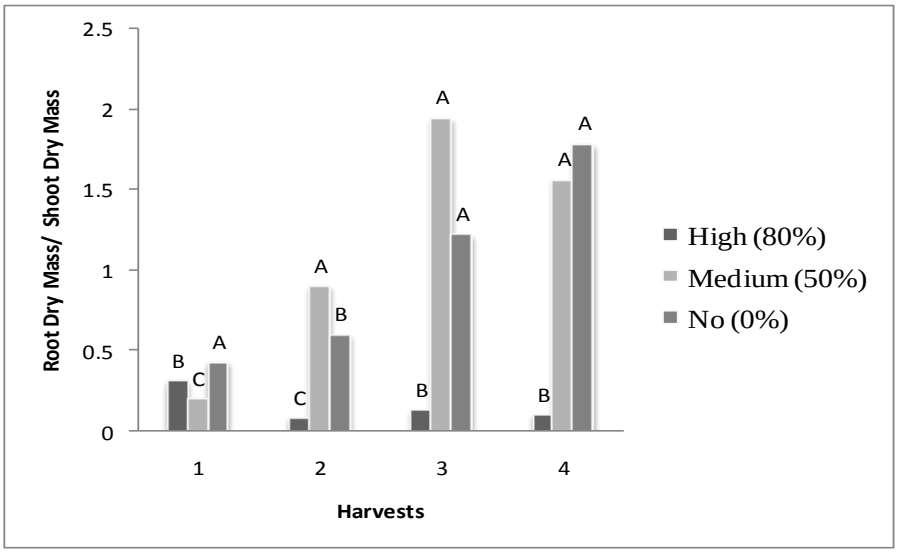


**Figure 4.** Effect of high (≈80%), medium (≈50%) and no shade on root to shoot dry mass ratio of *Moringa oleifera* on four subsequent seedling harvests (every four weeks) (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test)

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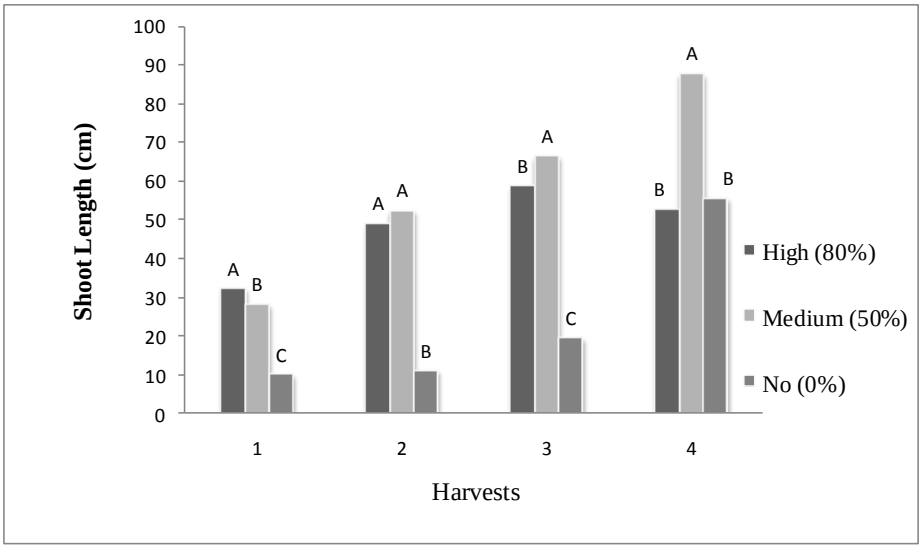


**Figure 5:** Effect of high (≈80%), medium (≈50%) and no shade on shoot length of *Moringa oleifera* on four subsequent seedling harvests. (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test).

**Table 2**

Effect of shade levels on the stem softness and resistance to cut of *Moringa oleifera* seedling growth after 12 weeks from seed sowing date

| Shade level | Stem development | | | | |
|---|---|---|---|---|---|
| | Softness | | Resistance to cut | | |
| | Soft | Hard | Easy | Hard | Very Hard |
| High shade (≈80%) | 100% | 0% | 75% | 25% | 0% |
| Medium shade (≈50%) | 10% | 90% | 0% | 15% | 85% |
| No shade | 30% | 70% | 0% | 55% | 45% |

The results of the study confirmed that shade level (high shade, medium shade and no shade) have significant effect on the germination, seedlings growth and stem wood development of *M. oleifera*. The medium shade (≈50%) showed that it was the suitable level for commercial seedling production under nursery conditions.

The result indicated that germination of seeds of *M. oleifera* can occur with high percent under all shade intensities (**Table 1**). This means the seeds of *M. oleifera* can germinate over a wide range of light intensity, as noted by Dishna **[6]**. The high speed and high total percent of seed germination of *M. oleifera* under medium shade may be due to its moderation of suitable temperature, light intensity, moisture and aeration. Also, it may be due to less evaporation of water from the soil, similar to that recorded by **[11]**. Also, Jahn*et al.* **[7]** indicated that half shade is the optimum light condition for germination of all *Moringa* species.

The highest dry mass accumulation in medium shade (**Figures 1,2, and 3**) may also, be attributed to the

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microclimatic condition around the seedlings that increased net photosynthesis (e.g. threshold light intensity, moderate temperature, high humidity etc.), similar to the findings of Jahn *et al*. **[7]** and Khan and Shanker **[12]** . Mohammed **[13]** indicated that plants with partially shaded condition receive more light that is essential for photosynthesis and then partitioning of carbohydrates. The high seedling root to shoot and the high length of roots under medium shade indicates allocation of photosynthate to root system to support seedling shoot growth. The shoot length of *M. oleifera* seedlings (**Figure 5**) under medium shade were similar to that concluded by Jahn *et al*. **[7]** and GFU **[14]**, and the stem is more lignified and developed (**Table 2**), similar to Ahmed *et al*. **[9]**.

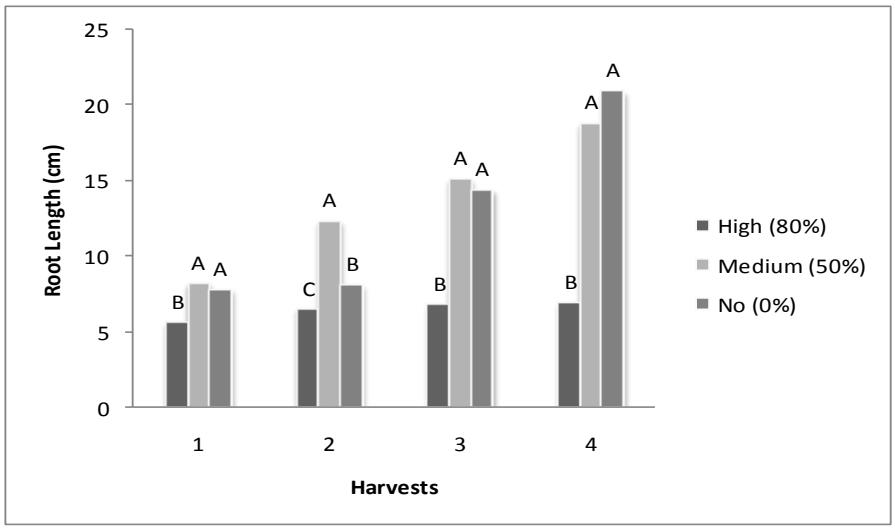


**Figure 6.** Effect of high (≈80%), medium (≈50%) and no shade on root length of *Moringa oleifera* on four subsequent seedling harvests (every four weeks) (Means with the same letter in the same harvest are not significantly different at P =0.05 according to Duncan's Multiple Range Test)

## IV. CONCLUSIONS

This study indicated that shade levels had significant effect on seed germination and seedlings growth of *M. oleifera*. Seed germination occurs with high percent under all shade levels; however, seedling growth is more affected by shade intensity. The seedling of *M. oleifera* under medium shade level produced significantly the highest biomass accumulation and partition. Also, the study indicated that stems seedling stems *M. oleifera* were affected by shade level; high shade produced succulent and tender shoot with small and weak root, while the medium and no shades produces erect and strong shoot with tuberous and swollen root. It is recommended to grow *Moringa oleifera* seedlings under medium shade level to enhance seedlings growth in the nursery.

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