***Original Research Article***

**Influence of light intensity and growing media on germination and growth of *Gmelina arborea* Roxb. seedlings in the south-eastern region of Rajasthan**

**ABSTRACT**

The multipurpose utility and fast-growing nature of *Gmelina arborea* Roxb.creates a demand for seedlings in nurseries. Various abiotic factors like the choice of media composition and light radiation plays a critical role in seed germination, seedling vigour, and overall plant development which ultimately affect the success of plantation. Therefore, the present study was conducted in the College of Horticulture and Forestry in Jhalawar district to produce robust seedlings under the influence of varying light intensity and growing media from July 2023 to March 2024. The study aimed to evaluate the germination and seedling performance of species under various growing media (soil, sand and FYM) in varying proportions, under different light intensities *i.e*., open condition, ~ 50% and ~25% light intensity in a completely randomized design (factorial). The result found that overall, the maximum germination percentage (80%) in the media comprising Soil: Sand: FYM (1:1:2) under ~50% light intensity. The seedlings raised in media containing Soil: Sand: FYM (2:1:2) in ~50% light intensity have recorded significantly superior seedling quality index (1.56 DQI). Among the various parameters *viz.,* seedling height, collar diameter, leaf count, taproot length and diameter, total fresh and dry weight, root shoot ratio, survival % and seedling quality index; the highest correlation found in seedling height with taproot length (r = 0.933) and the seedling quality was highly correlated with collar diameter (r >0.85). The findings support the use of species in reforestation, agroforestry, and commercial plantations, contributing to ecological restoration and sustainable timber production.

Keywords: *Gmelina arborea*, seedlings, growing media, light intensity, germination, seedling quality.

**INTRODUCTION**

*Gmelina arborea* Roxb., a very close relative of teak is gaining attention in the present situation. In addition to fulfilling domestic needs, wood and timber of the species has great demand in industrial agroforestry (Verma *et al.*, 2017). The multipurpose use of the tree including fuelwood, fodder, wood and other domestic needs etc makes it an ideal species under farm forestry, home garden and various afforestation initiatives.

*Gmelina arborea* locally known as White Teak and ‘Gamari’ or ‘Gamhar’ is an important deciduous tree which is most widely propagated and cultivated species of the family Verbenaceae. It is acknowledged for its fast and outstanding growth rate in low land regions with humid environment and abundant sunshine. It is adaptable to a wide range of climatic conditions. The tree is usually found scattered only in the moist localities of the country. It is particularly prevalent in the tropical mixed deciduous forests associated with *Tectona grandis*, *Terminalia tomentosa* and various species of bamboo. It is a medium to large sized deciduous tree with a straight trunk and numerous branches which develops a large shady crown.

At the seedling stage, the growth is rapid under favourable conditions, especially after the second year. The growth ceases in the winter months of November to January. After May, second season growth accelerates. The seedlings are quite hardy against drought and frost. The tree of *G. arborea* is a light demander, though it can stand more shade in comparison to the teak (Troup, 1921). It can resist frost but cannot withstand drought conditions. The tree coppices well and the coppice shoots grow vigorously.

It is a durable timber suitable for high-class plywood and paper pulp. It is produced on fellow land in India, particularly in the north, where it serves as a source of lumber, fodder, and industrial wood. The species has generated its utility in the agroforestry system. Due to its indigenous origin, rapid growth and considerable economic value, *G. arborea* has acquired widespread recognition as a plantation species. The lightweight wood of the tree is utilised in plywood, particle boards, artificial limbs, furniture, light construction, wooden handicrafts, matches, and packaging. Because of its several uses, state forest departments, non-governmental organisations, and private farmers have started large-scale plantation operations.

 For a successful plantation, quality seedlings play a key role over the quantity of the seedlings. However, this fact is generally ignored by the majority of the nursery owners (Bachar *et al*., 2021). Various nursery components like media composition, silvicultural characteristics of the seedlings and nursery practices play an important role in raising a quality stock in the nursery. In light of this, the present study was conducted to study the germination and growth aspects of *G. arborea* seedlings under the influence of various soil compositions and light intensities. Also, the understanding of the light requirements of seedlings in the initial stage can help in the utilisation of species in enrichment plantings.

**MATERIAL AND METHODS**

**Study site and experimental design**

The present study was conducted at the College of Horticulture and Forestry, Jhalrapatan (Jhalawar), at 24°53’ N-Latitude and 76°14’ E-Longitude in the South-Eastern region of Rajasthan from July 2023 to March 2024. The site is characterized by a subtropical and subhumid climate with hot summers and moderate winters, similar to the climate of Indo-Gangetic plain. In the study, the seedlings were raised under three different growing conditions, *viz.*, open conditions (L0), green shade net house with (approx.) 50% light intensity (L1) and (approx.) 25% light intensity (L2). The seeds were soaked in water for 48 hours before sowing in the polybags filled with growing media components including, soil, sand and Farm Yard Manure (FYM) in different ratios, making 12 treatments of growing media, *i.e.,* G0 (Soil), G1 [Soil: Sand(1:1)], G2 [Soil: FYM (1:1)], G3 [Soil: Sand(1:2)], G4 [Soil: FYM (1:2)], G5 [Soil: Sand: FYM (1:1:1)], G6 [Soil: Sand: FYM (1:1:2)], G7 [Soil: Sand: FYM (2:1:1)], G8 [Soil: Sand: FYM (1:2:1)], G9 [Soil: Sand: FYM (2:1:2)], G10 [Soil: Sand: FYM (1:2:2)] and G11 [Soil: Sand: FYM (2:2:1)]. Thus, all these 12 treatments of growing media were subjected to three different light conditions, forming a total of 36 treatment combinations statistically designed under completely randomized design with the factorial concept. Each treatment combination is replicated three times. Each replication contains 20 polybags, making 60 polybags in each treatment. The treatment differences were evaluated using an 'F' significance test based on the null hypothesis. In each case, the appropriate standard error (S. Em ±) was calculated, and the critical difference (C.D.) at a 5% significance level was determined to compare the treatments when the treatment effects were significant.

**Observation parameters**

Light measurements were carried out periodically twice a month at fortnightly intervals with the help of a lux meter throughout the study period of July 2023 to March 2024. The readings were taken at 8:00, 13:00 and 16:00 hours. To monitor the actual light intensity, the reading has been taken of all the media treatments in the all three different light conditions. The lux meter is placed just above the polybags and the growing seedlings in between the rows of the polybags arranged and the reading is expressed in kilo lux. The data of various germination parameters *i.e.*, number of days taken for germination, days required for 50% germination, span of germination, germination percentage and peak period of germination, was recorded by counting the number of seeds emerged on a daily basis.The shoot parameters, including seedling height, number of leaves, and collar diameter, of the 6 randomly selected seedlings from each replication of all the treatment combinations were recorded monthly from 30 days to 240 days after sowing. At the end of the trial, three of the six selected seedlings were randomly chosen to measure the root growth variables and biomass attributes. The survival rate is determined by dividing the number of plants that have survived at the end of the experiment by the total number of plants that initially germinated, then multiplying the result by 100 to express it as a percentage. Total fresh weight and total dry mass of the seedlings were measured at the end of the experimental trial. The fresh weight of the uprooted seedlings was measured using a digital weighing balance after thoroughly cleaning the soils and the roots. The seedlings were then kept in an oven for 3-4 days in a paper bag at 60₀ C, until the constant weight was not obtained. The chlorophyll a, chlorophyll b and total chlorophyll content in the leaves was measured by the method given by Sadasivam and Manickam (1997). The quality of the seedling was assessed by Dickson Quality Index. It was determined by using the following formula (Dickson *et al.*, 1960)-

 Dickson Quality Index = $\frac{Dry weight of seedlings (g)}{\frac{Seedling height (cm) }{Collar diameter (mm) }+ \frac{Dry weight of shoot (g) }{Dry weight of root (g) }}$

**RESULTS AND DISCUSSION:**

**Light intensity**

The result showed that the shade net house with ~50% light condition (L1) restricted 20-47% of light intensity compared to the full sunlight or open condition (L0). While 44 to 68% light reduction was recorded in shade net house with ~25% light intensity (L2) compared to the open condition (L0). The variation in the light intensity measurement among the different light conditions is summarized graphically in Fig 1.

**Figure 1 Light intensity (K Lux) measurement throughout the study period (July 2023- March 2024) in L0, L1 and L2.**

**Germination attributes**

Growing media, light conditions and their interactions imparted a significant difference in the germination aspect of the seedling (as shown in Table 1&2). Among the various media treatments, G9 [Soil: Sand: FYM (2:1:2)] exhibited significantly earliest germination in 8.22 days. This could be due to the influence of soil mixture which supports early sprouting by offering better aeration, sufficient nutrients, moisture retention and well-drainage. In aid of this, microbes present in FYM promote seed germination by decomposing organic content and releasing essential nutrients that are easily available for uptake. The minimum days taken for 50% germination were notably observed in G10 [ Soil: Sand: FYM (1:2:2)] (16.44 days). The early completion of germination within 22.89 days was significantly achieved in G8 [ Soil: Sand: FYM (1:2:1)] and G10 [ Soil: Sand: FYM (1:2:2)]. The early germination attributes in G10 and G8 could be the result of the higher proportion of sand with FYM in soil mixtures that provided better aeration, drainage and moisture retention capacity. The peak of germination was earlier observed in G6 [Soil: Sand: FYM (1:1:2)]. Besides this, G6 [Soil: Sand: FYM (1:1:2)] and G10 [ Soil: Sand: FYM (1:2:2)] significantly recorded the highest germination percentage of 73.89% and the lowest germination was seen in G0 (Soil) with 56.11%. The germination peak and high germination percentage in G6 indicate the efficiency of the potting media. The presence of a balanced composition of soil mixture improves the physico-chemical characteristics of soil and adequate availability of nutrients supports higher germination and early achievement of germination peak. The present outcomes are analogous to the previous research findings of Patel *et al.* (2020) in *Pterocarpus santalinus* and Rawat *et al.* (2023) in *Schleichera oleosa* seedlings.

The growing condition of L1 (~50% light intensity) recorded the significant early emergence of seedlings (8.65 days), early attainment of 50% seed germination (16.97 days), shortest germination span of 27.11 days, early achievement of germination peak within 14.53 days. Besides this, considerably the highest germination percentage (68.47%) was obtained in L2 (~25% light intensity) which remained at par with L1. The early emergence and fast of rate of germination in L1 and higher germination percentage in L2 over open conditions could be the result of higher moisture retention, regulated temperature and reduced wind and other abiotic stress, making a suitable microclimate for the seed germination. The emergent seedlings primarily rely on nutrient reserves within the seed, rather than photosynthesis, for their initial growth. Consequently, moisture is a more critical factor than light during germination (Morris et al., 2000). High moisture levels protect seeds from desiccation, as they are intolerant of dryness. The present findings closely resemble the previous studies of Patil *et al.* (2018) in *Gmelina arborea*, Ahmed *et al.* (2014) in *Moringa oleifera*, Das (2023) in *Spondias mombin* and Zainal *et al.* (2024)in *Pithecellobium jiringa.*

Among interactions, the early attainment of 50% germination in L1G7 (15 days), recorded the earliest completion of germination in L1G6, L1G10, L2G8 and L2G9 (22.33 days), germination peak by L1G6 notably in 13.33 days. The highest germination was significantly observed in L2G6 with 80%. Therefore, the combined effect of media and light intensity agree with the outcomes of Patel *et al.* (2020) in *Pterocarpus santalinus* and Patil *et al.* (2018) in *Gmelina arborea.*

**Table 1. Effect of growing media, light intensities and their interactions on various germination attributes.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **No. of days taken for germination** | **Days required for 50% germination** | **No. of days taken to complete germination** | **Peak period of germination (days)** |
|  | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** |
| **G0** | 10.33 | 10.33 | 10.67 | **10.44** | 20.67 | 19.00 | 19.00 | **19.56** | 27.67 | 27.33 | 26.33 | **27.11** | 17.33 | 15.67 | 16.67 | **16.56** |
| **G1** | 9.00 | 7.67 | 8.67 | **8.44** | 18.67 | 17.67 | 17.67 | **18.00** | 25.33 | 24.67 | 25.00 | **25.00** | 15.67 | 15.00 | 15.33 | **15.33** |
| **G2** | 8.67 | 8.67 | 8.67 | **8.67** | 18.33 | 17.00 | 17.33 | **17.56** | 23.67 | 24.33 | 26.00 | **24.67** | 15.00 | 14.33 | 14.33 | **14.56** |
| **G3** | 8.67 | 8.67 | 8.67 | **8.67** | 17.33 | 17.33 | 18.33 | **17.67** | 23.67 | 24.33 | 23.33 | **23.78** | 16.33 | 15.33 | 16.33 | **16.00** |
| **G4** | 9.33 | 7.67 | 8.33 | **8.44** | 17.67 | 17.67 | 17.00 | **17.44** | 26.33 | 23.67 | 25.33 | **25.11** | 14.33 | 13.67 | 16.33 | **14.78** |
| **G5** | 9.33 | 8.67 | 8.67 | **8.89** | 16.67 | 18.33 | 18.33 | **17.78** | 24.67 | 23.67 | 25.67 | **24.67** | 14.67 | 15.67 | 15.67 | **15.33** |
| **G6** | 8.33 | 8.67 | 8.33 | **8.44** | 17.33 | 16.33 | 16.67 | **16.78** | 23.00 | 22.33 | 25.33 | **23.56** | 14.67 | 13.33 | 14.67 | **14.22** |
| **G7** | 9.33 | 9.00 | 8.33 | **8.89** | 18.67 | 15.00 | 16.67 | **16.78** | 24.67 | 23.33 | 21.67 | **23.22** | 16.00 | 13.67 | 15.33 | **15.00** |
| **G8** | 8.33 | 8.33 | 8.33 | **8.33** | 17.67 | 16.00 | 17.67 | **17.11** | 23.67 | 22.67 | 22.33 | **22.89** | 15.67 | 14.67 | 15.33 | **15.22** |
| **G9** | 8.67 | 7.67 | 8.33 | **8.22** | 17.67 | 16.33 | 17.00 | **17.00** | 26.33 | 21.33 | 22.33 | **23.33** | 15.33 | 14.33 | 14.67 | **14.78** |
| **G10** | 8.67 | 8.67 | 8.00 | **8.44** | 17.00 | 16.00 | 16.33 | **16.44** | 23.67 | 22.33 | 22.67 | **22.89** | 15.67 | 13.67 | 14.67 | **14.67** |
| **G11** | 8.67 | 8.67 | 9.33 | **8.89** | 16.67 | 17.00 | 16.33 | **16.67** | 23.67 | 22.67 | 22.67 | **23.00** | 15.00 | 15.00 | 15.67 | **15.22** |
| **Mean** | **8.94** | **8.56** | **8.69** |  | **17.86** | **16.97** | **17.36** |  | **24.69** | **23.56** | **24.06** |  | **15.47** | **14.53** | **15.42** |  |
|  |
|  |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |
|  | **G** | 0.52 | 0.18 | 6.33 | **G** | 0.90 | 0.32 | 5.48 | **G** | 0.77 | 0.27 | 3.39 | **G** | 0.67 | 0.24 | 4.71 |
|  | **L** | 0.23 | 0.08 |  | **L** | 0.40 | 0.14 |  | **L** | 0.34 | 0.12 |  | **L** | 0.30 | 0.11 |  |
|  | **G × L** | **NS** | 0.32 |  | **G × L** | 1.55 | 0.55 |  | **G × L** | 1.33 | 0.47 |  | **G × L** | 1.16 | 0.41 |  |

**Table 2. Effect of media and light intensities and their interactions on the germination percentage in *Gmelina arborea* Roxb.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Light intensity (L)** | **Open condition (L0)** | **~50% Light intensity****(L1)** | **~25% Light intensity****(L­2)** | **Mean** |
| **Growing media (G)** |
| **G0** | Soil (control) | 1 | 56.67 | 60.00 | 51.67 | **56.11** |
| **G1** | Soil: Sand | 1:1 | 61.67 | 66.67 | 66.67 | **65.00** |
| **G2** | Soil: FYM | 1:1 | 65.00 | 63.33 | 73.33 | **67.22** |
| **G3** | Soil: Sand | 1:2 | 65.00 | 63.33 | 66.67 | **65.00** |
| **G4** | Soil: FYM | 1:2 | 65.00 | 70.00 | 73.33 | **69.44** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 63.33 | 71.67 | 66.67 | **67.22** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 66.67 | 75.00 | 80.00 | **73.89** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 60.00 | 65.00 | 66.67 | **63.89** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 71.67 | 73.33 | 65.00 | **70.00** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 61.67 | 63.33 | 61.67 | **62.22** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 70.00 | 75.00 | 76.67 | **73.89** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 70.00 | 63.33 | 73.33 | **68.89** |
| **Mean** | **64.72** | **67.50** | **68.47** |  |
|  |
|  |  | **CD** | **SE(m)** | **CV** |  |  |
|  | **G** | 3.38 | 1.20 | 5.38 |  |  |
|  | **L** | 1.51 | 0.54 |  |  |  |
|  | **G ×** **L** | 5.86 | 2.08 |  |  |  |

**Growth attributes**

**Shoot parameters**

The growing media treatment G9 [Soil: Sand: FYM (2:1:2)] significantly recorded the highest mean seedling height of 95.31 cm, average leaf count of 7.96 and mean collar diameter of 12.88 mm. The enhanced growth of seedlings observed in G9 may be attributed to several factors related to the addition of FYM to the growing media. Firstly, FYM improves the physical structure of the soil, increasing its water retention capacity compared to sand or soil alone. The better moisture availability, combined with the higher nutrient content provided by FYM, stimulates seedling growth, leading to taller plants with more leaves and longer and wider shoots. Secondly, FYM plays an influential role in regulating nutrient assimilation, further promoting plant health and development. The present findings regarding the progression of shoot growth were in close agreement with the study of Bhasotiya and Tandel in *Ailanthus excelsa* (2017), Patel *et al.* (2013) in *Terminalia bellerica,* Parasana *et al.* (2013) in seedlings of *Mangifera indica* and Rawat *et al.* (2023) in *Schleichera oleosa* seedlings.

Under various light intensities, the significantly highest mean seedling height was obtained in L2 (79.12 cm), remained at par with L1 and the lowest in L0 (69.76 cm) at the end of the study period. The longer shoot length in low light intensity could be attributed to the adaptive mechanism of plants to elongate their shoots to reach the maximum light. The considerably highest leaf count of 6.04 and collar diameter of 10.08 mm was obtained in L1, statistically at par with L0 and the least was seen in L2 with the values of 5.43 and 9.80 mm for the number of leaves per seedling and collar diameter respectively at 240 DAS. The higher collar diameter and leaf production in moderate light intensity (L1) reflect the optimum microclimatic conditions for the healthy growth of plants, where plants invest their photosynthates in strengthening the stem and leaf production. Seedlings in open conditions (L0) exhibited a lower height-diameter ratio suggesting seedlings under low light intensity prioritise the maximum allocation of photosynthates in shoot elongation over the diameter increment (Sevillano *et. al.*, 2016). Patil *et al.* (2018) obtained maximum seedling growth of *G. arborea* under agro-shade net over open conditions. The study of Iroko (2019) in *Khaya senegalensis* and Olajuyigbe and Oladejo (2023) in *Synsepalum dulcificum* seedlings obtained a similar growth pattern of in terms of seedling height and collar diameter in accordance with the present outcomes and concluded higher seedling growth and collar diameter in light intensity of ~25% and 100% respectively. The present inference is in proximity with the findings of Ahmed *et al.* (2014) in *Moringa* andDas (2023) in *Spondias mombin* seedlings.

Among interactions, the highest seedling height in the treatment combinations L1G9 (101.38 cm), notably the highest leaf count in L0G6 (9.16) and the significantly highest collar diameter was observed in L0G9 (13.04 mm) at the end of observation. The results obtained partially agree with the outcomes of Egbadzor *et al.* (2023) in *Adansonia* seedlings.

**Root parameters**

The growing media treatment G6 [Soil: Sand: FYM (1:1:2)] found to be superior over others in terms of significantly highest tap root length (19.43 cm) and tap root diameter (14.79 mm). Similar observations were found in the study of Patel *et al.* (2013) in *Terminalia bellerica* seedlings, Rana *et al.* (2017) in *Parkia roxburghii*. Bhasotiya and Tandel (2017) obtained the highest root length in media constituting soil, sand and FYM (1:2:2) in six-month old seedlings of *Ailanthus excelsa*. The significant maximum mean root length (16.93 cm) and the thickest tap root diameter (13.50 mm) were obtained under L1. The minimum length of the tap root was significantly observed in L0 (14.26 cm) whereas the tap root diameter was significantly lower in L2 (10.73 mm). The higher mean value of tap root dimensions in L1 could be due to the optimum microclimatic conditions providing lower temperature and adequate moisture, leading to the enhancement of the thickness and length of tap root. Also, the extensive root development in seedlings grown under ~50% light intensity indicates a strategic allocation of photosynthetic energy to the root system, facilitating subsequent shoot growth. The findings are analogous to the previous outcomes of Patil *et al.* (2018) in *Gmelina arborea*, Ahmed *et al.* (2014) in *Moringa* seedlings*.* The treatment combination L2G9 exhibited maximum growth in tap root length (21.0 cm) and the significantly highest root diameter was obtained in the combination of L1G6 (16.47 mm). The significant effect of interactions can be justified by the observations of Patel *et al.* (2013), Patil *et al.* (2018) in *Gmelina arborea* and Ahmed *et al.* (2014) in *Moringa* seedlings. The data regarding shoot and root parameters are summarised in Tables 3 & 4.

|  |  |  |  |
| --- | --- | --- | --- |
| **Light intensity (L)** | **Seedling height (cm)** | **No. of leaves** | **Collar diameter (mm)** |
| **Growing media (G)** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** |
| **G0** | Soil (control) | 1 | 51.86 | 55.68 | 49.40 | **52.31** | 3.82 | 5.91 | 4.40 | **4.71** | 8.02 | 7.09 | 6.00 | **7.04** |
| **G1** | Soil: Sand | 1:1 | 55.81 | 64.30 | 58.29 | **59.47** | 4.26 | 5.00 | 4.75 | **4.67** | 9.01 | 7.54 | 7.38 | **7.98** |
| **G2** | Soil: FYM | 1:1 | 63.87 | 76.91 | 77.57 | **72.78** | 5.98 | 4.98 | 6.07 | **5.68** | 9.97 | 11.09 | 9.49 | **10.18** |
| **G3** | Soil: Sand | 1:2 | 48.52 | 52.83 | 48.32 | **49.89** | 1.79 | 4.15 | 3.03 | **2.99** | 5.83 | 5.85 | 5.58 | **5.75** |
| **G4** | Soil: FYM | 1:2 | 77.24 | 84.35 | 90.35 | **83.98** | 7.98 | 9.07 | 5.19 | **7.41** | 11.30 | 12.24 | 12.68 | **12.07** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 70.80 | 85.29 | 84.06 | **80.05** | 7.32 | 5.14 | 6.98 | **6.48** | 10.27 | 11.25 | 10.84 | **10.79** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 83.73 | 97.37 | 96.76 | **92.62** | 9.12 | 7.02 | 6.82 | **7.65** | 12.69 | 12.69 | 12.58 | **12.66** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 79.92 | 86.11 | 90.53 | **85.52** | 7.03 | 5.01 | 5.95 | **6.00** | 10.96 | 11.49 | 10.47 | **10.97** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 74.43 | 73.38 | 84.99 | **77.60** | 4.07 | 5.07 | 4.81 | **4.65** | 9.57 | 8.92 | 8.96 | **9.15** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 83.73 | 101.38 | 100.82 | **95.31** | 8.90 | 7.97 | 7.01 | **7.96** | 13.04 | 12.82 | 12.78 | **12.88** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 76.01 | 81.46 | 88.25 | **81.90** | 6.32 | 5.11 | 4.79 | **5.41** | 9.74 | 10.42 | 10.56 | **10.24** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 71.19 | 77.57 | 80.10 | **76.29** | 5.00 | 8.02 | 5.35 | **6.12** | 10.14 | 9.56 | 10.28 | **9.99** |
| **Mean** |  | **69.76** | **78.05** | **79.12** |  | **5.97** | **6.04** | **5.43** |  | **10.04** | **10.08** | **9.80** |  |
|  |
|  |  |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |
|  | **G** | 2.54 | 0.90 | 3.57 | **G** | 0.17 | 0.06 | 3.09 | **G** | 0.27 | 0.09 | 2.84 |
|  | **L** | 1.14 | 0.40 |  | **L** | 0.08 | 0.03 |  | **L** | 0.12 | 0.04 |  |
|  | **G × L** | 4.40 | 1.56 |  | **G × L** | 0.29 | 0.10 |  | **G × L** | 0.46 | 0.16 |  |

**Table 3. Shoot growth attributes of seedlings at 240 DAS.**

**Table 4. Root dimensions and Survival percentage of seedlings at 240 DAS.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Light intensity (L)** | **Taproot length (cm)** | **Diameter of tap root (mm)** | **Survival %** |
| **Growing media (G)** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** |
| **G0** | Soil (control) | 1 | 12.52 | 12.91 | 8.96 | **11.46** | 10.20 | 9.41 | 8.02 | **9.21** | 62.22 | 66.67 | 67.88 | **65.59** |
| **G1** | Soil: Sand | 1:1 | 13.16 | 14.93 | 10.90 | **13.00** | 10.75 | 12.26 | 9.15 | **10.72** | 70.30 | 67.58 | 72.34 | **70.08** |
| **G2** | Soil: FYM | 1:1 | 14.02 | 16.28 | 17.60 | **15.97** | 11.85 | 14.13 | 12.03 | **12.67** | 66.73 | 73.81 | 70.48 | **70.34** |
| **G3** | Soil: Sand | 1:2 | 11.55 | 12.12 | 10.26 | **11.31** | 7.57 | 9.30 | 7.90 | **8.26** | 58.97 | 63.25 | 62.45 | **61.56** |
| **G4** | Soil: FYM | 1:2 | 15.06 | 20.10 | 20.97 | **18.71** | 14.03 | 15.46 | 11.28 | **13.59** | 71.89 | 76.19 | 81.75 | **76.61** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 13.58 | 16.79 | 19.67 | **16.68** | 10.49 | 11.83 | 9.92 | **10.74** | 71.15 | 79.05 | 72.34 | **74.18** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 17.75 | 20.07 | 20.46 | **19.43** | 14.99 | 16.47 | 12.93 | **14.79** | 82.42 | 86.92 | 83.42 | **84.26** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 16.14 | 18.54 | 18.94 | **17.87** | 14.20 | 16.11 | 10.45 | **13.58** | 69.44 | 89.50 | 77.38 | **78.77** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 14.98 | 15.18 | 15.42 | **15.19** | 10.76 | 12.18 | 9.40 | **10.78** | 65.08 | 73.21 | 74.36 | **70.88** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 16.32 | 20.94 | 21.00 | **19.42** | 14.46 | 15.86 | 13.59 | **14.64** | 78.42 | 79.06 | 83.76 | **80.41** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 15.58 | 19.36 | 19.51 | **18.15** | 12.53 | 15.04 | 12.23 | **13.27** | 80.95 | 86.63 | 82.64 | **83.41** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 14.94 | 16.01 | 16.41 | **15.79** | 12.46 | 13.95 | 11.81 | **12.74** | 71.49 | 86.97 | 79.52 | **79.33** |
| **Mean** |  | **14.63** | **16.93** | **16.67** |  | **12.02** | **13.50** | **10.73** |  | **70.76** | **77.40** | **75.69** |  |
|  |
|  |  |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |
|  | **G** | 0.52 | 0.18 | 3.41 | **G** | 0.32 | 0.11 | 2.79 | **G** | 4.49 | 1.59 | 6.40 |
|  | **L** | 0.23 | 0.08 |  | **L** | 0.14 | 0.05 |  | **L** | 2.01 | 0.71 |  |
|  | **G × L** | 0.90 | 0.32 |  | **G × L** | 0.55 | 0.19 |  | **G × L** | 7.78 | 2.76 |  |

**Survival Percentage**

The significantly highest survival percentage of 84.26% was observed in G6 [ Soil: sand: FYM (1:1:2)] and the minimum survival was obtained in G3 [Soil: sand (1:2)] (61.56%). The lowest mortality in G6 indicates the efficiency of balanced compositions of mixtures in growing media suitable for the early growth of the seedlings. Similar conclusions were drawn by Bhasotiya and Tandel (2017) in *Ailanthus excelsa* and Patel *et al.* (2013) in *T. bellerica* seedlings. The highest survival in L1 (77.40%) might be the result of an ameliorated environment due to improved microclimate suitable for most of the combinations of mixtures in the media. Lowering the value of light intensity greatly affects the evaporative demand of the plants and prevents them from photodamage leading to a reduction in mortality over open conditions (Mbailwa *et al.*, 2024). The inference of survival of *G. arborea* in the present study is analogous with the previous work of Das (2023) in *Spondias mombin* and Ahmed *et al.* (2014) in *Moringa* seedlings.

Among the treatment combinations, L1G7 recorded the significant maximum survival of 89.50% and the lowest value was observed in L0G3 with a survival of 58.97% (Table 4). Therefore, the effect of interactions between media composition and light intensity aligns with the earlier studies of Bhasotiya and Tandel (2017) and Ahmed *et al.* (2014).

**Biomass attributes**

The growing media treatment G6 [Soil: Sand: FYM (1:1:2)] has shown significantly highest average total fresh weight of 47.15 g and significantly highest mean value of total dry weight of 15.85 g was observed in G9 [Soil: Sand: FYM (2:1:2)]. The treatment G9 [Soil: Sand: FYM (2:1:2)] significantly recorded highest root: shoot ratio of 0.41. The superior performance of G6 and G9 could be the result of balanced nutrients and well drained media which can sustain moisture availability. Considering the light intensities, the significant mean value of the total fresh weight and total dry weight was obtained in L1 (41.12 g) and L0 (11.88 g) respectively. The root shoot ratio was found superior in L1 with a value of 0.35. This could be due to the higher moisture retention in the plants raised in L1 while the maximum biomass allocation in L0 could be the result of maximum photosynthate accumulation in seedlings as a defensive mechanism against the abiotic stress in exposed conditions. Biomass distribution in root and shoot parts was higher in ratio under L1 could be the result of higher values of root dimensions which implies a relatively higher accumulation of biomass in root to the support the shoot growth. Ahmed *et al.* (2014) in Moringa,Das (2023) in *Spondias mombin* and Xue and Li (2016) in *Alhagi sparsifolia* concluded the mitigating effects of moderate shade which facilitate the higher biomass accumulation in the seedlings by optimizing the photosynthesis. The treatment combinations L1G9 recorded significantly highest total fresh weight and total dry weight with the average values of 52.10 g and 17.43 g respectively. Concerning the root: shoot ratio, the highest remarkable value of 0.43 was obtained in treatment combination L0G10. The outcomes are in proximity to the findings of Tanjung *et al.* (2023) in *Switenia* seedlings.

**Table 5 Biomass attributes of seedlings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Light intensity (L)** | **Total fresh weight (g)** | **Total dry weight (g)** | **Root: Shoot ratio** |
| **Growing media (G)** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** |
| **G0** | Soil (control) | 1 | 23.86 | 25.69 | 24.77 | **24.77** | 9.56 | 9.56 | 6.53 | **8.55** | 0.30 | 0.31 | 0.30 | **0.30** |
| **G1** | Soil: Sand | 1:1 | 24.91 | 30.97 | 27.32 | **27.73** | 11.07 | 11.10 | 8.70 | **10.29** | 0.35 | 0.36 | 0.36 | **0.36** |
| **G2** | Soil: FYM | 1:1 | 30.40 | 39.55 | 38.23 | **36.06** | 11.89 | 12.00 | 9.96 | **11.28** | 0.35 | 0.36 | 0.35 | **0.35** |
| **G3** | Soil: Sand | 1:2 | 20.44 | 34.86 | 26.05 | **27.12** | 7.94 | 7.70 | 7.76 | **7.80** | 0.28 | 0.30 | 0.29 | **0.29** |
| **G4** | Soil: FYM | 1:2 | 40.95 | 50.18 | 44.99 | **45.37** | 13.26 | 12.87 | 11.83 | **12.65** | 0.37 | 0.40 | 0.38 | **0.38** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 39.71 | 42.56 | 38.91 | **40.39** | 12.05 | 11.64 | 11.72 | **11.81** | 0.34 | 0.38 | 0.34 | **0.36** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 43.28 | 51.72 | 46.45 | **47.15** | 15.58 | 15.53 | 12.27 | **14.46** | 0.39 | 0.42 | 0.38 | **0.40** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 40.57 | 44.32 | 39.87 | **41.58** | 12.86 | 12.24 | 11.34 | **12.15** | 0.36 | 0.35 | 0.39 | **0.37** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 39.12 | 36.51 | 40.75 | **38.79** | 7.99 | 9.20 | 8.95 | **8.71** | 0.33 | 0.36 | 0.37 | **0.35** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 41.68 | 52.10 | 46.57 | **46.78** | 17.12 | 17.43 | 13.00 | **15.85** | 0.40 | 0.41 | 0.42 | **0.41** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 40.13 | 43.94 | 40.35 | **41.47** | 11.79 | 12.41 | 11.39 | **11.86** | 0.43 | 0.41 | 0.34 | **0.39** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 32.97 | 41.04 | 39.28 | **37.76** | 11.37 | 10.54 | 9.98 | **10.63** | 0.38 | 0.40 | 0.33 | **0.37** |
| **Mean** | **34.83** | **41.12** | **37.80** |  | **11.88** | **11.85** | **10.29** |  | **0.36** | **0.37** | **0.35** |  |
|  |
|  |  |  |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |
|  |  |  | **G** | 1.40 | 0.50 | 3.92 | **G** | 0.40 | 0.14 | 3.74 | **G** | 0.02 | 0.01 | 5.54 |
|  |  |  | **L** | 0.62 | 0.22 |  | **L** | 0.18 | 0.06 |  | **L** | 0.01 | 0.01 |  |
|  |  |  | **G × L** | 2.42 | 0.86 |  | **G × L** | 0.69 | 0.24 |  | **G × L** | 0.03 | 0.01 |  |

**Chlorophyll content**

The data accomplishment (in Table 6) revealed that chlorophyll-a, chlorophyll-b and total chlorophyll imparted significant differences among various growing media. Among the growing media treatments, the chlorophyll-a content was significantly highest in G10 [Soil: Sand: FYM (1:2:2)] and G11 [Soil: Sand: FYM (2:2:1)] (0.96 mg/g tissue). The treatment of G6 [Soil: Sand: FYM (1:1:2)] notably recorded the highest chlorophyll-b (1.89 mg/g tissue) and total chlorophyll content (1.89 mg/g tissue). The improvement in chlorophyll content may be due to the increase in nitrogen uptake from the organic fertilizer (FYM) in the media. Ananth *et al.* (2011) also reported higher chlorophyll content in the treatments containing vermicompost and FYM.

Under different light intensities, the maximum significant value of chlorophyll-a was observed under open conditions (L0) and ~50% light intensity (L1). This may be because L0 and L1 provide sufficient light intensity to produce chlorophyll-a pigment, a primary Light-Harvesting Complex majorly produced in high light irradiance. The ~25% light intensity (L2) growing conditions showed a considerable maximum mean value of chlorophyll-b and total chlorophyll content. The total chlorophyll content increases with an increase in reduction of light intensity as the minimum was observed under L0, then followed by L1. This could be due to the adaptive mechanism of plants to increase light absorption efficiency by producing more accessory pigments (chlorophyll-b) leading to an overall increase in total chlorophyll in lower light intensity. Similar trends were recorded in the previous findings of Li *et al.* (2019) in *Vernicia fordii* andCalixto-Valencia *et al.* (2019) in *Swietenia humilis* seedlings.

The differences between the interactions remained non-significant in chlorophyll-a. The treatment combinations of L2G4 obtained the significantly highest value of chlorophyll-b and the total chlorophyll content was significantly maximum in the combinations of L2G4 and L2G9. Similarly significant interactions were obtained between the growth media and shade regimes on *Adansonia* seedlings regarding chlorophyll content, where chlorophyll content was higher due to the combined effect of media containing soil and partial shade (Egbadzor *et al.* (2023).

**Table 6 Effect of growing media, light intensities and their interactions on the presence of chlorophyll content (mg/g tissue) in *Gmelina arborea* Roxb. seedlings.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Light intensity (L)** | **Chlorophyll-a** | **Chlorophyll-b** | **Total chlorophyll** |
| **Growing media (G)** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** | **L0** | **L1** | **L2** | **Mean** |
| **G0** | Soil (control) | 1 | 0.90 | 0.92 | 0.90 | **0.91** | 0.79 | 0.80 | 0.90 | **0.83** | 1.69 | 1.72 | 1.80 | **1.74** |
| **G1** | Soil: Sand | 1:1 | 0.91 | 0.92 | 0.89 | **0.92** | 0.83 | 0.80 | 0.98 | **0.87** | 1.74 | 1.72 | 1.87 | **1.78** |
| **G2** | Soil: FYM | 1:1 | 0.92 | 0.93 | 0.91 | **0.91** | 0.84 | 0.87 | 1.00 | **0.90** | 1.76 | 1.79 | 1.91 | **1.82** |
| **G3** | Soil: Sand | 1:2 | 0.92 | 0.92 | 0.91 | **0.92** | 0.78 | 0.79 | 0.92 | **0.83** | 1.70 | 1.71 | 1.83 | **1.74** |
| **G4** | Soil: FYM | 1:2 | 0.92 | 0.92 | 0.91 | **0.93** | 0.92 | 0.88 | 1.03 | **0.94** | 1.84 | 1.80 | 1.93 | **1.86** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 0.93 | 0.94 | 0.91 | **0.93** | 0.88 | 0.89 | 0.95 | **0.90** | 1.81 | 1.82 | 1.86 | **1.83** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 0.93 | 0.93 | 0.92 | **0.93** | 0.94 | 0.99 | 0.96 | **0.96** | 1.87 | 1.92 | 1.88 | **1.89** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 0.94 | 0.93 | 0.92 | **0.93** | 0.94 | 0.95 | 0.84 | **0.91** | 1.88 | 1.89 | 1.77 | **1.84** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 0.93 | 0.94 | 0.93 | **0.93** | 0.82 | 0.86 | 0.83 | **0.84** | 1.75 | 1.80 | 1.76 | **1.77** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 0.93 | 0.94 | 0.93 | **0.94** | 0.95 | 0.90 | 1.00 | **0.95** | 1.88 | 1.84 | 1.93 | **1.88** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 0.93 | 0.94 | 0.94 | **0.94** | 0.83 | 0.87 | 0.91 | **0.87** | 1.76 | 1.81 | 1.85 | **1.81** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 0.94 | 0.95 | 0.93 | **0.92** | 0.81 | 0.84 | 0.90 | **0.85** | 1.75 | 1.79 | 1.83 | **1.79** |
| **Mean** | **0.93** | **0.93** | **0.92** |  | **0.86** | **0.87** | **0.93** |  | **1.78** | **1.80** | **1.85** |  |
|  |
|  |  |  |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |  | **CD** | **SE(m)** | **CV** |
|  |  |  | **G** | 0.01 | 0.01 | 1.71 | **G** | 0.02 | 0.01 | 2.03 | **G** | 0.02 | 0.01 | 1.18 |
|  |  |  | **L** | 0.01 | 0.01 |  | **L** | 0.01 | 0.01 |  | **L** | 0.01 | 0.01 |  |
|  |  |  | **G ×** **L** | **NS** | 0.01 |  | **G ×** **L** | 0.03 | 0.01 |  | **G ×** **L** | 0.03 | 0.01 |  |

**Seedling quality**

The statically interpreted outcome of the study regarding seedling quality shows a significant difference among media, light intensity and their interactions based on the values of the Dickson Quality Index (DQI) (Table 7). The highest considerable value of DQI of 1.45 was observed in G9 [Soil: Sand: FYM (2:1:2)]. The highest DQI of G9 might be attributed to the significantly larger seedling growth and higher biomass accumulation in the plants, which implies the robustness of the seedlings. Prasad *et al.* (2002) obtained the highest DQI of 0.26 in *Acacia nilotica* in the media containing soil and compost.

The light condition of L0 (Open condition) and L1 (~50% light intensity) showed significantly the highest DQI of 1.13 and the lowest was recorded in L2 with the value of1.06. The higher DQI in L0 implies the ability of seedlings to perform better in higher irradiance which might be the result of light-demanding nature of the species. Luna and Chamoli (2008) reported the same regarding higher DQI value in open conditions over shade net in the seedlings of *Albizia procera, Eucalyptus tereticornis* and *Acacia catechu.* In a similar contention, Das (2023) concluded that higher 60% light intensity produced more stable and robust seedlings of *Spondias mombin* over other conditions. Similarly, Mazzanatti *et al.* (2015) obtained higher DQI of 0.18 in open conditions over shade in the light-demanding seedlings of *Heliocarpus popayanensis*.

Among combinations of treatments, L1G9 recorded the highest DQI of 1.56 and the minimum value was obtained in L2G0 (0.61). The significant effect of media and light intensity is thus justified with the findings of Luna and Chamoli (2008).

**Table 7 Impact of growing media, light intensities and their interactions on Dickson Quality Index of seedlings.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Light intensity (L)** | **Open condition (L0)** | **~50% Light intensity****(L1)** | **~25% Light intensity (L2)** | **Mean** |
| **Growing media (G)** |
| **G0** | Soil (control) | 1 | 0.83 | 0.86 | 0.61 | **0.77** |
| **G1** | Soil: Sand | 1:1 | 1.05 | 0.98 | 0.87 | **0.97** |
| **G2** | Soil: FYM | 1:1 | 1.28 | 1.23 | 1.18 | **1.23** |
| **G3** | Soil: Sand | 1:2 | 0.64 | 0.70 | 0.67 | **0.67** |
| **G4** | Soil: FYM | 1:2 | 1.26 | 1.31 | 1.29 | **1.29** |
| **G5** | Soil: Sand: FYM | 1:1:1 | 1.18 | 1.10 | 1.14 | **1.14** |
| **G6** | Soil: Sand: FYM | 1:1:2 | 1.47 | 1.49 | 1.35 | **1.44** |
| **G7** | Soil: Sand: FYM | 2:1:1 | 1.28 | 1.19 | 1.13 | **1.20** |
| **G8** | Soil: Sand: FYM | 1:2:1 | 0.79 | 0.84 | 0.88 | **0.84** |
| **G9** | Soil: Sand: FYM | 2:1:2 | 1.47 | 1.56 | 1.32 | **1.45** |
| **G10** | Soil: Sand: FYM | 1:2:2 | 1.17 | 1.21 | 1.15 | **1.17** |
| **G11** | Soil: Sand: FYM | 2:2:1 | 1.15 | 1.13 | 1.13 | **1.14** |
| **Mean** | **1.13** | **1.13** | **1.06** |  |
|  |
|  |  |  | **CD** | **SE(m)** | **CV** |  |
|  |  | **G** | 0.05 | 0.02 | 4.98 |  |
|  |  | **L** | 0.02 | 0.01 |  |  |
|  |  | **G ×** **L** | 0.09 | 0.03 |  |  |

**Correlation analysis**

The correlation analysis of the phenotypic growth attributes *viz*., seedling height, collar diameter, leaves count, root dimensions, biomass attributes survival percentage and seedling quality was estimated as shown in Table 8. It was found that the seedling height and taproot length exhibited the highest correlation (r = 0.933). The correlation was higher (r > 0.85) in the dry weight and seedling quality with the collar diameter of seedlings. The least correlation was seen between the number of leaves and the survival of the seedlings.

**Table 8. Correlation analysis**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Height** | **Collar dia.** | **No. of leaves** | **Taproot length** | **Taproot dia.** | **Total Fresh weight** | **Total Dry weight** | **Root Shoot ratio** | **Survival %** |
| **Collar diameter** | 0.895\*\* |  |  |  |  |  |  |  |
| **No. of leaves** | 0.605\*\* | 0.721\*\* |  |  |  |  |  |  |  |
| **Taproot length** | 0.933\*\* | 0.856\*\* | 0.539\*\* |  |  |  |  |  |  |
| **Taproot diameter** | 0.701\*\* | 0.796\*\* | 0.673\*\* | 0.697\*\* |  |  |  |  |  |
| **Total Fresh weight** | 0.928\*\* | 0.855\*\* | 0.673\*\* | 0.867\*\* | 0.776\*\* |  |  |  |  |
| **Total Dry weight.** | 0.701\*\* | 0.853\*\* | 0.768\*\* | 0.675\*\* | 0.815\*\* | 0.695\*\* |  |  |  |
| **Root Shoot ratio** | 0.768\*\* | 0.758\*\* | 0.670\*\* | 0.697\*\* | 0.743\*\* | 0.759\*\* | 0.727\*\* |  |  |
| **Survival %** | 0.799\*\* | 0.731\*\* | 0.511\*\* | 0.752\*\* | 0.711\*\* | 0.772\*\* | 0.587\*\* | 0.764\*\* |  |
| **Seedling Quality Index** | 0.796\*\* | 0.927\*\* | 0.790\*\* | 0.781\*\* | 0.836\*\* | 0.778\*\* | 0.936\*\* | 0.777\*\* | 0.686\*\* |

\*\* Correlation is significant at 0.01 level

**CONCLUSION**

From the study, it can be concluded that the species can withstand a wide range of light spectrum though around 50% light intensity remained optimum for raising seedlings.Overall, the seedlings raised in media containing Soil: Sand: FYM (2:1:2) in ~50% light intensity (L1G9) have recorded superior seed quality and performed well in terms of growth and survival and can be suggested for further plantation if the cost factor is ignored. However, while considering both the cost factor and quality of the seedlings, the plants raised in the treatment combinations of L1G6 and L1G7 are preferred due to their optimized performance in terms of quality and survivability. The outcomes of the study can ensure higher survivability and growth rate of species where degraded forests or understocked areas require restoration by utilizing the recommended media compositions and light conditions.

Disclaimer (Artificial intelligence)

The Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**REFERENCES**

Ananth, G. R., Gunasekar, R., Arun, N., Sundaravel, K. and Ramachandran, R. (2011). Potentiality screening of FYM and vermicompost in disease resistance of mulberry. *Asian Journal of Environmental Science*, **6**(2): 131 -135.

Bhasotiya, H. C. and Tandel, M. B. (2017). Influence of potting mixtures on germination, growth and survival of *Ailanthus excelsa*. *Trends in Biosciences*, **10**(3): 1122-1124.

Calixto-Valencia, C. G., Cetina-Alcalá, V. M., Antúnez, P., López-López, M. Á., Ángeles-Pérez, G., Equihua-Martínez, A. and Basave-Villalobos, E. (2024). Morpho-physiological adjustment of *Swietenia humilis* Zucc. plants to varied nutrient and light conditions and their performance in nurseries and fields under soils with different preparations. *Forests*, **15**(12): 2125.

Das, N. (2023). Effects of light intensity on seed germination and early growth seedlings of *Spondias mombin* in Bangladesh. *Cell Biology and Development*, **7**(2): 82-88.

Dickson A, Leaf AL and Hosner JF. (1960). Quality appraisal of white spruce and white pine seedling stock in nursery. *The Forestry Chronicle*, **36**(1):10-13.

Egbadzor, K. F., Akumah, A. M., Titriku, J. K. and Akuaku, J. (2023). Effect of growth media and shade regimes on performance of baobab (*Adansonia digitata* L.) seedlings. *Forests, Trees and Livelihoods*, **32**(3): 207–217.

Iroko, O. A. (2019). Seedling growth performance of *Khaya senegalensis* (Welw.) C. DC under different light intensities and soil textural classes. *Ethiopian Journal of Environmental Studies and Management*, **12**(3):328-335.

Li, Z., Shi, K., Zhang, F., Zhang, L., Long, H., Zeng, Y., Liu, Z., Niu, G. and Tan, X. (2019). Growth, physiological, and biochemical responses of tung tree (*Vernicia fordii*) seedlings to different light intensities. *Hortscience*, **54**(8): 1361-1369.

Luna, R. K. and Naresh Chamoli, N. C. (2008). Evaluation of quality of seedlings raised under agro-net shade and direct sunlight. *The Indian Forester*, 134(1): 17-2.

Mazzanatti, T., Calzavara, A. K., Pimenta, J. A., Oliveira, H. C., Stolf-Moreira, R. and Bianchini, E. (2015). Light acclimation in nursery: morphoanatomy and ecophysiology of seedlings of three light-demanding neotropical tree species. *Brazilian Journal of Botany*, **39**: 19-28.

Mbailwa, Y. S., Mwambusi, J. N., Mwendwa, B. A. and Chamshama, S. A. (2024). Effect of Nursery Shading Intensity, Potting Mixture and Pot Size on the Performance of *Pericopsis angolensis* (Baker) Meeuwen Seedlings. *Journal of Agricultural, Earth and Environmental Sciences,* **3**(3): 1- 9.

Morris, M. H., Negreros-Castillo, P. and Mize, C. (2000). Sowing date, shade, and irrigation affect big-leaf mahogany (*Swietenia macrophylla* King). *Forest Ecology and Management*, **132**(2-3): 173-181.

Olajuyigbe, S. O. and Oladejo, B. A. (2023). Effect of moisture and light intensity on the early growth of miracle berry (*Synsepalum dulcificum* (Schum. and Thonn.) Daniell): A Threatened tropical shrub species. *Journal of Agriculture and Environment*, **18**(2):91-106.

Parasana, J. S., Leua, H. N. and Ray, N. R. (2013). Effect of different growing media mixture on germination and seedlings growth of mango (*Mangifera indica* L.) cultivars under net house conditions. *The Bioscan*, **8**(3): 897-900.

Patel, V. S., Patil, N. S. and Tandel, M. B. (2013). Germination of *Terminalia bellerica* (Gaertn.) Roxb. as affected by various potting media. *Indian Forester*, **139**(1): 33-36.

Patel, Y. D., Tandel, M. B., Prajapati, V. M., Pathak, J. and Patel, S. M. (2020). Effect of growing media on seed germination of red sanders (*Pterocarpus santalinus* Linn.). *International Journal of Chemical Studies*, **8**(5): 2424-2427.

Patil, Y. B., Saralch, H. S., Mahale, S. R., Chauhan, S. K. and Sharma, R. (2018). Effect of Growing Environment, Fruit Maturity and Sowing Time on Germination and Seedling Growth of *Gmelina arborea* Roxb. *International Journal of Current Microbiology and Applied Sciences,* **7**(12): 2543-2552.

Prasad, R., Lohra, R. R., Mertia, R. S., Rathore, S. S., Shukla, U. and Kumar, S. (2002). Growth and quality of *Acacia nilotica* seedlings raised in root trainers with potting media varying in physical and chemical properties in arid zone. *Annals of Arid Zone*, **41**(2).

Rana, A., Leishangthem, C. L., Kadiri, H. and Ziipoa, B. N. N. (2017). Effect of seed size, pre sowing treatment and potting mixture on the seedling growth of *Parkia roxburghii* G. Don seeds. *International Journal of Current Microbiology and Applied Science*, **6**(8): 629-638.

Rawat, P., Ram, S., Singh, O., Thapliyal, M. and Singh, I. (2023). Effect of different growing media on seed germination and growth of Indian lac tree (*Schleichera oleosa*) in nursery conditions*.International Journal of Farm Sciences*,**13**(2): 122-126.

Sadasivam, S. and Manickam, A. (1997). Biochemical Method. New Age International Publishers, New Delhi, 187-188.

Sevillano, I., Short, I., Grant and O’Reilly, C. (2016). Effects of light availability on morphology, growth and biomass allocation of *Fagus sylvatica* and *Quercus robur* seedlings. *Forest Ecology and Management*, **374**: 11-19.

Sood, K. K., Ahmed, F. and Raina, N. S. (2018). Effect of container and growing media on *Terminalia bellirica* Roxb. seedling performance under nursery conditions. *Indian Journal of Ecology*, **45**(2): 270-275.

Tanjung, H. U. and Tata, H. L. (2023). The growth of mahogany seedlings (*Swietenia macrophylla* King.) in various planting media and shade intensity. In *IOP Conference Series: Earth and Environmental Science*, **1271**(1): 012023.

Troup, R.S. (1921). The silviculture of Indian trees. *Clarendon Press*, Oxford, **2**:769-775.

Verma, P., Bijalwan, A., Shankhwar, A. K., Dobriyal, M. J., Jacob, V. and Rathaude, S. K. (2017). Scaling up an Indigenous tree (*Gmelina arborea*) based agroforestry systems in India. *International Journal of Science and Qualitative Analysis*, **3**(6): 73-77.

Xue, W. and Li, X. (2016). Moderate shade environment facilitates establishment of desert phreatophytic species *Alhagi sparsifolia* seedlings by enlarge fine root biomass. *Acta Physiologiae Plantarum*, **39**: 1-12.

Zainal, A., Satria, B., Mawati, I. and Wulantika, T. (2024). The Effect of Shade on Germination and Seedling Growth of Two Dogfruit (*Pithecellobium jiringa*) Genotypes. *Journal of Applied Agricultural Science and Technology*, **8**(2): 211-227.