ISSN: 3049-0677 (Online)

PhytoTalks

October 2024; Volume 1: Issue 3: 191-197

https://doi.org/10.21276/pt.2024.v1.i3.5

Safavid e-publishers

Research Article

OPEN ACCESS

Assessment of Early Growth of *Aquilaria malaccensis* Lam. in Behraich: Insights for Sustainable Agarwood Production and Conservation

Alok Yadav[1*], Sanchili Verma[1], Rahul Nishad[1] and Kuldeep Chauhan[1]

[1]I.C.F.R.E. - Eco Rehabilitation Centre, Prayagraj Uttar Pradesh India

*Corresponding author Email: yadava@icfre.org

Article History
Received: 17.09.2024
Accepted: 16.10.2024
Availabale online
Version: 1

Additional Information
Peer review: The publisher expresses gratitude to the anonymous reviewers and sectional editors for their invaluable contributions during the peer review process.
.

Reprints and Permissions Information is available at: https://phytotalks.com/journal/index.php/PT/open_acess_policy

Publisher's note: Regarding jurisdictional claims in published maps and institutional affiliations, PhytoTalks maintains its objectivity.
.

Cite this article: Yadav A, Verma S, Nishad R, Chauhan K. Assessment of Early Growth of *Aquilaria malaccensis* Lam. in Behraich: Insights for Sustainable Agarwood Production and Conservation *PhytoTalks*. 2024; 1(3): 191-197.

Abstract

Aquilaria malaccensis L., a critically endangered species native to Southeast Asia, is highly valued for producing agarwood, a resin used in perfumery, traditional medicine, and religious practices. Overexploitation has led to a sharp decline in wild populations, prompting increased efforts to cultivate the species both within and beyond its natural range. This study evaluates the growth performance of *Aquilaria malaccensis* seedlings over a one-year period in Behraich, Uttar Pradesh, India. The seedlings were divided into three height classes and monitored for changes in height and girth. The results indicated a steady increase in both parameters across different height classes, with notable differences in height growth becoming evident in the later stages of the study. In contrast, significant differences in girth growth were observed initially but diminished over time. These findings provide valuable insights into the early developmental stages of *A. malaccensis*, which could prove useful for improving cultivation techniques and conservation efforts. While the study is preliminary, it lays the groundwork for optimizing agarwood production and supporting the conservation of this endangered species.

Keywords: Cultivation, Agarwood, Seedling, Growth Performance, Conservation.

1. Introduction

Aquilaria malaccensis L., a species belonging to the Thymelaeaceae family, is native to the tropical rainforests of Southeast Asia, including regions such as Malaysia, Indonesia, Thailand, and India[1, 2]. It thrives in low to medium elevation areas with high annual rainfall ranging from 1500 to 6500 mm and temperatures between 20 and 28°C[3]. This species is renowned for producing agarwood, a resin-laden heartwood highly sought after in perfumery, traditional medicine, and religious practices[4]. The high demand for agarwood has resulted in extensive overharvesting, significantly depleting wild populations. Due to habitat degradation, illicit logging, and unsustainable harvesting, *Aquilaria malaccensis* is now listed as "Critically Endangered" on the IUCN Red List[5].

In response, cultivation efforts have increased both within and outside the species' native range. The National Medicinal Plants Board (2008) has promoted afforestation efforts to boost *Aquilaria malaccensis* populations in India.

Successful cultivation has been reported in northeastern India (Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, West Bengal, and Assam), and in non-native regions like Andhra Pradesh, Telangana, Bihar, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Kerala, Maharashtra, Odisha, Punjab, Rajasthan, and Tamil Nadu. Current estimates indicate the Extent of Occurrence (EOO) and Area of Occupancy (AOO) of cultivated populations in India are 3,424,785.525 km² and 2,284 km², respectively[6].

Despite these efforts, there is limited data on the early growth of *A. malaccensis*. To address this gap, an experimental trial was established in Behraich, Uttar Pradesh, India, a region with a semi-tropical climate and fertile alluvial soils. The growth performance of the species was monitored over one year under controlled plantation conditions.

2. Material and Methods

An experimental trial was established at Behraich in the year 2022. Two-year-old seedlings of *A. malaccensis* were procured from Rain Forest Research Institute, Jorhat, Assam, and segregated into three different height classes: Group-I 40-60 cm, Group-II- 60-80 cm and Group-III 80 cm and above, comprising 30 plants each. Seedling height was determined by measuring with a measuring tape from the ground base of the plant to the tip of the highest living leaf, or last bud. The girth of all the seedlings was measured from 5 cm above the ground. Vernier calipers were used to measure the diameter**.** Data collection was done 6 and 12 months after the establishment of the trial while analysis of data was performed at T_1 (0-6 months), T2 (6-12months) and T_3 (0-12 months).

3. Results

The data collected was analyzed using SPSS 27 for descriptive analysis of growth parameters *viz.*, height and girth. The results are as below for different groups of plants. One way ANOVA was performed to assess the growth performance of seedlings of different height classes during the periods of 6 and 12 months in different trials.

Seedlings of 40 – 60 cm in length

Height

Descriptive statistics showed that the maximum and minimum increment in height was 41 cm and 35 cm respectively at the end of 6 months, while it was found to be 41 cm (maximum) and 25.82cm (minimum) within 6-12 months. The maximum and minimum increment in height was 80 cm and 64 cm respectively after the completion of 12 months. The average height recorded was found to be 38.65cm (SD ±1.70) after 6 months of trial, 34.10 cm (SD ±4.35) within 6-12 months, and 72.80 cm (SD ±4.76) at the end of 1 year of experimental trial.

Girth

The maximum increase and decrease in terms of girth were found to be 3.81 mm and 2.7 mm respectively after 6 months, whereas it was found to be 8.04 mm (maximum) and 3.89 mm (minimum) within 6-12 months. Data recordings of the highest and lowest increase in terms of girth after the completion of 12 months are 11.77mm and 6.59 mm respectively. The mean of the girth recorded appeared as 3.35 mm (SD ±0.30) at the end of 6 months, 7.02 mm (SD ±1.10) within 6-12 months, and 10.38 mm (SD ±1.35) after the completion of 1 year.

Seedlings of 60 – 80 cm in length

Height

The descriptive statistics revealed that after 6 months the height increments ranged from a minimum of 36 cm to a maximum of 41 cm. Subsequently, height increments ranged from 38.59 cm (minimum) to 44 cm (maximum) in 6-12 months. By the end of 1 year, the maximum and minimum height increments were 83 cm and 77 cm respectively. The average height observed was 38.87 cm (SD ±1.39) after 6 months, 41.25 cm (SD ±1.30) within 6 – 12 months period and 80.14 cm (SD±1.64) at the end of the 1-year experimental period.

Girth

The largest and smallest increase in girth over 6 months were 4.47 mm and 3.64 mm respectively, while in 6 to 12 months, it measured 8.57 mm (maximum) and 7.26 mm (minimum). After a year, the highest and lowest girth increase was

recorded as 12.99 mm and 11.38 mm respectively. The mean girth measurements were 4.08 mm (SD±0.21) at 6 months, 7.96 mm (SD±0.31) between 6 and 12 months, and 12.05 mm (SD±0.51) after the completion of 1 year.

Seedlings of 80 cm and above

Height

Descriptive statistics illustrate that during the first 6 months, height increments ranged from 35 cm (minimum) to 48 cm (maximum), while from months 6 to 12, it varied from 36 cm to 49 cm. After the completion of 1 year, the height increment reached a maximum of 90 cm and a minimum of 81 cm. The average height increment measurements were 39.12 cm (SD± 3.22) after 6 months, 45.90 cm (SD±2.44) within 6- 12 months, and 85.12 cm (SD±2.55) after one year of experimentation.

Girth

After the initial 6 months, the largest and smallest girth increases measured at 3.62 mm and 4.69 mm respectively. Subsequently, over 6 to 12 months, it extended to 9.7 mm (maximum) and 8.03mm (minimum). Upon completing 12 months, the highest and lowest girth increments were recorded at 13.46mm and 12mm respectively. Mean girth increment measurements stood at 4.08 mm (SD±0.25) at 6 months, 8.48 mm (SD±0.39) between 6 and 12 months, and 12.55 mm (SD±0.30) after 1 year.

Analysis of variance

T1 (0-6 months)

Height

The study aimed to determine the effect of three groups of plants on height increment. A One-way Analysis of Variance (ANOVA) was conducted to determine the effect of three groups of plants based on their lengths: 40 cm – 60 cm, 60 cm – 80 cm, and 80 cm and above as the independent variable on height increment as the dependent variable. The result indicated no significant effect of the group of plants on mean height increment $F(2, 87) = 0.114$, $p = 0.893$. Therefore, we accept the null hypothesis and conclude that there are no significant differences in mean height increments among the three groups over the initial 6 months.

Girth

ANOVA revealed a statistically significant difference in girth increment over six months in the groups, $F(2, 87) = 75.913$, $p = 0.000$ indicating a highly significant difference and acceptance of the alternative hypothesis. A post hoc analysis was conducted using Tukey's HSD test to examine these differences further. The post hoc multiple comparisons identified significant differences in the groups and the results are summarized in Table 2. The mean girth increment for the Group-I (M = 3.842, SD ±0.42) was significantly lower than that of the Group-II (M =4.08, SD ±0.21) and from Group-III (M = 4.07, SD ±0.25). There was no significant difference between the mean girth increment of the Group-II and Group-III. These findings suggest that Group-II significantly improves in girth increment compared to the Group-I in the time interval of 0-6 months. However, effectiveness marginally differs in the Group-II and Group-III of plants. Under optimal circumstances, the group of plants measuring between Group-II, and Group-III show comparable girth increments, despite their varying lengths, over six months without any treatment.

T2 (6 – 12 months)

Height

The result indicated a significant difference in the group of plants on mean height increment $F(2, 87) = 122.73$, $p = 0.00$. The post hoc multiple comparisons identified significant differences in the groups and the results are summarized in Table 2. The mean height increment of the Group-I, II, and III was 34.15 (SD ±4.35), 41.25 (SD ±1.30), and 46.13 (SD ±2.44) respectively. The findings show an increasing trend of mean height increment across the groups over 6-12 months, suggesting an initial phase of plant elongation in various experimental groups.

Girth

ANOVA revealed a statistically significant difference in girth increment in the groups, F (2,

87) = 28.17, p = 0.000 indicating a highly significant difference and acceptance of the alternative hypothesis. The post hoc multiple comparisons identified significant differences in the groups and the results are summarized in Table 2. The mean girth increment of Group-I, II, and III was 7.09mm (SD ±1.10), 7.96 (SD ±0.39), and 8.46 (SD ±0.39) respectively. The findings show a high rise comparing Group I to Group II and a low rise comparing Group II to Group III over 6- 12 months.

T3 (0-12 months)

Height

The result indicated a significant difference in the group of plants on mean height increment F (2, 87) = 107.03, p = 0.00. A post hoc analysis was conducted using Tukey's HSD test to examine these differences further. The post hoc multiple comparisons identified significant differences in the groups and the results are summarized in Table 2. The mean height increment of the Group-I, II, and III was 72.85 (SD ±4.76), 80.15 (SD ±1.64), and 85.10 (SD ±2.55) respectively. The findings show an increasing trend of mean height increment across the groups over 0-12 months, suggesting a phase of plant elongation only in various experimental groups.

Girth

Analysis revealed a statistically significant difference in girth increment over 12 months in the groups, F (2, 87) = 48.79, p = 0.00 indicating a highly significant difference and acceptance of the alternative hypothesis. The mean girth increment of the Group-I, II, and III was 10.46mm (SD ±1.35), 12.04 (SD ±0.51), and 12.54 (SD ±0.30) respectively. The findings show a slight rise in mean girth increment comparing Group-I and Group-II and almost similar recordings in comparing Group-II and Group-III

4. Discussion

The data indicated that at Behraich, Group I (seedlings with an initial height of 40-60 cm) had the highest average height increment at 6 months (41 cm) and maintained this lead at 12 months (41 cm). Group –III (seedlings with an initial height of 80 cm and above) showed the slowest growth rate at 6 months (35 cm) but had the highest average height increment at 12 months (48 cm). This suggests that Group –III seedlings may take some time to establish themselves but then exhibit a faster growth spurt later on. Group - II (seedlings with an initial height of 60-80 cm) had an intermediate growth rate throughout the measurement period. There was no significant difference in height increment among the three groups at T_1 (0-6 months). One-way ANOVA indicated that at T_2 (6-12 months) and T_3 (0-12 months), there was a significant difference in height increment among the groups. The mean height increment increased across the groups, suggesting an initial phase of plant elongation whereas at T_1 (0-6 months), there was a significant difference in increment among the groups. The 60 -80 cm group had a significantly higher mean girth increment compared to the 40-60 cm group. There was no significant difference between the mean girth increment of the 60-80 cm group and the 80 cm and above group. At T_2 (6-12 months) and T_3 (0-12 months), there was a significant difference in girth increment among the groups. The mean girth increment increased across the groups. These findings suggest that the initial height and girth of the seedlings at Behraich possibly influence their subsequent growth patterns. The 60-80 cm group appears to have an advantage in terms of early girth increment, but all groups showed similar increases in height and girth over the longer term (12 months).

5. Conclusion

The present study aimed to assess the growth performance of *A. malaccensis* seedlings at different stages in Behraich, Uttar Pradesh. The investigation focused on growth parameters such as height and girth increment over a specified period. Results indicate a consistent growth pattern, with seedlings exhibiting an increase in both height and girth over time. Behraich demonstrated significant differences in height increment among seedling groups at certain stages. In terms of girth increment, the site exhibited initial differences among groups, but these disparities diminished over time. This suggests that factors

Table 1 - Descriptive table for increment of height and girth among different group of seedlings at Behraich									
	During 0-6 months			**During 6-12 months**			**During 0-12 months**		
Height (in cm)	**40- 60 cm**	**60- 80 cm**	**80cm and above**	**40- 60 cm**	**60-80 cm**	**80cm and above**	**40- 60 cm**	**60- 80 cm**	**80cm and above**
R. max	41	41	48	41	44	49	80	83	90
R. mini	35	36	35	25.824	38.592	36	64	77	81
Mean	38.65	38.87	39.12	34.10	41.25	45.90625	72.80131	80.14163	85.125
S. D.	1.704962	1.398275	3.221515	4.350413	1.302017	2.445733	4.763097	1.647073	2.550862
S. size	30	30	30	30	30	30	30	30	30
S. E.	0.056832	0.046609	0.107384	0.145014	0.043401	0.081524	0.15877	0.054902	0.085029
C.V.%	4.410574	3.596848	8.233905	12.7547	3.156109	5.327669	6.542598	2.055203	2.996607
Girth (in mm)									
R. max	3.81	4.47	4.69	8.04	8.57	9.7	11.77	12.99	13.46
R. mini	2.7	3.64	3.62	3.89	7.26	8.03	6.59	11.38	12
Mean	3.356875	4.083438	4.084375	7.026563	7.96125	8.489063	10.38094	12.05813	12.55531
S. D.	0.303423	0.214922	0.256817	1.10171	0.397819	0.394056	1.352631	0.51052	0.306914
S. size	30	30	30	30	30	30	30	30	30
S. E.	0.010114	0.007164	0.008561	0.036724	0.013261	0.013135	0.045088	0.017017	0.01023
C.V.%	9.038847	5.26325	6.287796	15.67922	4.99694	4.641924	13.02995	4.233828	2.444498

Table 2 -One Way ANOVA Table of Behraich Trial							
			Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
T_1 0-6 Month	HEIGHT	Between Groups	1.156	2	.578	.114	.893
		Within Groups	441.967	87	5.080		
		Total	443.122	89			
	GIRTH	Between Groups	10.335	2	5.167	75.913	.000
		Within Groups	5.922	87	.068		
		Total	16.257	89			
T_2 6-12 Month	HEIGHT	Between Groups	2176.813	2	1088.407	122.739	.000
		Within Groups	771.485	87	8.868		
		Total	2948.299	89			
	GIRTH	Between Groups	28.691	2	14.346	28.178	.000
		Within Groups	44.292	87	.509		
		Total	72.983	89			
T_3 0-12 Month	HEIGHT	Between Groups	2276.750	2	1138.375	107.034	.000
		Within Groups	925.298	87	10.636		
		Total	3202.048	89			
	GIRTH	Between Groups	71.054	2	35.527	48.791	.000
		Within Groups	63.349	87	.728		
		Total	134.403	89			

other than initial seedling size might influence girth growth more prominently in the later stages. The findings of this study provide valuable insights into the early growth stages of *A. malaccensis* in the Terai regions. By understanding the growth patterns and identifying factors affecting growth, stakeholders can develop effective management strategies for this economically important species. Overall, the study contributes to the existing knowledge base on *A. malaccensis* growth and highlights the need for further research to elucidate the complex interplay of factors influencing its development[7]. Largely, the study provides crucial benchmarks for future research and commercial agarwood production initiatives. The cultivation of *A. malaccensis* outside its natural habitat also presents a viable alternative to traditional agarwood harvesting practices, supporting ecological preservation while meeting the growing global demand for agarwood. However, the results at this stage are still very preliminary, and further studies are needed to draw definitive conclusions.

6. Acknowledgement

Authors are thankful to the Indian Council of Forestry Research and Education, Dehradun for extending financial support to the study.

7. Authors Contribution

AY understood the experiment, planned it, collected the data, and analyzed it. **SV** helped with the first draft's writing and the findings analysis. The statistical analysis and data analysis were completed by **RN**. **KC** has completed the data collection and paper editing. The final manuscript has been approved by all authors.

Conflicts of interest

Authors declare no conflict of interest.

References

1. Oldfield S, Lusty C, MacKinven A (compilers). The World List of Threatened Trees. World Conservation Monitoring Centre, Cambridge, UK and IUCN, Gland, Switzerland. 1998.
2. Yadav A, Chauhan K, Nishad R, Singh S. Exploring Novel Habitat for Critically Endangered *Aquilaria malaccensis* Lam. in Terai Region of Uttar Pradesh. PhytoTalks. 2024; 1(2): 110-113.
3. Beniwal BS. Silvical characteristics of *Aquilaria agallocha* Roxb., *Indian Forester*. 1989; 115: 17–21. http://dx.doi.org/10.36808/if%2F1989%2Fv115i1%2F8987
4. Yagura T, Shibayama N, Ito M, Kiuchi F, Honda G. Three novel diepoxy tetrahydrochromones from agarwood artificially produced by intentional wounding. Tetrahedron Letters. 2005; 46(25):4395-4398. https://doi.org/10.1016/j.tetlet.2005.04.072
5. Harvey-Brown Y. *Aquilaria malaccensis* Lam. The IUCN Red List of Threatened Species.2018: https://doi.org/10.2305/IUCN.UK.2018-1.RLTS.T32056A2810130.en
6. Botanical Survey of India, Ministry of Environment, Forest & Climate Change, Non-detriment Findings NDFs. of Aquilaria malaccensis Lam. Agarwood. in India. 2024.
7. Ved DK, Goraya GS. Demand and Supply of Medicinal Plants in India. National Medicinal Plants Board, New Delhi Foundation for Revitalisation of Local Health Traditions, Bangalore. 2008.