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Research Article

# Effects of Different Potting Mixture on Early Development of *Afzelia quanzesis* Welw. Species Seedlings

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## Abstract

Planting native plant species is becoming increasingly important as the world begins to realise the importance of restoring ecosystems, especially since many valuable species are on the brink of extinction due to human over-exploitation. *Afzelia quanzensis* Welw. is one of the valuable timber species, highly targeted in uncontrolled selective loggings, hence threatening its existence. This study assessed the effects of different potting mixtures on *A. quanzensis* early seed germination, which is an essential step for its mass propagation. Four different potting mixtures: T1 (forest soil, agricultural residues, tobacco, and cow manures), T2 (forest soil, tobacco manure), T3 (forest soil and cow manure), and T4 (forest soil and agricultural residues) were utilised. Employing a completely randomised design with each mixture replicated four times, the study monitored growth parameters, such as leaf count and seedling height, over one month. Results from two-way ANOVA with Turkey's multiple comparisons test showed that forest soil and cow manure (T3) yielded the tallest plants and highest scores of leaf count. The study provides valuable insights for nursery managers and researchers working on the mass propagation of the *A. quanzensis* tree species for plantations in the region.

## Keywords

Potting Mixture, Seedlings, Height, Leaf Count, *Afzelia quanzensis*

## 1. Introduction

In the wake of the massive destruction of natural forest cover, restoration of degraded lands by planting native trees has received worldwide attention [15, 30]. However, mass production of valuable native species for restoration is challenging due to limited knowledge of the propagation mechanism for most of the native tree species [29]. Native tree species often receive little attention because they are slow growers and are usually associated with poor growth form, difficulties in seed germination, and nursery establishment [20, 18, 4]. Various silvicultural methods for preserving and restoring tree species have been used during nursery management and field establishment [6, 16, 22, 30]. Different nursery operations are carried out, and other silvicultural methods are employed to preserve and restore the tree species covers [1, 13, 30].

*Afzelia quanzensis* Welw. (*A.quanzensis*) commonly known as pod mahogany [6], lucky beans [12], and Mkongo in Tanzania, is a native tree which belongs to the family Fabaceae [21, 24]. It is native to different countries, including Botswana, Kenya, Mozambique, Somalia, South Africa,

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Zimbabwe, and Tanzania [21, 9]. The *A.quanzensis* stems produce valuable timber, which is highly demanded due to its high durability and aesthetic appearance [28, 9, 21]. The IUCN classified *A.quanzensis* as Least Concern, but it is known to be widely harvested due to its quality wood [16], putting it on the verge of threatening species at the local level [11, 24]. Illegal selective harvesting has been constantly depleting and, in some cases, exhausting harvestable stocks of *A.quanzensis* trees [8, 17]. Hence, devising propagation methods that could lead to domestication is necessary to ensure the continuous supply of benefits from this valuable timber species.

Much research has been done on the efforts of domestication of *A.quanzensis* trees, including the effects of seed sizes [21] and different pre-treatment methods (mechanical, soaking and concentrated sulphuric acid at various time intervals, hot water treatments) on germination and seedling growth of *A.quanzensis* Welw. [9]. However, to ensure the proper support, moisture, and nutrients for seedling growth, potting mixture selection is a very crucial process [26]. The properties of potting mixtures can affect soil chemistry and physical characteristics, including water-holding capacity [2, 23] and nutritional availability [22, 27, 30], which influences seed germination and seedling development [2, 25]. According to [19], using top garden soil, forest soil, and commercial compost on pod mahogany (*Afzelia quanzensis*) seedlings showed favourable early-stage growth impacts by increasing plant height only when top garden soil was utilised.

This study sought to assess the effects of several other potting mixture combinations, including forest soil, agricultural residues, tobacco, and cow manures, on *A.quanzensis* early seed development, particularly seedling height growth and leaf development. By identifying the optimal potting combinations for the growth of *A. quanzensis* seedlings, our study contributes to preserving and restoring this species. Ultimately, this study provides valuable insights for nursery managers and researchers working on the propagation of indigenous tree species and has the potential to impact the conservation of the threatened *Afzelia quanzensis* species.

# 2. Methodology

## 2.1. Experimental Site

The study was conducted at the Tree Seed Production Station (TSPS) nursery, formerly the Tanzania Tree Seed Agency (TTSA), in Kihonda, Morogoro municipality, Tanzania. Tree Seed Production Station (TSPS) nursery is 5 km from the Msamvu bus stands along the Morogoro - Dodoma highway at latitude 06°36 S and Longitude 37°39 E. The area is a sub-humid tropical type of climate with a bi-modal rainfall distribution. The mean annual rainfall in the region is 740 mm, with the mean monthly minimum and maximum rainfall of 440 and 1094 mm, respectively. The mean annual temperature is 25.1 ℃ with the monthly minimum and maximum temperature of 19.7 ℃ and 30.6 ℃, respectively.

## 2.2. Experimental Design and Treatments

The tree seeds were purchased directly from the Tree Seed Production Station (TSPS). The experiments were laid out in completely randomised designs (CRD) with four different potting mixtures, each replicated four times. The four potting mixtures that were used as treatments in this study were as follows: $T_1$ (forest soil, agricultural residues, tobacco and cow manures), $T_2$ (forest soil, tobacco manure), $T_3$ (forest soil and cow manure), and $T_4$ (forest soil and agricultural residues). The agricultural residues were prepared from different harvested farms and sun-dried completely. Tobacco fertiliser was bought from agricultural supply stores, and the forest soil was collected from the natural forests in the Morogoro region.

The *A.quanzensis* seeds were de-pulped, washed and sun-dried for 24 hours to enhance germination. Each treatment consisted of 75 seed samples, replicated three (3) times and sown in polyethene tubes, yielding 900 samples from all treatments. The experiment was conducted under a 60% green net shade to minimise water loss. To maintain adequate moisture for germination and seedling growth, seedlings were watered twice daily (morning and afternoon). No fertiliser was supplied to the seedlings.

## 2.3. Growth Parameters

The effect of the potting mixture on early seedling development was assessed by measuring the height of the seedlings and counting the number of leaves for one (1) month. Data was continuously recorded after every (1) week of the experiment. Shoot height was measured from the tip of the branch (pot soil surface) to the highest apical meristem. The feasible leaves were counted from each plant/seeding.

## 2.4. Data Analysis

We evaluated the number of leaves and shoot height development under different pre-sowing treatment conditions to assess the effects of different potting mixtures on early seed development of *Afzelia quanzesis* Welw.

Two-way analysis of variance (ANOVA) with Turkey's multiple comparisons test was done to test the effects of different potting mixtures on the leaf count development and shoot height development of the seedlings in different potting mixtures. All statistical analysis and visualisations were performed using R statistical computing software version 4.2.0. All probabilities were tested at an alpha ($\alpha$) = 0.05 significance level.

# 3. Results

*Growth parameters under different potting mixtures*

Different potting media significantly affected plant seedling growth. There was a slight difference in shoot and leaf development between T3 and the rest of the potting mixture treatments (T1, T2, and T4) (Figure 1), with magnitudes of approximately 4.64 mm for shoots and four leaves in T1, 4.46 mm for shoots and three leaves in T2, and 2.72 mm for shoots and three leaves in T4 (Table 1).

There was a significant difference in plant shoot height development in T3 compared to other treatments, where T3, had the tallest plants (Figure 1).

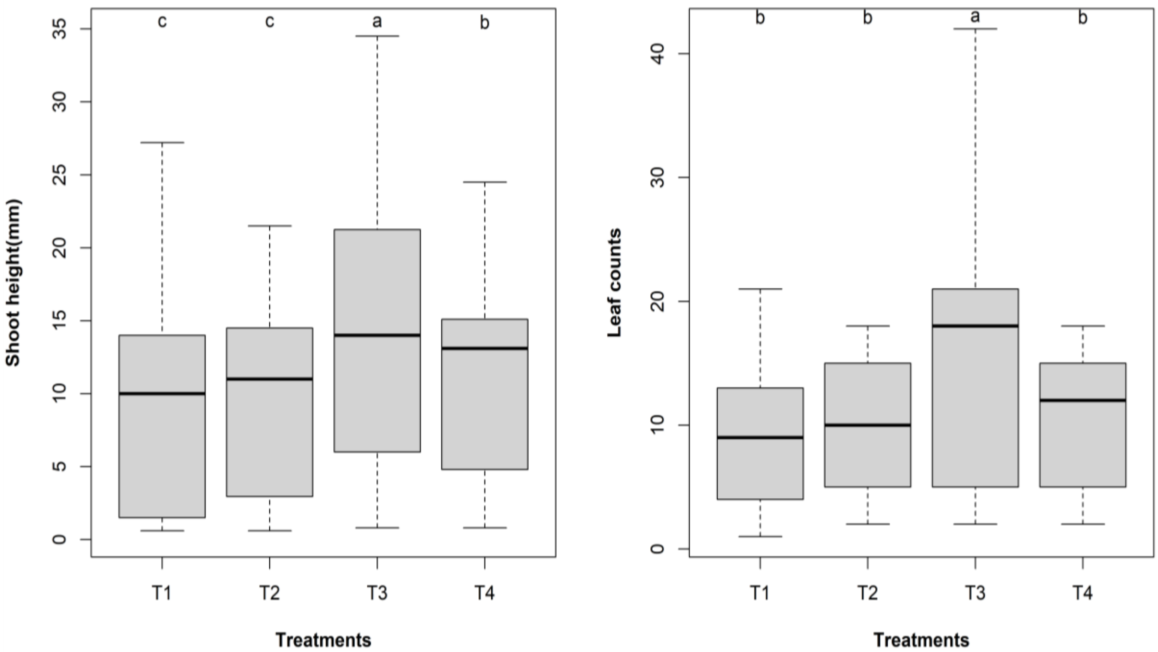


***Figure 1.*** *Boxplots showing the variability in A. quanzensis seedlings include (a) height among different potting media and (b) leaf counts among different potting media. The whiskers represent the minimum and maximum values of shoot height and leaf counts per treatment.*

***Table 1.*** *Effect of the potting mixture on the growth of A.qunzensis seedlings.*

| Potting mixture | Shoot height (mm) | Leaf count |
|---|---|---|
| Forest soil, cow manure, tobacco manure and agricultural residues (T1) | 9.62 ±6.3 = 4.64 | 9 ±5 |
| Forest soil, tobacco manure (T2) | 9.80 ±5.9 = 4.46 | 10 ±5 |
| Forest soil and cow manure (T3) | 14.26 ±9.8 | 13 ±9 |
| Forest soil and agricultural residues (T4) | 11.54 ±6.6 | 10 ±6 |

The plant shoot height increased progressively throughout the study. However, there were no significant differences ($p>0.05$) in the development of shoot height among T1, T2 and T3 treatments at the end of the study. The first three weeks showed slight differences in shoot height development among the treatments (Table 2). By the fourth week, T3 showed a significantly ($p<0.05$) higher shoot height development than the other treatments. In contrast, *A. quanzensis* seedlings grown in T2 were significantly ($p < 0.01$) shorter than those in the different treatments, with a height increase of less than 2 mm from the third week. Moreover, at week 4, the mean height value of T4 seedlings was only slightly taller (17.63 mm) than those in T1 (16.49 mm), as shown in Table 2.

***Table 2.*** *The effects of potting media on A. quanzensis seedling height (mm) over time.*

| Potting media | Week 1 | Week 2 | Week 3 | Week 4 |
|---|---|---|---|---|
| Forest soil, manure, and agricultural residues (T1) | 1.025[a] | 9.49[b] | 11.49[b] | 16.49[b] |
| Forest soil, tobacco manure (T2) | 1.013[b] | 10.63[b] | 12.63 [b] | 14.93[c] |
| Forest soil and cow manure (T3) | 1.276[a] | 12.93[a] | 14.93[a] | 27.89[a] |
| Forest soil and agricultural residues (T4) | 1.108[ab] | 12.73[a] | 14.70[a] | 17.63[b] |

The mean seedling heights of *A. quanzensis* as separated by Least Significance Difference (LSD) Test at p <0.05. Themeans within columns followed by the same letters are not significantly different.

Likewise, *A.quanzesis* leaves differed among treatments over time. The leaf number increased over time for all treatments, with the highest increase observed in T3 on the third and fourth weeks. At the end of the experiment (the fourth week), leaf count development was significantly ($p < 0.001$) higher when forest soil and cow manure (27.9 mm) were used than in other treatments. Meanwhile, the use of forest soil, manure (cow and tobacco), and agricultural residues (T1) provided the lowest number of leaves (15) at the end of the study. On week 4, *A. quanzensis* seedlings had no significant difference in growth when using a mixture of forest soil, tobacco manure (T2) and forest soil and agricultural residues (T4).

***Table 3.*** *Number of leaves in A. quanzensis seedlings over time.*

| Potting media | Week 1 | Week 2 | Week 3 | Week 4 |
|---|---|---|---|---|
| Forest soil, manure, and agricultural residues (T1) | 2[b] | 5[a] | 12[c] | 15[c] |
| Forest soil, tobacco manure (T2) | 3[ab] | 6[ab] | 13[bc] | 16[b] |
| Forest soil and cow manure (T3) | 3[a] | 6[a] | 19[a] | 22[a] |
| Forest soil and agricultural residues (T4) | 4[a] | 7[a] | 14 [b] | 17[b] |

The mean seedling leaves of *A. quanzensis* as separated by Least Significance Difference (LSD) Test at p <0.05. The means within columns followed by the same letters are not significantly different.

## 4. Discussion

Different potting media have a significant effect on the growth of plant seedlings [2, 4, 5, 7, 14]. The main reason for applying different contents of potting mixtures to the soil is to improve the organic matter amendment of the soil and provision of potential nutrients to plants [12, 27, 30]. Our study analysed the effects of different potting mixtures (forest soil, tobacco manure, cow manure and agricultural residues) on early seed development of *Afzelia quanzesis* Welw, particularly seedling height growth and leaf development.

The study observed a significant increase in height and number of leaves when forest soil and cow manure (T3) were used compared to other treatments (Figure 1). The use of forest soil in the potting mixture provides a favourable microbial community that contributes to the growth and development of the seedlings [12]. The increase in the number of leaves and shoot height development with the use of forest soil and cow manure (T3) could probably have been enhanced by the improved organic matter amendment of the soil, high water holding capacity of the soil and high nutrient availability in cow manure [27, 30, 33] which accelerated the early growth of the seedlings in the first three weeks. The increased growth parameters observed with T3 treatment are consistent with previous studies that have demonstrated the beneficial effects of animal manure on plant growth [7, 5, 32-34]. The observed increase in shoot height and leaf development may be attributed to the nutrient-rich composition of cow manure [21], which is believed to be readily available and provide essential elements, such as nitrogen (N), phosphorous and exchangeable potassium (K), necessary for plant growth and development [18].

The most extensive seedling development was after that observed when agricultural residues (T4) were used (Tables 2 and 3). This is a different case when tobacco manure was used (T2). This may be attributed to the fact that tobacco residues contain high levels of alkaloids (nicotine) and other chemicals that can affect crops and the environment [12, 10, 23, 31]. The nicotine in tobacco manure may have negatively impacted the growth and development of the seedlings, leading to reduced height and leaf number compared to other treatments. The toxic effects of tobacco manure have also been documented in other studies [12, 3] whereby continuous tobacco farming was found to deplete soil nutrients and cause the accumulation of heavy metals in the soil, posing environmental concerns [23].

Similarly, the combination of forest soil, manure, and agricultural residues (T1) provided the least growth parameters. The lower seedling height and leaf development observed in the treatment (T1) could be attributed to the dilution effect caused by including multiple in the potting mixture. The presence of various components in these mixtures could have resulted in a more dispersed distribution of nutrients and microbial activity. The proportions of the four elements in the T1 mixture may have been comparatively lower, hindering the overall effectiveness of the nutrient provision and organic matter amendment, resulting in suboptimal growth performance. Moreover, including tobacco manure in T1 treatment may have contributed to the suboptimal growth results due to its toxic trait [23, 31]. Despite other components such as forest soil, agricultural residues, and cow manure, the adverse effects of tobacco manure on seedling development could have outweighed the potential benefits of the other components in the mixture.

## 5. Conclusion

Establishing precise silviculture methods in Nursery operations to ensure the continuous supply of beneficial native species in the current phases of the highest increase in timber demands is necessary. Our findings suggest that the combination of forest soil and cow manure (T3) appears to be the most favourable potting mixture for promoting the early seed development of *Afzelia quanzensis* seedlings. This combination offers a beneficial microbial community, high water holding capacity, and ample nutrient availability, all contributing to the enhanced growth of *A.quanzensis* seedlings. Tobacco manure is reported to be potentially toxic due to its high alkaloid content; however, if tobacco manure must be used, caution should be exercised by composting it with other organics, which can reduce phytotoxic (alkaloid content) and convert tobacco waste into valuable products. These findings highlight the importance of carefully selecting and balancing the components in potting mixtures for optimal seedling growth. By understanding the effects of different mixtures on seedling development, we can make informed decisions when choosing the most suitable potting mixture for tree nurseries and during restoration efforts.

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## Conflicts of Interest

The authors declare no conflicts of interest.

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