



Evaluating the Potential of Ectomycorrhizal Fungi in Enhancing Germination and Early Growth of Some Native Tree Species

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Abstract

This study was carried out to examine the influence on the potential of ecto mycorrhiza fungi (EMF) in enhancing the germination and early growth of selected tree species in Nigeria, using the Federal Polytechnic Bauchi, Department of Forestry and Environmental Technology at the nursery site. This research revealed the early growth performance of three tree species including: *Gmelina arborea*, *Parkia biglobosa* and *Azadirachta indica*. Two treatments combination were carried out T₁ (cow dung + shaft sand + Ecto mycorrhiza) and T₂ cow dung+shaft sand, served as the (control) were evaluated. A total of 30 experimental units (3 species ×2 treatment×5 replications) were carried out over a period of 12 weeks and data collection were conducted at two-weeks intervals. The parameters assessment including the plant height, stem grith and number of leaves. Data were analyzed using two-way ANOVA with replications. From the findings it was indicated that both treatments had significant effect on all measured growth parameters, while in their interaction was not significant. Seedlings under T₁ showed markedly improved performance in height and leaf number compared to those under T₂. Among the species, *Gmelina arborea* consistently recorded the heights growth values, followed by *Parkia biglobosa* and *Azadirachta indica* which indicate the least growth response. The research also revealed that mycorrhiza fungi inoculation can be a valuable and sustainable practice in nursery and reforestation establishment and programs.

Keywords: Ectomycorrhizal fungi, seed germination, nursery, seedling growth, forest restoration

Introduction

Forests play a crucial role in maintaining ecological balance, supporting biodiversity, and providing resources for both humans and wildlife. Native tree species are particularly important as they are well-adapted to local environmental conditions and contribute significantly to ecosystem stability. However, the germination and early growth of these species can be limited by various factors, including poor soil fertility and environmental stress (Hoeksema *et al.*, 2020).

Ecto-mycorrhizal fungi (EMF) have gained attention for their potential to enhance tree growth and survival. These fungi form mutualistic associations with the roots of many tree species, facilitating nutrient uptake, improving water absorption, and providing resistance against pathogens (Ogbonna *et al.*, 2012). Despite their ecological benefits, there is limited research on the specific role of EMF in improving germination and early growth of native tree species. This study seeks to evaluate the potential of ecto-mycorrhizal fungi in enhancing the germination and growth of selected native tree species, contributing to sustainable forestry practices (Josaly *et al.*, 2016).

Mycorrhizal fungi are used to restore degraded areas because they provide better conditions for plants to grow and compete for environmental resource. They act as root extensions, capturing resources (water and minerals) otherwise not accessible to plant roots, and contribute to soil aggregation by producing the glycoprotein glomalin (Kubota *et al.*, 2017). These beneficial fungi can also be used as biological indicators: the lower

their density and diversity, the higher the degradation. Because of their benefits, mycorrhizal fungi are an excellent tool for the production of forest seedlings. In particular, arbuscular mycorrhizal fungi stand out for their symbiotic efficiency and easy adaptation to the soil or substrate (Thirkell *et al.*, 2016).

Study Area and Plant Materials

The study was conducted at the Plant Nursery facilities of the Federal Polytechnic Bauchi, chosen for representativeness of local forest nursery conditions. Seeds from native tree species were collected from mature trees in natural forests within the region.

Ectomycorrhizal Fungi Isolation and Inoculum Preparation

Ectomycorrhizal fungi were isolated from healthy roots of mature trees via standard techniques and cultured on modified Melin-Norkrans medium. Fungal inoculum consisting of pure mycelial cultures was prepared for application to seedlings.

Experimental Design

A 2 X 3 factorial experiment arranged in a Completely Randomized Design (CRD) was conducted to evaluate the effect of Ecto-mycorrhizal fungi inoculation on yje growth performance of three tree species. The two factors include:

Factor A (Inoculation treatment)

T₁: Inoculated with Ecto-mycorrhizal fungi

T₂: Non-inoculated (Control)

Factor B (Tree species): *Azadirachta indica*, *Parkia biglobosa*, *Gmalina arborea*

Treatment

Each treatment combination was replicated five times, resulting in a total of 30 experimental units (2 inoculation treatments x 3 species x 5 replicates).

The inoculant was obtained by collecting soil from the root zones of ecto-mycorrhiza-associated trees around the polytechnic environment. All seeds were soaked in water at room temperature for 24 hours before planting.

Growth parameters such as plant height, stem girth diameter and number of leaves were measured at intervals of two weeks.

Treatment structure and Replications

Treatments	<i>A. indica</i>	<i>P. biglobosa</i>	<i>G. arborea</i>
Inoculated (T ₁)	T ₁ R ₁	T ₁ R ₁	T ₁ R ₁
	T ₁ R ₂	T ₁ R ₂	T ₁ R ₂
	T ₁ R ₃	T ₁ R ₃	T ₁ R ₃
	T ₁ R ₄	T ₁ R ₄	T ₁ R ₄
	T ₁ R ₅	T ₁ R ₅	T ₁ R ₅
Non-inoculated (T ₂)	T ₂ R ₁	T ₂ R ₁	T ₂ R ₁
	T ₂ R ₂	T ₂ R ₂	T ₂ R ₂
	T ₂ R ₃	T ₂ R ₃	T ₂ R ₃
	T ₂ R ₄	T ₂ R ₄	T ₂ R ₄
	T ₂ R ₅	T ₂ R ₅	T ₂ R ₅

Data Collection

Parameters measured included:

Germination percentage.

Seedling height and collar diameter.

Root length and biomass

Rate of ectomycorrhizal root colonization assessed microscopically

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) to determine the effects of inoculation, tree species and their interaction on the measured growth parameters.

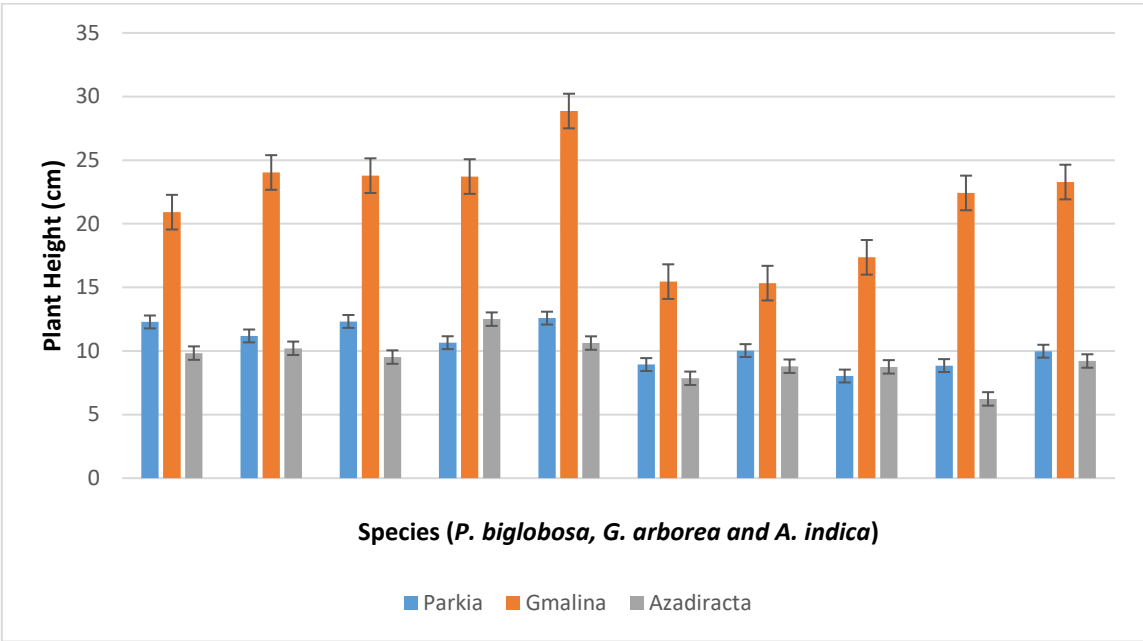
Result and Discussion

Figure 1: Mean Plant Height (cm) across species under two treatments (T₁, T₂). Error bars represent ± 1 standard deviation (n=5 per group)

The results presented in Figure 1 above show the mean plant height (cm) across the three tree species (*P. biglobosa*, *G. arborea* and *A. indica*) under two treatments: T₁ (Cow dung + Shaft sand + ecto-mycorrhiza) and T₂ (Cow dung + Shaft sand). Overall, the T₁ exhibited a notably higher mean plant height across all species compared to their T₂ counterparts.

Among the species, *G. arborea* recorded the highest mean plant height under both treatments with $24.15 \pm 2.89\text{cm}$ (T_1) while T_2 recorded a height of $18.77 \pm 3.82\text{cm}$ indicating its vigorous response to ecto-mycorrhiza. *P. biglobosa* followed in height performance with T_1 recording $14.94 \pm 0.84\text{cm}$ and T_2 with $9.16 \pm 0.84\text{cm}$, while *A. indica* consistently recorded the lowest mean plant height with $10.54 \pm 1.17\text{cm}$ and 8.17 ± 1.19 . Error bars representing ± 1 standard deviation showed minimal variation within replicates, suggesting consistent growth responses within treatment groups. The significant higher height recorded in seedlings under T_1 , particularly *G. arborea*, aligns with the findings of Sun *et al.*, (2023), who reported enhanced growth due to ECN-enhanced nitrogen uptake in their study “Ectomycorrhizal fungi enhance nitrogen uptake and growth of tree seedlings by regulating gene expression of nutrient transporters.

Figure 1: Effect of Ecto-Mycorrhizal Inoculation on Mean Plant Height



Source: Field Suurvey, 2025

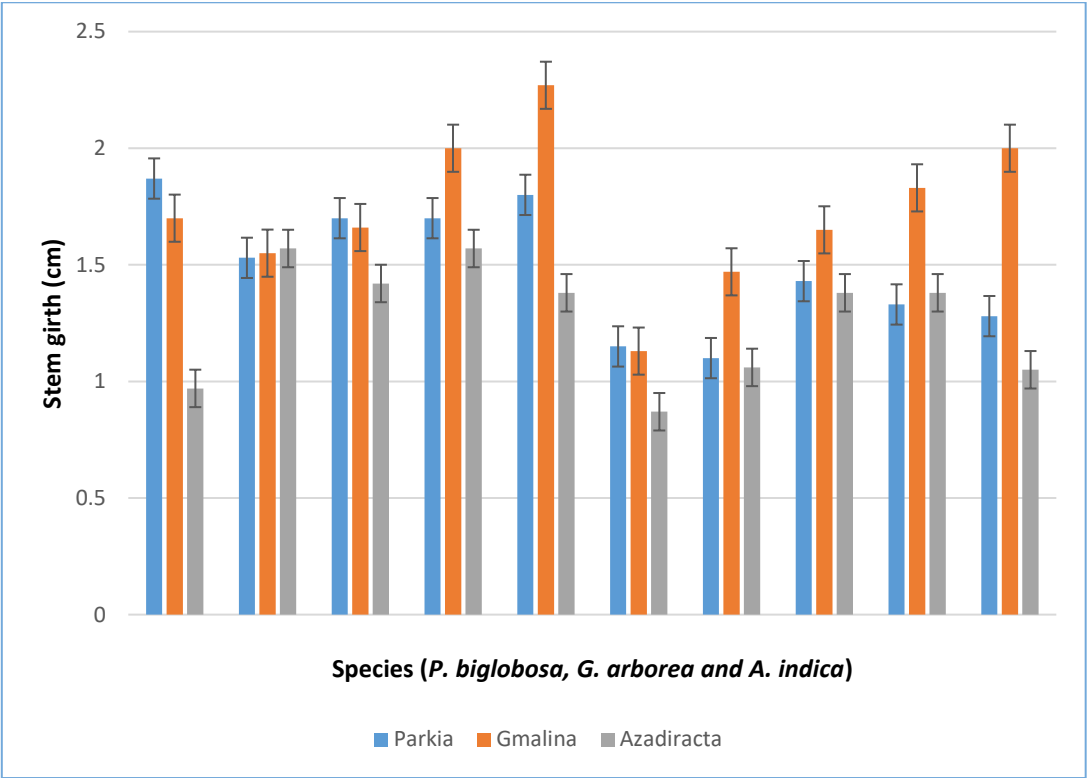
Figure 2: Mean Stem Girth (cm) (cm) across species under two treatments (T_1 , T_2). Error bars represent ± 1 standard deviation ($n=5$ per group)

As shown in Figure 2 above, the chart shows a similar trend to plant height, where T_1 seedlings exhibits thicker stems than those under T_2 . *G. arborea*, recorded the highest mean girth with $1.84 \pm 0.29\text{cm}$ for T_1 and $1.62 \pm 0.34\text{cm}$ for T_2 , *P. biglobosa* followed with $1.72 \pm 0.13\text{cm}$ for T_1 and $1.62 \pm 0.13\text{cm}$ for T_2 while *A. indica* recorded the lowest stem girth with $1.38 \pm 0.25\text{cm}$ for T_1 and $1.15 \pm 0.22\text{cm}$ for T_2 . The error bars showed overlapping ranges for some groups, but general pattern suggests positive influence of T_1 on stem diameter development.

The greater stem girth observed in *G. arborea* under T_1 agrees with Li *et al.*, (2024) in their study “Ectomycorrhizal colonization enhances growth and drought tolerance in *Pinus*

massoniana seedlings”, who found that ECM inoculation improves stem diameter in drought-prone environments by increasing water-use efficiency.

Figure 2: Effect of Ecto-mycorrhizal Inoculation on Mean Stem Girth



Source: Field Suurvey, 2025

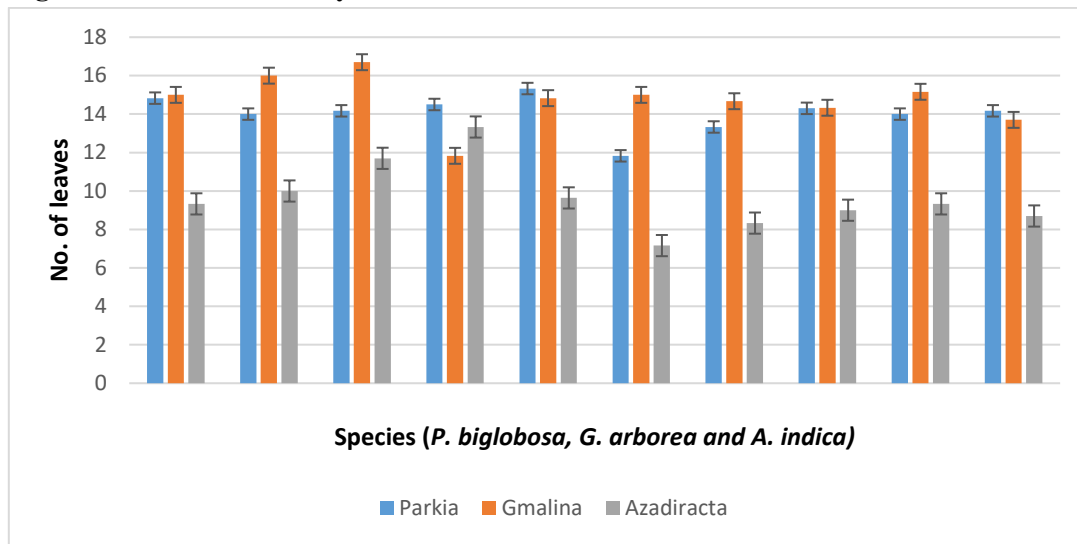
Figure 3: Mean Number of leaves across species under two treatments (T1, T2). Error bars represent ± 1 standard deviation (n=5 per group).

Figure 3 above present the average number of leaves produced by the three species under both treatments. Leaf number as an indicator of photosynthetic capacity and plant vigor was also higher under T₁ across all species. *G. arborea* recorded 14.89 ± 1.86 for T₁ while T₂ recorded 14.57 ± 0.58 Which is the highest, followed by *P. biglobosa* followed with 14.57 ± 0.53 for T₁ and 13.53 ± 1.02 for T₂, the least was recorded by *A. indica* with a mean plant height of 10.80 ± 1.67 for T₁ and 8.50 ± 0.83 for T₂.

The difference between T₁ and T₂ is particularly distinct in *G. arborea*, suggesting that ecto-mycorrhizal fungi may promote foliar development by enhancing phosphorus uptake. The relative tight error bars reinforce the consistency of responses within treatment groups.

The higher leaf production under T₁ is in line with the findings of Chen *et al.*, (2024) in their study “Ectomycorrhizal fungi Improve nutrient uptake and cold tolerance in alpine tree seedlings under stress conditions”, where they reported that ECM fungi improved nutrient uptake and foliar development in alpine tree seedlings.

Figure 3: Effect of Ecto-mycorrhizal Inoculation on Number of Leaves



Source: Field Suurvey, 2025

Table 1: Analysis of Variance for Mean Plant Height

Source of Variation	SS	df	MS	F	P-value	F crit
Treatment	91.80501	1	91.80501	20.33928	0.000144	4.259677
Species	902.7666	2	451.3833	100.0034	2.29E-12	3.402826
Interaction	14.96141	2	7.480703	1.65734	0.21173	3.402826
Error	108.3284	24	4.513682			
Total	1117.861	29				

Table 1 above shows a Two-way Analysis of Variance for plant height which revealed that both treatment and species had statistically significant effects on the seedling height. Treatment had a highly significant effect ($F= 20.34$, $P= 0.0001$), indicating that seedlings in T_1 (cow dung + shaft sand + ecto-mycorrhiza) grew significantly taller than those in T_2 (cow dung + shaft sand).

Species also showed a significant effect ($F= 100.00$, $P < 0.0001$), with *G. arborea* attaining the heighest mean plant height, followed by *P. biglobosa* and *A. indica*. The interaction between treatment and species was not statistically significant ($F= 1.66$, $P= 0.212$), suggesting that the effect of treatment on plant height was consistently across all three species

Table 2: Analysis of Variance for mean stem girth

Source of Variation	SS	df	MS	F	P-value	F crit
Treatment	0.699213	1	0.699213	12.15777	0.001903	4.259677
Species	1.062887	2	0.531443	9.240618	0.001057	3.402826
Interaction	0.092287	2	0.046143	0.80233	0.459946	3.402826
Error	1.38028	24	0.057512			
Total	3.234667	29				

For stem girth, the ANOVA results also showed a significant treatment effect ($F= 12.16$, $P= 0.0019$) as shown in table 2 above, confirming that seedlings grown with ecoto-mycorrhiza (T_1) developed a thicker stems compared to those in T_2 . Species had significant impact as well ($F= 9.24$, $P= 0.0011$), with *G. arborea* again displaying the largest mean stem girth, followed by *P. biglobosa* and *A. indica*.

No significant interaction effect was observed ($F= 0.80$, $P=0.459$), indicating that all species responded similarly to the treatments in terms of stem diameter.

Table 3: Analysis of Variance for Mean Number of Leave

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Treatment	11.01708	1	11.01708	7.621569	0.010875	4.259677
Species	151.5637	2	75.78185	52.42557	1.74E-09	3.402826
Interaction	5.09096	2	2.54548	1.760952	0.193372	3.402826
Error	34.69232	24	1.445513			
Total	202.3641	29				

The ANOVA for number of leaves in table 3 above showed a significantly effect of treatment ($F= 7.62$, $P= 0.011$), with T_1 producing more leaves across all species compared to T_2 . Species also differed significantly in leaf production ($F= 52.43$, $P< 0.0001$), with *G. arborea* and *P. biglobosa* showing higher leaf count than *A. indica*.

The treatment * species interaction was again not significant ($F= 1.76$, $P= 0.193$), confirming that the positive effect of the T_1 treatment was uniform across the three species.

Across all growth parameters; plant height, stem girth and number of leaves, the use of ectomycorrhizal fungi in treatment T_1 significantly enhanced seedling performance. The non-significant interaction effects indicate that this positive influence was consistent across the three tree species studied. This results are consistent with recent findings by Li *et al.*, (2024) in *Pinus massoniana* seedlings, where ECM inoculation significantly increased both height and ground diameter, particularly under drought condition in their study “Ectomycorrhizal colonization enhances growth and drought tolerance in *Pinus massoniana* seedlings” Similarly, Sun *et al.*, (2023) reported enhanced nitrogen transporter expression and growth in seedlings inoculated with EMC fungi in their study “Ectomycorrhizal fungi enhance nitrogen uptake and growth of tree seedlings by regulating gene expression of nutrient transporters, supporting our observed increase in biomass traits under T_1 treatment. Furthermore, studies by Nash *et al.*, (2020) in their research” Does ectomycorrhizal fungal Biodiversity affect tree growth? Experimental evidence from temperate and tropical seedlings” indicate that ECM fungal diversity positively influences tropical tree seedlings growth, which may explain the stronger response observed in *G. arborea* in this study.

Conclusion

This study confirms the positive influence of ectomycorrhizal fungi in combination with cow dung and shaft sand on the early growth performance of tree seedlings. The application of T_1

treatment significantly improved plant height, stem girth, and number of leaves in all three species evaluated, with *Gmelina arborea* showing the highest overall response. These results suggest that mycorrhizal inoculation can be a valuable and sustainable practice in nursery and reforestation programs.

Recommendations

- i. Ectomycorrhizal fungi be incorporated into seedling production protocols, especially for fast-growing and nutrient-demanding species like *Gmelina arborea*.
- ii. Further studies be conducted on field performance and long-term survival of mycorrhiza-treated seedlings.
- iii. Similar trials be expanded to include more native species and varying soil types for broader ecological applicability.

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