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Original Article

Influence of Arbuscular mycorrhiza on the growth potential of *Entandrophragma cylindricum* seedlings

OPEN ACCESS

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ABSTRACT

The study assessed the effects of Arbuscular mycorrhiza on the growth of *Entandrophragma cylindricum* seedlings, valued for their premium timber and medicinal properties. Seeds were germinated, and 42 healthy seedlings were transplanted into pots containing 2 kg of topsoil, treated with varying amounts of A. mycorrhiza (30 g, 60 g, 90 g, 120 g, and 150 g), alongside a control group without mycorrhiza. The study utilized a Completely Randomized Design (CRD) and measured variables such as plant height, stem diameter, leaf area, biomass accumulation, chlorophyll content, and leaf count. The results showed that the 120 g treatment produced the best growth: an average height of 37.48 cm, a stem diameter of 6.33 mm, and 17.14 leaves, along with higher biomass and chlorophyll levels. In contrast, the control group exhibited the lowest growth, with only 8 leaves and a height of 13.55 cm. Statistical analysis revealed significant differences in height, stem diameter, leaf area, and leaf count, while biomass and total chlorophyll showed no significant differences. The interaction between A. mycorrhiza and soil nutrients was significant, indicating a positive effect on seedling growth. It is recommended to use 120 g of A. mycorrhiza for nursery cultivation to achieve robust growth and high yields of *E. cylindricum.*

KEYWORDS: *Arbuscular Mycorrhiza, Entandrophragma cylindricum, Growth-Potential, Seedlings*

INTRODUCTION

The transformation of the world's ecosystems during this period has had serious impacts on biodiversity and important consequences for resource management (Deepika & Kothamasi 2021). The pressure on the world's forests to deliver economic, social, and environmental services has reached unsustainable levels in many places. This situation requires urgent implementation of novel forest management approaches (Bhardwaj *et al.,* 2023). Forest plantations are often put forward as part of the answer to these questions. However, tree plantations in use today are conceptually and practically much more diverse and fulfil a variety of objectives, including, in many cases, conservation. (Zalasiewicz *et al*. 2008)

Entandrophragma cylindricum belong to meliaceae family, under natural conditions, seeds germinate abundantly, but mortality of seedlings is high, less than

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1% reaching 10 cm stem diameter. Seedlings grow slowly, 20–40 cm/year. Root development takes considerable time. Seedlings up to 2 years old require light shade, but thereafter they should be gradually exposed to more light. They can survive for several years in the shade without significant growth, but when a gap is created in the forest providing enough light further development into a tree starts. The mean annual diameter increment for trees in the Central African Republic has been established at 3.9 mm, but the variability is large (Caitlyn *et al.,* 2023). The average annual height growth for 40 years was 30–50 cm and average annual diameter growth 4–8 mm.

Deciduous, dioecious large tree up to 55(–65) m tall; bole branchless for up to 40 m, straight and cylindrical, up to 200(–280) cm in diameter, with low, blunt buttresses up to 2 m high, rarely up to 4 m; bark surface silvery grey to greyish brown or yellowish brown, becoming irregularly scaly with scales leaving shallow pits with numerous lenticels, inner bark pinkish, soon becoming brown upon exposure, fibrous, with a strong cedar-like smell; crown rounded; young twigs brownish short-hairy, marked with lenticels. Leaves alternate, clustered near ends of twigs, paripinnately compound with 10–19 leaflets; stipules absent; petiole 5–13 cm long, flattened or slightly channeled, often slightly winged at base, rachis 7–17 cm long; petiolules 1–6 mm long; leaflets opposite to alternate, oblong-elliptical to oblong-lanceolate or oblong-ovate, 4–15 cm × 2–5 cm, cuneate to rounded and slightly asymmetrical at base, usually short-acuminate at apex, papery to thinly leathery, almost glabrous, pinnately veined with 6–12 pairs of lateral veins. Inflorescence an axillary or terminal panicle up to 25 cm long, short hairy. Flowers unisexual, regular, 5-merous; pedicel 1–2.5 mm long; calyx cup-shaped, lobed to about the middle, 0.5–1 mm long, sparsely short-hairy outside; petals free, ovate, 3–4 mm long, sparsely short-hairy outside, greenish white; stamens fused into an urn-shaped tube c. 2 mm long, with 10 anthers at the slightly toothed apex; disk cushion-shaped, with 20 indistinct ridge (Keay *et. al* 1989)

Mycorrhizas (mutualistic associations between specialised basidio-, asco-, and zygomycetous fungi and roots of higher plants) constitute the most efficient nutrient uptake facilitators, particularly in nutrient-deficient soils of tropical regions. Therefore, presence of mycorrhizas results in increased plant fitness and forest tree productivity (Smith & Read,1997).

In the humid tropics, two major types of mycorrhizal associations of trees have been reported, viz. ectomycorrhiza (ECM) and arbuscular mycorrhiza (AM). In general, AM dominate secondary forests and many of primary forests (Kevin *et al.,* 2022). ECM occurs either isolated in a mosaic of AM species or in clumps in undisturbed forest where they dominate the canopy (Birhane *et al*., 2012). The AMFs are potential as a biofertilizer in which the fungus penetrates the cortical cells of a vascular plant's roots (Campo *et al.*, 2020). The AMFs initially penetrate root cells and develop into the root cortex of the host plant to generate two types of specialized structures, namely arbuscular and vesicles. Plant treatments with AMF are intended to lessen transplant stress and increasing soil hydration and fertility. Also, AMFs association can allow the treated plant host to obtain nutrients in an organic form that would otherwise be unavailable. Compared to the control of non-treated plants with AMF, mycorrhizal root structures can successfully take up phosphorus from lower amounts. In this regard, the AMFs are responsible for up to 80% of the total phosphorus uptake by treated plants (Caitlyn *et al.,* 2023).

An increase in host plant development, ascribed to a rise in nutrient uptake, is one of the most significant effects of AMF inoculation, especially in plants with low soil mobility and nutrient concentration. By absorbing the necessary carbon, providing the plant with nutrients, and increasing the efficiency of photosynthesis, they induce the chlorophyll organs of the plant to expand, and this demonstrated that mycorrhiza-inoculated tree plants have more dry matter than non-inoculated

Hence, the study is necessary to understand the role of arbuscular mycorrhiza inoculation as well as macro-nutrient deficiency on growth and development of the seedlings of *E. cylindricum* in the tropical environment. The result serves to enhance the realization of full and wider benefits from the species.

MATERIALS AND METHODS

The experiment was carried out at the Forestry Research Institute of Nigeria Ibadan, Oyo State. Nigeria. The area's climate is tropical, dominated by rainfall patterns ranging between 1400mm-1500mm. The mean maximum temperature is 31.90C, minimum 24.20C while the mean daily relative humidity is about 71.9%. The eco-climate of the area is rainfall with two distinct seasons which is dry season (usually from November to March) and wet season (usually from April to October (Afolabi *et al*. 2021). The area lies between latitude 7.392570^0 and longitude 3.862857^0 The materials used for the study of the influence of Arbuscular mycorrhiza on the growth potential of *E. cylindricum* are seeds, polythene pots, topsoil, Glomus morae mycorrhiza, river sand buckets sensitive scale, vernier caliper. The seeds of *Entadrophragma cylindricum* were obtained from seed section of Sustainable Forest Management Department of FRIN, the Arbuscular mycorrhiza was obtained from the Agronomy Department of University of Ibadan ,the inoculation was carried out according to Kareem et al

2012 in which mycorrhiza were added into three-quarter of the soil in each polythene pot before the remaining one-quarter of the soil is added into the polythene pot; The mycorrhiza were been added in six levels (30g, 60g, 90g and 120g ,150g) and control.

The uniform seedlings of *E. cylindricum* were carefully transplanted into 2kg of polythene pots already filled with topsoil. Growth parameters were assessed such as leaf production, plant height, collar diameter, leaf area, and chlorophyll content and the experiment lasted for 16 weeks. The experimental design used for the experiment was completely Randomized Design (CRD). This consists of 6 treatments and 7 replicates making a total of 42 experimental units Data generated from growth parameters measurement was subjected to Analysis of Variance (ANOVA) and means separation with least significant difference (LSD) at a 5% probability level of significance.

RESULTS AND DISCUSSION

The result presented in Table 1 below showed the effect of A. mycorrhiza on the number of leaves of *E. cylindricum* seedlings raised with 120g of A. mycorrhiza (T4) performed best with the mean value of 17.14 followed by seedlings raised with 150g of A. mycorrhiza (T5) with the mean value of 12.00. Seedlings used as the control (T6) performed least with the mean value of 8.00 from the observation. However, the result obtained revealed that leaf numbers of the seedlings vary because of the different levels of A. mycorrhiza applied to them. However, the increased number of leaves in A. mycorrhiza inoculated plants compared to non-mycorrhiza ones has been reported for other species (Kilronomos, 2003, Kareem *et al*.2012, 2023).

The greater leaf number measured from treatments inoculated with 120g of mycorrhiza could be due to enhanced nutrient uptake probably because of increased root surface area that ultimately improved plant growth rate (Ortas and Ustuner 2014). Birhane *et al.* (2012), also reported a positive mycorrhiza effect on the growth of *Boswellia papyrifera* seedling over control seedlings, due to significantly improved phosphorus nutrient. The result from the Analysisof variance indicated that there was significant difference among the treatment at % level of probability.

Table 1: Showing the mean of value Influence of Arbuscular mycorriza on the growth potential of *E. cylindricum*

TREATMENT	HEIGHT	LEAF PRODUCTION	COLLAR DIAMETER	LEAF AREA
T1	17.15±2.34a	10.00±0.00a	3.87±0.13a	25.97±4.73a
T2	19.84±3.38ab	9.71±1.38a	4.29±0.47ab	25.84±4.17a
T3	25.56±3.61bc	10.86±1.95ab	4.48±0.44ab	32.03±5.67ab
T4	37.48±4.05d	17.14±1.07c	6.33±0.49c	49.07±4.21c
T5	28.95±3.01cd	12.00±2.00b	5.18±0.39bc	41.82±1.94bc
T6	13.55±0.61a	8.00±1.63a	3.39±0.33a	18.82±4.36a
P-value	4.22E-16	4.25E-12	6.15E-15	7.35E-15
LSD$\alpha_{0.05}$	1.1526	1.15081	0.3051	3.3185

T1 – 30g; T2 – 60g; T3 – 90g; T4 – 120g; T5 – 150g and T6 – 0g

The result in Table 1 above revealed the influence of A. mycorrhiza on the height of *E. cylindricum* seedlings. It was observed that seedlings raised with 120g of mycorrhiza (T4) performed best with the mean value of 37.48, followed by seedlings raised with 150g of mycorrhiza with the mean value of 28.95. Seedlings raised with T1 (control) had least height with the mean value of 13.55 from the observation. However, the result obtained revealed that height of the seedlings varies because of the different levels of mycorrhiza applied to them. Therefore, these findings support the observations made by Michelsen and Rosendahl (1990) on *Acacia. auriculiformis, Albizia lebbeck* and *Leucenia leucocephala.* Similarly, Al-Hmoud & Al-Momany (2017) reported that A. mycorrhiza inoculation increased plant growth, mostly in height and root growth. The result from the Analysis indicated that there was significant difference among the treatment at 5% level of probability.

Table 1 above revealed the influence of mycorrhiza on the stem diameterof E .cylindricum seedlings. It was observed that seedlings raised with 120g of A.mycorrhiza (T4) performed best with the mean value of 6.33 followed by seedlings raised with 150g of A mycorrhiza (T5) with the mean value of 5.18. Seedlings raised with T1 (control) performed least (Kareem *et.al* 2019; Kareem *et.al* 2023) with the mean value 3.39 from the observation. However, the result obtained revealed that the stem diameter of the seedlings varies because of the different levels samples applied to them.

Therefore, the increase in stem diameter recorded in this experiment can be attributed to A.mycorrhiza ability to improve symbiosis and suggested phosphorus nutrition as an important beneficial for greater responsiveness to and dependence of glomusmoceae is characteristics of A. mycorrhiza plants grown at lower soil phosphorus concentrations and low tissue phosphorus concentrations (Campo *et al.*, 2020). The result from the Analysis of Variance indicated that there was significant difference among the treatments at 5% level of probability.

The result presented in table 1 above revealed the influence of mycorrhiza on the leaf area of *E. cylindricum.* seedlings. It was observed that seedlings raised with 120g of A .mycorrhiza (T4) performed best with the mean value of 49.07 followed by seedlings raised with 150g of A mycorrhiza (T5) with the mean value of 41.82. Seedlings raised with T1 (control) performed least with the mean value 18.00 from the observation. However, the result obtained revealed that the leaf area of the seedlings varies because of the different soil samples applied to them. Therefore, the increase in leaf area recorded in this experiment can be attributed to A. mycorrhiza ability to improve symbiosis and suggested phosphorus nutrition as an important benefit. The result from the Analysis of Variance indicated that there was significant difference among the treatments at 5% level of probability.

Table 2: Showing the mean value of biomass accumulation of Arbuscular mycorrhiza on the growth potential of *E. cylindricum*

	Biomass			No of root	Root length
	Root	Stem	Leaf		
Treatment					
T1	3.956±2.523a	1.670±0.262a	5.866±0.986a	18.00±6.00ab	31.00±6.00a
T2	4.836±2.724a	2.406±0.784ab	7.376±1.003ab	20.00±6.00ab	36.00±6.00ab
T3	6.166±2.722ab	3.936±2.510bc	11.953±6.449bc	21.00±6.00b	42.33±6.50bc
T4	10.070±3.512bc	5.566±4.115c	16.866±9.765c	24.66±7.02bc	60.67±18.72c
T5	8.336±3.695abc	4.556±3.360bc	14.300±9.765bc	22.67±7.02bc	53.33±18.14bc
T6	2.273±1.525a	1.203±0.127a	4.21±1.669a	11.33±5.033a	24.33±3.21a
PV	0.05452	0.2530	0.1154	0.214NS	0.0190*
LSDα0.05	10.338	4.3075	5.1106	11.062	20.59

T1 – 30g; T2 – 60g; T3 – 90g; T4 – 120g; T5 – 150g and T6 – 0g Mean with same alphabet are not significantly different from one another, values after ± are standard deviation

The result presented in table 2 above revealed the influence of mycorrhiza on the biomass of *E. cylindricum*. seedlings. It was observed that seedlings raised with 120g of A .mycorrhiza (T4) performed best with the mean value in term of root, stem, leaf, number of root and root length respectively 10.070, 5.566 , 16.866, 24.66 and 60.67 followed by seedlings raised with 150g of A mycorrhiza (T5) with the mean value in term of root, stem, leaf number of root and root length respectively 8.336, 4.556 , 14.300, 22.67 and53.33. While Seedlings raised with T1 (control) performed least with the mean value in term of root, stem, leaf, number of root and root length respectively, 2.273, 1.203, 4.21,11.33and 24.33 from the observation. The result from the Analysis indicated that there was no significant difference among the treatment at 5% level of probability.

Table 3: Showing the mean value of total chlorophyll content of Arbuscular mycorriza on the growth potential of *E. cylindricum*

Treatment	Chlorophyll a	Chlorophyll b	Total chlorophyll
T1	16.6216±13.6381a	8.8676±6.0047a	25.48933±19.0242a
T2	20.784±15.6996a	12.2886±8.07686ab	33.07267±23.4121ab
T3	26.4176±16.9312a	17.7010±12.2486bc	44.11873±29.1474bc
T4	36.445±26.1957b	25.6983±16.1774c	62.14333±41.8889c
T5	33.231±24.1057ab	20.3873±13.2010bc	53.61833±37.0016bc
T6	11.381±9.0359a	5.8066±4.1573a	17.36167±13.0695a
p-value	0.557452	0.287248	0.437921
LSD$\alpha_{0.05}$	32.9534	19.2781	51.6329

T1= 30g; T2= 60g; T3= 90g; T4 =120g; T5= 150g and T6 = 0g Mean with same alphabet are not significantly different from one another, values after ± are standard deviation.

The result presented in table 4 above revealed the influence of mycorrhiza on the total chlorophyll of *E .cylindricum* seedlings. It was observed that seedlings raised with 120g of A.mycorrhiza (T4) performed best with the mean value of 62.14333 followed by seedlings raised with 150g of A mycorrhiza (T5) with the mean value of 53.61833. Seedlings raised with T1 (control) performed least with the mean value 17.36167 from the observation. The increase in chlorophyll content recorded in this experiment can be attributed to A. mycorrhiza ability to improve symbiosis and suggested phosphorus nutrition as an important benefit. This is in line with Analysis of leaf chlorophyll content of Paddy plants during vegetative stage grown in soil media containing macroalgae organic fertilizer (Kurniawan *et al*, 2021)

The result from the Analysis indicated that there was no significant difference among the treatment at 5% level of probability.

CONCLUSION AND RECOMMENDATIONS

The study showed a positive influence on *E. cylindricum* seedlings if inoculated properly with A.mycorrhiza. However, from the data analyzed it was observed that, the interaction between mycorrhiza and soil nutrients was significant because of positive mycorrhiza influence on young seedlings of *E. cylindricum.* The increase in number of leaves, stem girth and plant height, leaf area, chlorophyll content recorded indicates mycorrhiza displayed no parasitic effects on any of the treatments, but it served as a growth promoter on all the treatments applied. However, the effects exerted on the seedlings were dependent on the quantity of mycorrhizal applied at different levels as its observed. Consequently,120g of mycorrhiza (T4) had best influence in all parameters with respect to the growth potential of *E. cylindricum* to the morphological characteristics of seedlings.

From the results obtained, it is therefore recommended that; the use of 120g of A. mycorrhiza should be employed in raising the seedling of *E. cylindricum* as one of the indigenous tree species to increase production in the nursery. Furthermore, more research works of A. mycorrhiza on tree species should be encouraged to enhance their growth in the nursery stage.

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Authors Contributions

Authors AOO and ONS performed the experiment and collection of data, while GOA and KAO analyse the data. AAK conceived and design the experiment, reviewed draft of the paper and approved the final draft. All authors have read and agreed to the published version of the manuscript.

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