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Initial growth performance of agar (*Aquilaria malaccensis*) plantations at public and private sectors in Bangladesh

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ABSTRACT

The study was undertaken to determine the growth performance of Agar plantations (Aquilaria malaccensis Lamk.) at Forest Department (Harbang, Borduara and Fasiakhali) and private sector (Barlekha of Maulvibazar) plantations in Bangladesh. The study was conducted during January to June, 2016. Simple random sampling method was followed to collect data from 40 sample plots (20 m x 20 m) of 12-16 years old plantations. The results showed that the cylindrical volume increment was highest (19.19 m^3/ha/yr) in 16 years old agar plantations at Barlekha. The mean annual increment in height (m) was also highest (0.92 m/yr) at Barlekha and the mean annual diameter increment (cm) was highest (1.12 cm/yr) in the 12 years old plantation at Harbang. The highest basal area (17.98 m^2/ha) was found at Barlekha. The cylindrical volume (per hectare) of Harbang, Borduara, Fasiakhali and Barlekha were 72.59 m^3, 161.18 m^3, 148.75 m^3 and 307.08 m^3 respectively and the stems per hectare were 468, 975, 968 and 960 respectively for the same plantation sites. As it has favorable climatic condition for agar plantation, the Forest Department (FD) can raise agar plantations in denuded and encroached forest areas of Bangladesh. People participation in agar plantation and development of small entrepreneurship may improve the livelihood of the local farmers.

Key Words: *Agar tress, Secondary products, Attar, Nailing, Raw materials and Perfume.*

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I. Introduction

Agar oil or Agar wood is the most expensive and exalted perfumery raw materials in the world, which is an occasional product of a few genera of *Aquilaria* and *Gyrinops* in the plant family Thymelaeaceae (Blanchette, 2006). The species may attain a height of about 40 m and tropical evergreen in nature (Chang et al., 1997; Chowdhury et al., 2003; Hayder et al., 2005). Agar deposition occurs in small irregular patches and streaks in trunk, branch or even roots. Naturally it is found in 8-10% of standing trees only (Baksha et al., 2009). Agar occurs widely in south and south-east Asia, including in Bhutan, Nepal, India, Myanmar, Malaysia, Indonesia, Thailand, Vietnam and Papua New Guinea (Rahman and Khisa, 1984). In the past, agar tress naturally grows in the forests of greater Sylhet, Chittagong and Chittagong Hill Tracts of Bangladesh (Baksha et al., 2009). Agar is a highly priced product which can be

used in fragrance, incense, medicines aromatherapy and religious ceremonies. Agar (*Aquilaria malaccensis)* is one of the most promising non-timber forest products (NTFPs) of Bangladesh, earned Tk. 300 million through exports of *attar* (agar oil) in 2004 (Hayder et al., 2005). About 25,000-30,000 workers were engaged in cultivation, collection, processing and marketing of agar and agar-based products in the country (Baksha et al., 2009). Despite the huge demand of Agar in local and international markets, no major extension program has so far conducted by Governments or other agencies in Bangladesh. The Forest Department (FD) raised some agar plantations in denuded and encroached forest areas of Chittagong, Sylhet, Chittagong Hill Tracts (Rangamati, Khagrachari and Bandarban hill districts) and Cox's Bazar districts. There are also some privately owned agar plantations in the north-east, particularly in Maulvibazar district where many families have been engaged in production and marketing of agar and agar-based secondary products for several decades (Uddin et al., 2008). Bangladesh has suitable weather to produce agar and this is why it can be promote agar cultivation by developing agar sector. According to officials of Bangladesh Forest Research Institute (BFRI), Bangladesh can earn more than Tk 100 crore annually by developing its agar wood sector and exporting agar products abroad. As it is a highly priced non-timber forest product, we have to ensure the quality and market of agar that we produce. Otherwise, we will not get desired price of agar products in abroad. As agar tree can grow and yield on infertile soil and good agar oil can be produced with little efforts, it can be planted on along the side of the canals, water streams, roads, railway line boundaries and especially in the degraded hilly areas. Foreign currency may be earned if these land areas can bring under agar cultivation and production. To develop the agarwood sector, it should be stressed to adopt a high yielding agar producing technologies. The aim of the study is to explore the initial growth and development of agar plantations both in the Forest Department and existing private sectors in Bangladesh.

II. Materials and Methods

Study Site: The experiment was conducted in 4 plantation sites of Public (Forest Department) and Private land in Bangladesh (Figure 01) during January to June, 2016. The physical and climatic features of the selected agar growing areas are given in Table 01. Forest Department plantation sites include Harbang (Chakaria, Cox's Bazar, Borduara (Satkania, Chittagong) and Fasiakhali (Chakaria, Cox'sBazar) while Private Sector site includes Barlekha (Maulvibazar, Sylhet).

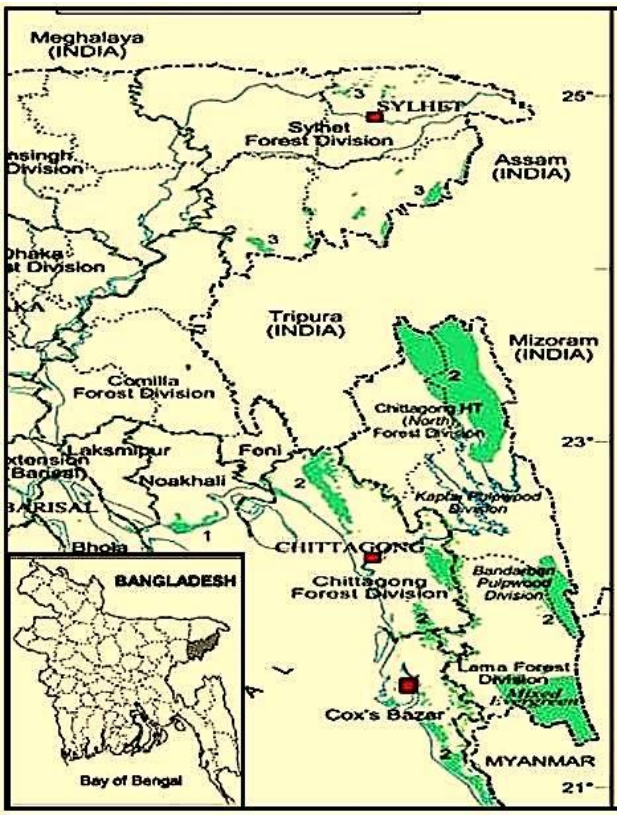

Figure 01. Map of study sites (red mark in the map).

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Table 01. Physical and climatic features of the agar growing areas

Location	Mean Annual Rainfall (mm)	Mean Annual Temperature (^{0}C)	Latitude (North)	Longitude (East)	Soil Conditions
Harbang	3565	20.4-28.7	21^{0}5'10''	92^{0}3'0''	sand, sandy loam,
Borduara	2735	25.10	22^{0}7'58''	92^{0}9'37''	sandy loam,
Fasiakhali	3634	16.3-34.85	21^{0}45'-21^{0}40'	92^{0}4'-92^{0}8'	sand, sandy loam, loamy clay
Barlekha	3334	13.6-33.2	24^{0}33'-24^{0}50'	92^{0}02'-92^{0}18'	Sandy-loam to clay-loam

Sources: www.google.com (accessed 20/06/2016); (SRDI, 2001); (Baksha et al., 2009) and (Uddin et al., 2008).

Sampling procedure: Selected area was visited to ascertain the age of plantations. Age of the plantations was determined by consulting with the public or private growers who established and maintained the plantations. Total Forty (40) plots in four experimental locations were taken by using simple random sampling methods. The size of the sample plot was 20 m x 20 m.

Measurements: Parameters measured were total height (m) of the trees and diameter (cm) at breast height (DBH). The measurement of the height was taken from the ground to the tip of the tree by using Suunto clinometers and measuring tape. DBH (cm) were measured above 1.37m from the ground level by using Diameter tape. The measurement of height (m) and dbh (cm) of every tree were recorded on the field note book. The cylindrical volume and basal area of each sample tree was calculated by using the following formula:

- Cylindrical Volume (V) = $\pi r^2 h$

  $= \pi D^2 h/4$
- Basal Area = $\pi D^2/4$

Here,

V = Volume of each tree.
h = Height of tree (From top to bottom).
D = Diameter at Breast Height (DBH).
π = 3.1416 (Constant).

III. Results and Discussion

Tree density

It was observed that the highest number of stems/ha was found 975 in 12 years' old agar plantations of Borduara which is less disturbed by human activities. Whereas, the lowest number of stems per hectare was found in the 12 years old plantation of Harbang which is disturbed by human interference, particularly by Rohinga refugees or illegal felling. Similarly 968 and 960 stems per hectare were found in the 16 years old plantations of Fasiakhali and Barlekha respectively. On the other hand, Akter and Neelim (2008) reported that the number of stems was 426 in 1.56 acres of 4-years old agar plantations at Karnafuli Tea Estate, Chittagong. The basal area per hectare was highest for the 16 years old plantations of Barlekha and it was 17.98 m^2/ha (Table 02). The lowest basal area per hectare was for the 16 years old plantation of Harbang which is much disturbed by human activities and it was found 6.96 m^2/ha only. It was also 14.23 and 14.71 m^2/ha stems per hectare for the plantations of Borduara and Barlekha respectively.

Tree height and diameter growth

Mean annual height increment (m) of *A. malaccensis* was fast earlier stages but it decreased gradually with age. Mean annual height increment was highest for the 16 years old plantations of Barlekha and

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height increased was 0.92 m per year (Table 02). Height increment was also 0.8m, 0.8m and 0.60m in 12, 12 and 16 years old plantation respectively. It was observed that the highest mean annual dbh increment (1.12cm per year) was in 12 years old plantations of Harbang. The lowest mean annual dbh increment (0.85cm) was for the 16 years old plantation of Fasiakhali (Table 02) and it was 0.85cm per year. Similarly dbh increment was also 1.10 cm and 0.93cm in 12 years and 16 years old plantations respectively. On the other hand, Akter and Neelim (2008) reported that the mean annual height and dbh increment were 0.68m/yr and 0.56 cm/yr respectively after 4 years of agar plantations at Karnafuli Tea Estate, Chittagong. La Frankie (1994) reported that the annual growth rates of dbh ranged from 0 to 1.95 cm/yr at Pasoh Forest Reserve, Malaysia. He also stated that the distribution of growth rates of dbh was strongly skewed with a mean value of 0.33cm/yr and a median value of 0.22 cm/yr. The growth rates achieved by the twelve fastest growing trees (the 90% percentile) exceeded 0.80cm/yr.

Tree volume

The total cylindrical volume production per hectare was found highest in the 16 years old plantations of Barlekha (307.08 m^3/ha) (Table 02). The lowest volume production per hectare was in the 12 years old plantation of Harbang (72.59 m^3/ha). Similarly volume production was 161.18 m^3/ha and 148.75 m^3/ha in the plantations of Borduara and Fasiakhali respectively (Table 02). The highest volume increment was 19.19 m^3/ha/yr in the 16 years old plantation of Barlekha and the lowest volume increment was in the 12 years old plantation at Harbang (6.05m^3/ha/yr). The 12 years old plantations of Borduara and 16 years of Fasiakhali also possessed 13.43 m^3/ha/yr and 9.39 m^3/ha/yr respectively.

Table 02. Growth performance of agar trees in four selected plantation sites

Plantation sites	Age (Year)	Mean DBH (cm)	Mean DBH Increment (cm/yr)	Mean Height (m)	Mean Height Increment (m/yr)	Basal Area (m^2/ha)	Cylindri-cal volume (m^3/ha)	Volume Increment (m^3/ha/yr)	Stem /ha
Harbang	12	13.49	1.12	9.90	0.83	6.96	72.59	6.05	468
Borduara	12	13.1	1.10	9.96	0.83	14.23	161.18	13.43	975
Fasiakhali	16	13.56	0.85	9.59	0.60	14.71	148.75	9.30	968
Barlekha	16	14.82	0.93	14.67	0.92	17.98	307.08	19.19	960

Ecology shares with economics a special interest in limits. The growth rates of *Aquilaria* do not present a problem for its economic exploitation. The median and maximum growth rates are comparable to growth rates for many timber trees in natural forests (Appanah and Weinland, 1993). These rates suggest that *Aquilaria* could be economically grown in plantations or small gardens. It also shows a capacity for coppicing, suggesting that these species could be rapidly cloned and brought into cultivation. It also found that a single tree within a hectare is all the more difficult when that same hectare is also occupied by 7000 other trees representing 500 or more species (La Frankie, 1994). However, the study has explored some main obstacles of agar cultivation in Bangladesh, e.g. research on agar to increase productivity, lack of training on agar plantation and product diversification, lack of knowledge on the value of agar trees to local people and limited access to Govt. forests for plantations and market development as mostly middlemen purchase Forest Department plantations. However, agar is becoming an elite tree crop in the plantation forests of Bangladesh (Hossain, 2015).

IV. Conclusion and Recommendations

The worldwide demand for agarwood for use as incense, carved ornaments, perfumes and traditional medicine has continued to increase in recent years. The loss of natural *Aquilaria* from the forests is a great concern and efforts are needed to protect the existing genetic diversity that remains in wild populations. If properly treated and managed, the agarwood is produced throughout the treated trees. For a successful agarwood program, it is necessary to establish nurseries to propagate *Aquilaria*, train people for the application of treatments needed to induce agarwood resin, facilitate the processing of the agarwood and produce end products with high value that can be commercially important. The hill

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agro-ecosystems of Bangladesh are ideally suited to grow *Aquilaria* and could be an excellent producer of cultivated agarwood. This high valued crop would benefit rural people and contribute greatly to the economy of the region. Bangladesh is densely populated country. However, it has suitable weather to produce agar and this is why it can promote agar cultivation by developing agar sector. But, popularization of agar tree cultivation might not be easy, though agar trees can grow and yield on infertile soil and viable agar oil can be produced with little efforts. Agar can be planted on alongside the canals, water streams, roads, railway line boundaries especially in the degraded hilly areas. Foreign currency may be earned if these fallow and unused land areas can bring under agar cultivation and processing. Both Government and non-government organizations may play a vital role in overcoming these constraints. According to officials of Bangladesh Forest Research Institute (BFRI), Bangladesh Forest Department has recently successfully established approximately 7,085 ha of agar plantations in denuded forest areas of Sylhet, Chittagong and CHT. The BFD can encourage planting on many other denuded and degraded areas, including fallow lands (i.e. unused government land) and other public land (e.g. along roads and railway tracks, canals and embankments) by allowing landless and marginal farmers to plant agar on a participatory basis.

Management and research for consideration of viable agar plantations:

- Filling the gap by planting new seedlings so that adequate stocking is ensured
- Regular monitoring of plantation is needed to identify any abnormalities and take remedial measures. Monitoring should include drainage, irrigation, growth (height and dbh width), leaf color (nutrient deficiency), mortality, pest attack etc.
- Identification of improved genetic diversity of agar through selecting best provenances/cultivar for maximum production
- Review of agarwood production rate and quality in different locations (naturally and with artificially inoculation), and
- Identify the compatible treatments (nailing, inoculants etc.)

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