

# Effect of Soil Fertility on the Growth Characteristics of Two Young Trees of the Neem Family

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## ABSTRACT

To select tree species suitable for growth under Chinese ephedra forests, this study set up three soil fertility treatments: pure sandy soil, V (sand): V (fertilizer) = 3:1, and V (sand): V (fertilizer) = 1:1, to investigate the effects of different soil fertility levels on the growth characteristics of two tree species, *Azadirachta indica* A. Juss (neem) and *Melia azedarach* (chinaberry). The results show that: (1) Under low light conditions and pure sandy soil, the height and basal diameter of neem significantly increased, while chinaberry showed a significant increase in height and basal diameter under the V (sand): V (fertilizer) = 1:1 condition. (2) Under the V (sand): V (fertilizer) = 1:1 condition, both neem and chinaberry exhibited maximum leaf growth characteristics, while there was a decreasing trend under the V (sand): V (fertilizer) = 3:1 condition. These results indicate that neem is more suitable for growth in pure sandy soil and is more tolerant to poor soil conditions, while chinaberry thrives under the V (sand): V (fertilizer) = 1:1 condition. This preliminary selection provides a theoretical basis for the initial screening of tree species for coastal defense forests.

## KEYWORDS

Soil fertility; *Azadirachta indica* A. Juss; *Melia azedarach*

## 1. INTRODUCTION

Chinese ephedra (*Casuarina equisetifolia* L.), known for its tolerance to poor soil conditions, fast growth rate, and strong wind resistance, serves as a protective species for barren lands. It exhibits excellent regional adaptability and resistance to wind and sand, making it a native protected species and a primary species for artificial protective forests in Hainan Island [1]. However, as an introduced species, Chinese ephedra inevitably faces challenges such as poor natural regeneration quality. Located in the tropical region, Hainan Island experiences a tropical monsoon climate with an average annual temperature ranging from approximately 22.5 to 25.6°C (Hao Qingyu et al., 2021). Some areas of Hainan Island receive about 5.5 hours of sunlight per day (Cai Daxin et al., 2010), while most areas receive more than 6 hours of average daily sunlight [2]. Despite ample sunlight, high average temperatures, and significant rainfall, the coastal ecological conditions of Hainan Island are harsh due to frequent typhoons, intermittent droughts, soil erosion, and poor water retention in sandy soils, posing challenges for selecting suitable tree species for afforestation. Environmental factors influence organisms, and organisms, in turn, influence the environment. Different soil fertility environments provide varying nutrient conditions, leading to morphological, internal structural, and physiological changes in plants to adapt to their surroundings. The coastal areas of Hainan Island, dominated by sandy soils, have impoverished soil conditions, making it challenging for many plants to thrive. Through the study of "the effects of soil fertility on the growth characteristics of two Meliaceae tree

species," preliminary soil fertility conditions suitable for the growth of *Melia azedarach* and *Azadirachta indica*, two Meliaceae tree species, were identified. This research provides some theoretical basis for increasing the diversity of tree species under Chinese ephedra protective forests [3].

*Azadirachta indica* A. Juss, commonly known as neem, belongs to the Meliaceae family. It is a tree species that thrives in dry, hot valleys, exhibiting tolerance to drought and high temperatures. Despite over 20 years of development and utilization of neem in China, research on this species remains relatively limited in terms of fundamental aspects [4]. Domestic research on neem primarily focuses on variety selection, introduction, cultivation, and product development (Liu Yun et al., 2018), with fundamental studies related to its environment, growth, and metabolism being relatively scarce (Wang Ruibo et al., 2004). *Melia azedarach*, also known as chinaberry, has a wide distribution spanning latitudes of 21° and longitudes of 34°. It is a deciduous tree belonging to the Meliaceae family. Chinaberry wood exhibits excellent quality and insect resistance, making it suitable for various applications such as musical instruments and furniture. Despite its short growth cycle and ease of processing, research on the metabolism and growth of chinaberry, influenced by soil fertility, remains relatively lacking. Currently, research on neem primarily focuses on afforestation, cultivation, and the extraction and processing of neem compounds (Zhang Changshun, 2007), while studies on the metabolism and growth of chinaberry affected by soil fertility are relatively insufficient [5].

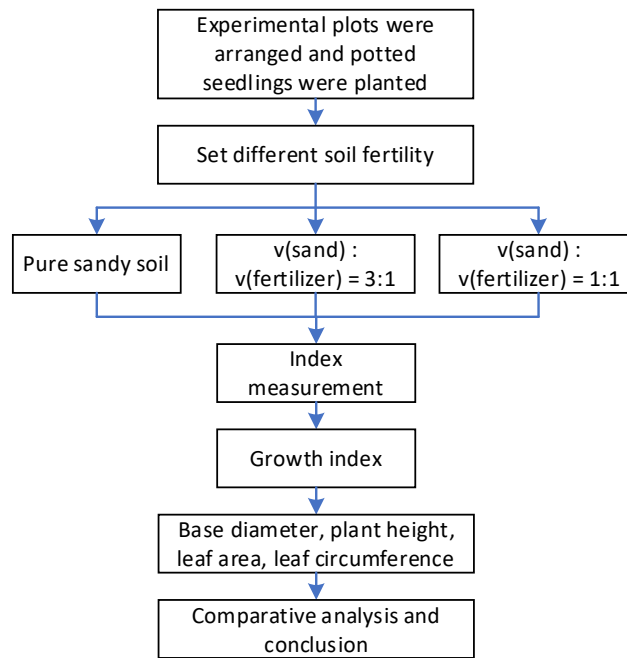
Soil nutrients provide a material basis for the growth and development of seedlings, and extensive research both domestically and abroad has shown that artificial fertilization during the plant growth period can promote plant height increase, stem diameter enlargement, and biomass production (Li Tianfang et al., 2009). During growth, plants need to absorb nutrients from the soil in certain proportions to meet their own needs. However, it is not simply a matter of applying a certain nutrient in a "force-feeding" manner to promote plant growth. Therefore, to ensure optimal seedling growth, it is essential to maintain appropriate soil fertility for seedling cultivation. If soil fertility is too low or too high, seedlings may lose physiological balance, resulting in reduced yield or even disease and death. Therefore, soil fertility is crucial for plant growth.

Based on the above content, this study established three soil fertility treatment groups: pure sandy soil, V (sand): V (fertilizer) = 3:1, and V (sand): V (fertilizer) = 1:1, to investigate the effects of different soil fertility levels on the growth characteristics of two tree species, *Azadirachta indica* A. Juss (neem) and *Melia azedarach* (chinaberry), during their seedling stage.

## 2. OVERALL FRAMEWORK

The study investigates the effects of different soil fertility levels on the growth morphology of seedlings, including comparative analyses of the height growth characteristics of *Melia azedarach* and *Azadirachta indica* (neem) under different soil fertility conditions, comparative analyses of the diameter growth characteristics of *Melia azedarach* and *Azadirachta indica* under different soil fertility conditions, and comparative analyses of the leaf morphology of *Melia azedarach* and *Azadirachta indica* under different soil fertility conditions.

The research framework is shown in Figure 1.



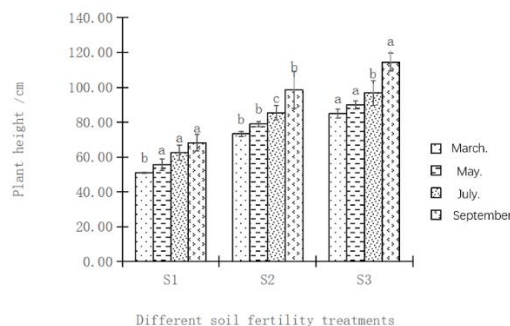
**Figure 1.** Research framework

Currently, there is a lack of research on soil fertility aspects concerning *Melia azedarach* and *Azadirachta indica*, highlighting the importance of this study for the sustainable development of coastal protective forests and the conservation and utilization of these two species to increase biodiversity. By selecting seedlings of both tree species and simulating natural environmental conditions of sunlight and shading, this study aims to conduct comparative analyses and evaluations based on multiple indicators, which can better demonstrate the variations in different tree species under varying light conditions, thus providing practical insights. By selecting two tree species and evaluating multiple indicators, this study aims to comprehensively analyze and assess the changes that occur under different soil fertility conditions, integrating with previous research findings. The factors selected for this study, namely natural environmental conditions of sunlight and shading, aim to realistically simulate the growth conditions of plants in the wild, thus holding practical value.

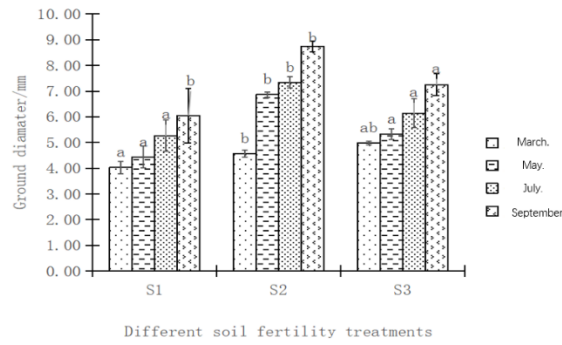
### 3. EFFECTS OF DIFFERENT SOIL FERTILITY ON SEEDLING HEIGHT AND BASE DIAMETER OF NEEM AND NEEM

#### 3.1. Effects of Different Soil Fertility on Seedling Height and Base Diameter of Neem and Neem

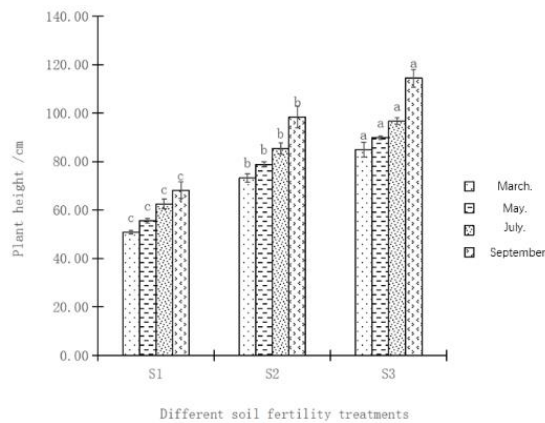
As shown in Figures 2 to 5, the growth conditions of the plant height and basal diameter of indigo and bitter chinaberry under three soil fertility conditions were compared. The analysis results are as follows.



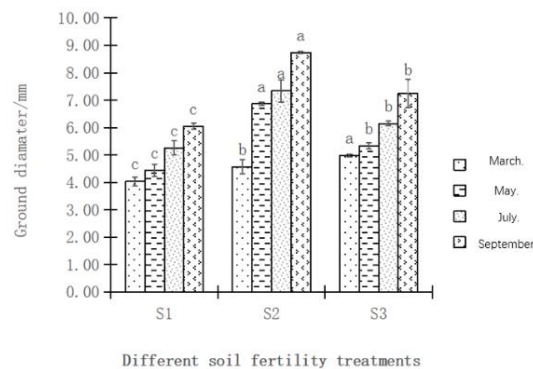
**Figure 2.** Effect of different soil fertility on plant height of *Azadirachta indica* A. Juss



**Figure 3.** Effects of soil fertility on Ground diameter of *Azadirachta indica* A. Juss



**Figure 4.** Effects of soil fertility on Plant height of *Melia azedarach* Saplings



**Figure 5.** Effects of soil fertility on Ground diameter of *Melia azedarach* Saplings

In the same month, there were significant differences in plant height and basal diameter among different treatment groups ( $P < 0.05$ ). The measurement results of indigo are as follows: Comparisons revealed that in March, under treatment condition S3, the maximum height of indigo was  $31.00 \pm 2.60$  cm, while in May, under treatment condition S1, the maximum height was  $37.10 \pm 3.32$  cm. In July, the maximum height was  $71.03 \pm 4.38$  cm, with treatment condition S1, and in September, the maximum height was  $81.73 \pm 5.18$  cm, with treatment condition S3. The maximum basal diameter of indigo in March, May, and July was  $2.76 \pm 0.25$  cm,  $3.62 \pm 0.43$  cm, and  $5.36 \pm 0.61$  cm, respectively, all under treatment condition S1. In September, the maximum basal diameter was  $8.87 \pm 0.43$  cm, under treatment condition S3.

The measurement data for bitter chinaberry are as follows: It was observed that in March, the maximum height of bitter chinaberry was  $84.90 \pm 3.11$  cm, in May it was  $89.90 \pm 0.72$  cm, in July it was  $96.77 \pm 1.34$  cm, and in September it was  $114.53 \pm 3.67$  cm. In all these four months, the

treatment condition with the maximum height was S3. The maximum basal diameter of bitter chinaberry in March was  $4.98 \pm 0.04$  cm, under treatment condition S3. In May, July, and September, the maximum basal diameter was  $6.87 \pm 0.06$  cm,  $7.34 \pm 0.41$  cm, and  $8.74 \pm 0.05$  cm, respectively, and all under treatment condition S2. Therefore, it can be concluded that under the soil environment with a sand to fertilizer ratio of 1:1, both indigo and bitter chinaberry show significant growth trends. However, compared to bitter chinaberry, indigo is more suitable for growth in pure sandy soil, while bitter chinaberry exhibits better growth characteristics in a soil environment with a sand to fertilizer ratio of 3:1.

As shown in the table below, the growth of indigo varies under different soil fertility treatments. There were no significant differences in the increase in plant height among the treatment groups ( $P > 0.05$ ), while there were significant differences in the increase in basal diameter among the treatment groups ( $P < 0.05$ ). Under soil condition S1, the maximum increase in plant height for indigo was observed, at  $52.33 \pm 5.16$  cm, whereas under soil condition S2, it was the minimum, at  $36.00 \pm 11.26$  cm. Under soil condition S3, indigo exhibited the maximum increase in basal diameter, at  $6.44 \pm 1.38$  cm, while under soil condition S2, it exhibited the minimum increase in basal diameter, at  $3.94 \pm 1.38$  cm.

The increase in plant height and basal diameter of bitter chinaberry shows significant differences among the treatment groups. Under soil condition S2, the basal diameter increase of bitter chinaberry is the highest, at  $4.17 \pm 0.25$  cm, while under S1 condition, it is the lowest, at  $2.02 \pm 0.15$  cm. Under S2 condition, the plant height increase is the highest, at  $29.63 \pm 5.61$  cm, while under S1 condition, it is the lowest, at  $17.33 \pm 2.74$  cm.

**Table 1.** effects of different soil fertility on growth characteristics of *Azadirachta indica* and *Melia azedarach*

species	Conditions	Increase of plant height /cm	Base diameter increase /mm
<i>Azadirachta indica</i> A. Juss	S1	$52.33 \pm 5.16a$	$4.01 \pm 1.20b$
	S2	$36.00 \pm 11.26a$	$3.94 \pm 0.16b$
	S3	$50.73 \pm 7.74a$	$6.44 \pm 1.38a$
<i>Melia azedarach</i>	S1	$17.33 \pm 2.74b$	$2.02 \pm 0.15b$
	S2	$25.20 \pm 3.01ab$	$4.17 \pm 0.25a$
	S3	$29.63 \pm 5.61a$	$2.26 \pm 0.51b$

### 3.2. Effects of different soil fertility on leaf growth characteristics of saplings of Neem and Chinaberry

As shown in Table 2, the leaf growth characteristics of indigo and bitter chinaberry vary under different soil fertility treatments. There are significant differences in leaf growth characteristics among the treatment groups ( $P < 0.05$ ). In terms of leaf area, under condition S3, both indigo and bitter chinaberry have the maximum leaf area, at  $10.77 \pm 2.11$  cm<sup>2</sup> and  $8.91 \pm 1.11$  cm<sup>2</sup>, respectively. The leaf area of indigo is the smallest under condition S2, at  $7.34 \pm 1.19$  cm<sup>2</sup>, while for bitter chinaberry, it is the smallest under condition S1, at  $7.44 \pm 1.11$  cm<sup>2</sup>. Regarding leaf perimeter, the maximum leaf perimeter of indigo is observed under condition S3, at  $17.94 \pm 2.48$  cm, while for bitter chinaberry, it is under condition S1, at  $16.76 \pm 2.13$  cm. The minimum leaf perimeter of indigo is observed under condition S2, at  $15.88 \pm 1.36$  cm, and for bitter chinaberry, it is under condition S3, at  $12.26 \pm 0.51$  cm. Concerning leaf length, both indigo and bitter chinaberry exhibit the maximum leaf length under condition S3, at  $7.20 \pm 0.82$  cm and  $6.7 \pm 0.62$  cm, respectively. The minimum leaf length for both plants is observed under condition S2, at  $6.20 \pm 0.52$  cm and  $5.73 \pm 1.10$  cm, respectively. Regarding leaf width, both indigo and bitter chinaberry exhibit the maximum leaf width under condition S3, at  $2.80 \pm 0.31$  cm and  $2.58 \pm 0.29$  cm, respectively. Under condition S2, the

minimum leaf width is observed for indigo, at  $2.16 \pm 0.16$  cm, while for bitter chinaberry, it is under condition S1, at  $2.45 \pm 0.25$  cm.

From this, it can be inferred that under dense forest conditions, with a sand to fertilizer ratio of 1:1, there is a tendency for an increase in leaf area, leaf length, leaf width, and other indicators for both indigo and bitter chinaberry. This is conducive to the photosynthesis and transpiration processes of the plants.

**Table 2.** effects of different soil fertility on leaf growth characteristics of *Azadirachta indica* and *Melia azedarach*

species	Conditions	Leaf area	Leaf circumference /cm
<i>Azadirachta indica</i> A. Juss	S1	8.73±1.20ab	17.89±1.72a
	S2	7.34±1.19b	15.88±1.36a
	S3	10.77±2.11a	17.94±2.48a
<i>Melia azedarach</i>	S1	7.44±1.11a	16.76±2.13a
	S2	7.61±1.91a	13.89±3.39a
	S3	8.91±1.11a	2.26±0.51b

#### 4. DISCUSSION AND CONCLUSION

Through this study, we found that bitter chinaberry exhibits significant increases in both plant height and basal diameter under soil conditions with a sand to fertilizer ratio of 1:1. Conversely, under experimental conditions of low light and pure sandy soil, indigo shows substantial increases in plant height and basal diameter. In pure sandy soil conditions, indigo exhibits maximum values in both plant height and basal diameter, indicating suitability for its growth. Bitter chinaberry, on the other hand, shows maximum plant height in pure sandy soil conditions and maximum basal diameter under soil conditions with a sand to fertilizer ratio of 1:1, suggesting suitability for its growth.

Indigo leaves exhibit maximum observed values in leaf area, perimeter, length, and width under soil conditions with a sand to fertilizer ratio of 1:1, indicating suitability for its growth. Conversely, under conditions with a sand to fertilizer ratio of 3:1, there is a trend of reduction in leaf growth characteristics. Bitter chinaberry leaves show maximum observed values in leaf area, length, and width under soil conditions with a sand to fertilizer ratio of 1:1, while under pure sandy soil conditions, the leaf perimeter has the maximum observed value, and leaf area and width have the minimum observed values. Therefore, it can be concluded that both indigo and bitter chinaberry exhibit an increasing trend in leaf area, length, width, and other indicators under low light and a sand to fertilizer ratio of 1:1, which is beneficial for photosynthesis and transpiration processes of the plants.

In summary, bitter chinaberry exhibits greater increases in plant height, basal diameter, and favorable leaf growth trends under forested conditions with a sand to fertilizer ratio of 1:1. Indigo, on the other hand, thrives in forested environments and pure sandy soil, with growth indicators performing comparatively less favorably under soil conditions with a sand to fertilizer ratio of 1:1. Therefore, preliminary screening suggests that indigo is more suitable for growth in pure sandy soil, while bitter chinaberry is more suited for growth under conditions with a sand to fertilizer ratio of 1:1.

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