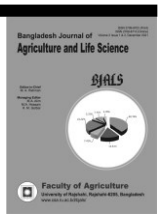
Original Article

Bangladesh Journal of Agriculture and Life Science
Faculty of Agriculture, University of Rajshahi
Rajshahi-6205, Bangladesh
Vol. 2(1): 25-34, 2021
http://csa.ru.ac.bd/bjals/



Agar Tree (*Aquilaria malaccensis*) Cultivation and its Economic Importance: A Case Study of Moulvibazar District of Bangladesh

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ARTICLE INFO

Article History
Received: April 229, 2022
Accepted: July 07, 2022
Online: December 12, 2024

Keywords
Aquilaria malaccensis
Importance
Cultivation & Marketing
Moulvibazar

ABSTRACT

The cultivation of Agar Plant (*Aquilaria malaccensis*) is a rising aspect of agricultural firms in Bangladesh, with some examples operating on a small scale, necessitating the development of appropriate techniques for spurring commercial output. As a result, the study aimed to discover commercial production strategies, producer returns, and risk-bearing abilities in small-scale agar plant farming. The research location was chosen as Barlekha upazila in Bangladesh's Moulvibazar district. During February-December 2016, sixty agar cultivators were selected randomly for agar processors, and agar tree chips/oil traders from three villages were randomly selected for the above purposes. The plants have an average life of around 15 years, and the number of trees in homestead of the farmers ranged from 0 to 500 with an average 68. About 30% of the respondent farmers sold total Agar Garden and 70% did not. The farmers who do not sell garden directly, among them 21.43% is involved in raw wooding, 64.29% is involved in processing Atar and 14.29% is involved in both raw and processed. Two marketing channels are prevalent in the study area. About 64% of the farmers sell agar trees before artificial wounding, by agreement between the agar farmers and the agar-based enterprise owners. About 36% of the farmers sell agar trees after artificial wounding. Agar tree dust was mainly used as a by-product for the raw materials of agar production. The profitability of Agar production (raw) revealed the discounted benefit-cost ratio (5.99). So, Agar tree production was found to be the most desirable and highly profitable. Moreover, the cultivation of Agar Plant has simultaneously improved participants' social, physical, human, and ecological capital. So, the study argues that this practice not only provides economic returns but also augment the livelihood capital of the local farmers, thus developing their community as a whole, and this research looks at some of the key aspects of that development. Therefore, it can be concluded that the cultivation of the Agar Plant can be the most effective strategy for generating income for the rural people in the study area and impact the local farmers' livelihoods in the Moulvibazar of Bangladesh.

Introduction

The resinous, aromatic, and very valuable heartwood of the Agar tree (*Aquilaria malaccensis*) belongs to the Indo-Malaysian tree genus *Aquilaria*, which belongs to the Thymelaeaceae family. It is a huge evergreen tree with white blossoms that grows to a height of 15-30 m and a diameter of 1.5-2.5 m. (Chakrabarty *et al.* 1994). Monsoon locations with a yearly rainfall of 2000 millimeters and tropical hills and mountains are the greatest places to cultivate them. The agar tree thrives in

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well-drained, high-to-medium-high soil with wet, shaded circumstances. It may also thrive in poor sandy soil and can withstand cold and hot temperatures. This genus, *Aquilaria* tree is a well-known agar wood-producing indigenous to Indomalesia (Lee and Mohamed, 2016). It is a valuable non-timber product derived from tropical trees (Rasool and Mohamed, 2016). Because of its fragrant scent, it is utilized as a raw ingredient in the production of incense and fragrances (Rasool and Mohamed, 2016). It has a great commercial value; however, the tree supply is seriously threatened by uncontrolled felling. The demand for this limited mineral has skyrocketed throughout the years (Rasool and Mohamed, 2016).

It is a fact that the Agar tree is over-harvested in the wild. IUCN-The World Conservation Union Red list categories of these six species are considered at risk from over exploitation of Agar wood (SRDI, 2001). The agar tree is an aphrodisiac in oil form and incense. Agarwood incense has been burned to produce a pleasant aroma for centuries, on important religious ceremonies, by Buddhists, Hindus, and Muslims (Ng and Azmi, 1997). The essence extracted from Agar wood is now widely used as a fragrance to manufacture beauty soaps and shampoos (Uddin *et al*. 2008). Agar wood is highly prized incense that is extremely rare. It has at least a 3000-year history in the Middle East, China, and Japan.

The history of Agar in Bangladesh is very ancient and grows naturally Sylhet, Chittagong, Cox's Bazar and Chittagong hill tracts from time immemorial but at present, naturally grown Agar tree is very hard to find. Agar is found irregularly in the forests of Sylhet, Chittagong and the Chittagong Hill Tracts (Hossen and Hossain, 2016). Agar has never been cultivated commercially at a wide range. Approximately 30 to 35 families of Patharia, Dakshinbhag and Sujanagar under Barlekha upazila of Moulvibazar district are directly involved with Agar production and processing. Agar trees are grown on their homestead in combination with other trees. Agar is one of the most promising non-timber forest products (NTFPs) of Bangladesh and earned Tk.1300 through exports of attar (Agar oil) in 2004 (Hayder *et al.* 2005).

Despite the huge demand in local and international markets, no major extension program has so far been conducted by governments or other agencies in Bangladesh. The Forest Department (FD) recently raised some Agar plantations in denuded and encroached forest areas of the Chittagong and Sylhet districts. Of the 121 registered Agar-based factories nationally, 111 are located within this region, making a major contribution to regional employment and gross domestic product (Hayder *et al*. 2005). Furthermore, opportunities would arise in the future for improving the livelihoods of poor people in the region by providing income-generating means.

Bangladesh is favorable for commercially Agar tree production (Ali and Kashem, 2019). However, very little information is available on cultivation practices, processing, and its problem and profitability (Ali *et al*. 2021). Now, there is a need to study the process as ample scope of a boost up its production, particularly in south-east hilly regions of the country. The present study attempted to analyze cultivation practices, processing and the cost and returns of Agar production in Bangladesh. It was expected that the present study would be very effective and informative for national research development and policy formulation.

Materials and Methods

Study Area

Agar plants have a long history in Bangladesh, and have been naturally growing in the Sylhet, Chittagong, Cox's Bazar, and Chittagong hill tracts from time immemorial. However, naturally grown agar trees are now exceedingly difficult to come by in the nation (Ali, S. and Kashem, M. A. 2019). The Barlekha upazila in the Moulvibazar district is well-known for its agar production and processing; hence it was chosen as the research area (fig 1). Between 24° 33' and 24° 50' north latitude, and 92° 20' and 92° 18' east longitude, the Barlekha upazila is located. Bianibazar (Sylhet) is on the north, India is on the east, Kulaura is on the south, and Golapganj and Shrimongal upazilas are on the west (Sylhet). The study was conducted in the three villages (Dakshinbhag, Patharia, and Sujanagar).

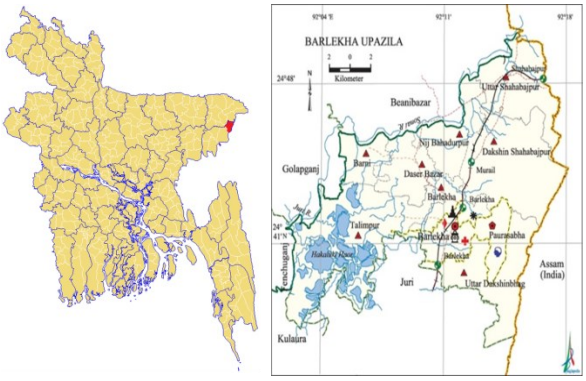

Fig.1. Location of Barlekha Upazila of Moulvibazar District in Bangladesh

Methods of Investigation

Several repeated visits were made to collect the data properly due to the farmer's negligence in conserving farm operational records. The steps followed in the present study were selecting the

area, specific records of the relevant factors, sampling technique, period of investigation, preparation of the interview schedule, rapport building with respondents, collection of data, processing and analyses of data. The respondent's age was measured by counting the period from his birth to the time of interview based on the respondent's response and was expressed in terms of years. The education level of the respondents of the study area was divided into 5 (five) categories (those are having no schooling), primary level (class I-V and only can sign), secondary level (class VIX), higher secondary level (XI-XII), and above (BA, BS, BSc, MS).

The family size of a respondent was determined in terms of the total number of members. The family member included the respondent himself, spouse, sons, daughters, and other dependents. The scoring was made by the actual member of family expressed by respondents. If a respondent had five members in his family, his score was given as 5. Farm size of the respondents of the study area was divided into 5 (five) categories like landless (having 0-0.20 ha land), marginal (having 0.21-0.60 ha land), small (having 0.61- 1 ha land), medium (0.01-3.04 ha land), and large (above 3.04 ha land).

Cultivation practice of Agar tree of the planters was determined by planting materials used, source of planting materials, and time of seedling, fertilizer use, maturity symptom and harvesting time. Planting materials for Agar tree cultivation in the study area was divided into three categories: seed that farmer collected from their garden for further cultivation, seedling that farmer collected from the nearest nursery and stem cutting, which farmer practices in their garden. The best time to plant seedling is during the rainy season (May-September).

Some farmers use fertilizer during cultivation, and some are not. Farmer who are used to fertilizer they used Cow dung, Urea and both of those (Urea and Cow dung). Problem was measured one way such as, using the closed form of questions as shown in item number 40 of the interview schedule. Training received of farmers was measured according to the duration of their training. For measuring the training attended by farmers a score of 1 was assigned for one-day training, 2 for two days of training and a zero (0) score was assigned for no training experience as shown in item No. 40 of the interview schedule.

Annual income was measured by the total income yearly earned by a respondent's family from agricultural and non-agricultural sources and expressed in Taka per year. A mature tree may contain a round hole on the surface of Agar tree and ants comes from it due to fungal infection. It has long been known that color is dark brown or black. Although the collection of Agar trees for oil extraction as well as for Agar is done almost throughout the year, the best time is during February-May, the dry season when the plants remain almost dormant or less active. The maximum concentration of oil with less waxy substances is obtained during this period.

Marketing System

Two marketing channels are prevalent in the study area for Agar wood as a raw material for Agar enterprises. To determine the profitability, it was considered to compute all the cost items and deduct them from the gross value of outputs, which the farmer produces. It was estimated by the following procedures:

Estimation of Costs

The farmers producing Agar had to incur costs for different inputs used in the production process. To calculate the production cost, the following components of cost were considered in the study area.

For calculating interest on operating capital, the following formula was used:

$$Interest\ on\ Operating\ Capital = \frac{Operating\ cost \times Rate\ of\ interest \times Time\ period\ (1st\ Year)}{2}$$

The gross margin was calculated by deducting the variable cost from the gross return, using the following formula:

$$Gross\ Margin = Gross\ Return - Variable\ Cost$$

Benefit-cost ratio is the ratio of discounted benefit divided by discounted cost. It implies the benefit derived from one unit of cost.

$$Benifit\ Cost\ Ratio\ (BCR) = \frac{\sum_{t-1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t-1}^{n} \frac{C_t}{(1+i)^t}}$$

Where, B = Gross benefit in i^{th} Year

C_t = Total Cost in i^{th} Year

t = Number of Years (1, 2, 3 . . . n)

i = Interest Rate

Sampling Technique and Data Collection Procedure

This study was conducted in the Moulvibazar district. Moulvibazar district is consisting of 7 upazilas. Out of 7, 1 upazilas namely Barlekha was randomly selected. Barlekha upazilas has 253 villages. Among them 3 villages namely

Dhakshinbhag, Patharia and Sujanagar were randomly selected. There is total 105 Agar production respondents' families in these selected villages. Out of 105 families, a sample of 60 respondents Dhakshinbhag, Patharia and Sujanagar (20 respondents from each village respectively) were selected randomly from the selected areas. A structured questionnaire was used to collect information on Agar production from the selected respondents. Final selection has been done by the (Yamane, 1967) formula:

$$n = \frac{N}{\{1 + N(e)^2\}}$$

Where,
n = Sampling Size
N = Population
e = Error of Precision

Preparation of the Interview Schedule

Based on the pre-test of this schedule, necessary modifications, addition and alteration were made to improve the validity and applicability of the schedule. Secondary data was collected from the Forest Department, Agricultural University and other sources.

Processing and Tabulation of Data

After collection of data, the first step was to look over the data of each and every interview schedule whether every question was replied properly or not. These were converted into standard units for the preparation of final tables. All the collected data were summarized and scrutinized and recorded in Microsoft Excel 2010 program, computer software. Finally, a few relevant tables were prepared according to the necessity of analysis and interpretation and to meet the purpose of the study. Data were averaged and standard deviation was calculated wherever necessary by SPSS-16.

Results

Demographic Characteristics of the Respondents

The case study observed that the variation of participants' households' size among the three villages was very insignificant, and their average size was more than 4.9 (Table 1). The mean ages of the participant farmers were 47.5 years (Table 1). The male and female ratio among the farmer households was almost the same in the three locations. In the case of the literacy rate, the farmers from Patharia, Dakshinbhag and Sujanagar possess a higher (54%, 49% and 45.5%) rate (Table 1) than the literacy rate of the general district (Moulvibazar) 51.10% (BBS 2021). The majority of participants' religion was Islam followed by Hinduism. The mean landholding of respondent households was 0.56 ha, 0.60 ha and 0.52 ha (Table 1) and the households' main source of income is dominantly agriculture (Table 1).

Advancements to Living Standards

More than 70% of participants (Table 2) were able to build their capacity on climate-smart agriculture and conservation agriculture practices in their land. Moreover, the participants had able to gain knowledge on homestead agroforestry management, tree plantation, livestock rearing, and vegetable cultivation. The literacy rate of the participants and their children was slowly increased (Table 2). The participants have received financial support from cultivating crops and vegetables in their land, and the result showed that about 71% of farmers already received different types of financial support. Participants' awareness of healthcare facilities has been improved and the government and non-government project extended their hands to provide basic healthcare facilities to the rural people in the study area.

On the other hand, rural road infrastructure was steadily improved and poor (made with mud) roads have been changed by the bitumen sealed roads (Table 2. The local government and roads and highway authority to improve the local roads infrastructure and often invited the government official to took part in the project. Often, the local farmers took their initiatives to improve and reconstructed their village roads. Islam and Sato (2012) mentioned in their report that the project activities had motivated local people to improve their road infrastructure by themselves. small and big livestock with the income they earned and crop cultivation. Besides, a few participants stated that they bought small television with the profit from the cultivation. The available labor of the participants' families had reduced, and it was due to the awareness of the participants and migration to the capital city for jobs.

Marketing channel and farmers product supply chain is a common problem faced by the participants and for this, the local farmers did not get the proper price of their product. A number of scientists had already stated that the market monopoly system and long intermediaries' channels have hindered the ultimate profit of the farmers all

over the country (Islam *et al*. 2013; Islam and Sato 2013; Muhammed *et al*. 2008). With the income of the homestead tree and cultivation, the participants can also manage their family healthcare systems and visit the local hospital/clinic for the treatments.

Planting Materials

The study's findings indicated that most of the respondent farmers (95%) used seedlings collected from the nursery for Agar cultivation, whereas only 5% of the respondent farmers used seed (Fig-2). From this figure, it is clear that most of the farmers depend on seeding from nurseries for better Agar cultivation Ador *et al.* (2014) found a similar result.

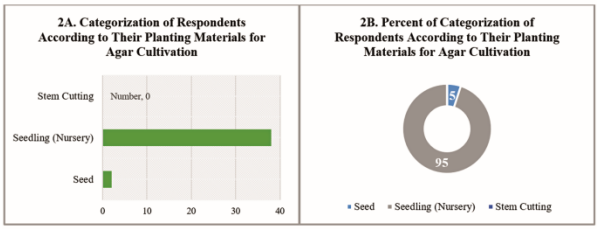

Fig. 2. Categorization of Respondents (A) and Percentage of Respondents According to Their Planting Materials for Agar Cultivation (B).

Source of Planting Materials

Results in the Fig-3 showed that Generally Agar tree is wild in nature and propagates by natural regeneration and farmers usually collect seedlings from nursery source. Most of the respondents (85%) used seedlings as planting materials, while 7.5% respondents collected from natural wilding. Results stated that farmer collected planting material from own home garden that was 5.00% and next neighbor was (2.5%). Alam (2004) found the similar result.

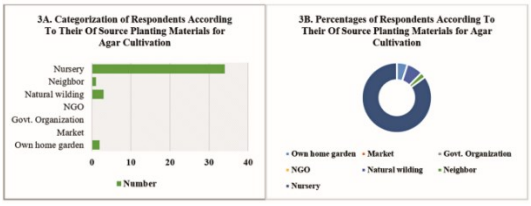

Fig. 3. Categorization of Respondents (A) and Percentage of Respondents According to Their of Source Planting Materials for Agar Cultivation (B).

Problems of Agar Tree Cultivation

Results presented in Fig-4 indicated that the respondent farmer mainly noticed nine problems. Among those growers, the major problem is the lack of advice from extension personnel. Extension officers are not available in local area. The second problem is the marketing problem; actually, the marketing system just depends on buyers who are in aboard. The third one is credit facility; Commercial Bank and NGOs usually do not provide loan for Agar purposes.

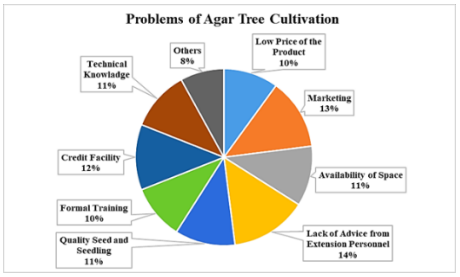

Fig. 4. Problems of Agar Tree Cultivation

Uses of Agar wood at Barlekha Upazila of Moulvibazar District

The present study observed that Agar wood is mostly used as fragrance where 77.50% respondent's uses Agar for this purpose and 12.50% uses Agar wood as Agarbati (Fig-5). And also, uses of Agar by respondents were Agar wood medicine 2.5%, Agar wood beads 2.50%, decorative sculptures 2.5% and others 2.5%.

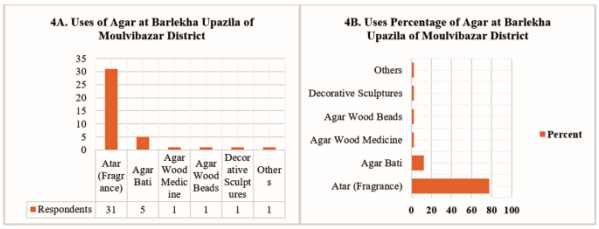

Fig. 5. Use of Agar and Uses Percentage of Agar at Study Area

Maturity Symptoms

There are some external signs that a tree may contain maturity. Investigation showed that 55% respondents think that Agar tree maturity signs when some round hole with black color and also sign of maturity were attack by ants and assisted by insects was 25% and 20%, respectively (Fig-6).

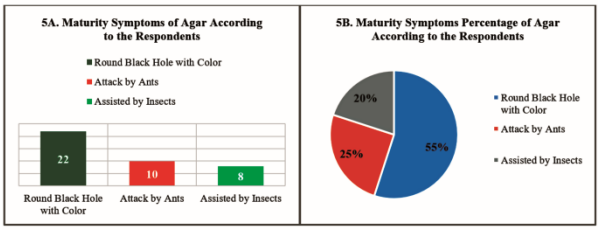

Fig. 6. Maturity symptoms of Agar according to the respondents.

Measures of Agar Preparation

Two types of commercial products are obtained from a harvested Agar tree (a) Agar or Agar wood that is used as incense and (b) Essential oil or Agar oil or Agar attar. Agar is obtained from older trees while oil is distilled from old as well as younger trees. After felling a tree, the leaves and smaller branches are removed. Then the tree is cut into logs (pieces of 2-2.5 ft.). After that, the logs are spitted to separate out the infected and non-infected woods. If detected, the Agar wood of any grade is first separated with the help of indigenous tools like hacksaw blade and Batali and graded based on the oleoresin impregnation, color density, specific gravity and finally the odor. These are then dried, and cleaned by removing the white woody portions as far as practicable, polished and graded for marketing. Agar oil is obtained by steam distillation of harvested wood chips or coarse powder in a special type of distillation unit. Distillation is continued for 5-10 days or more using firewood as the energy source.

Cost of Agar Cultivation

Cost of production of the respondents were Tk. 2010,500 ha^{-1} for first year, including cost of fencing and repair, land preparation, pit making, cost of seedlings, planting cost, compost, fertilizer, irrigation, application cost, after care/year, and miscellaneous cost were Tk. 1,500, Tk. 5,000, Tk. 8,500, Tk. 3,400, Tk. 9,000, Tk. 15,000, Tk. 5,000, Tk. 3,400, Tk. 5,000 and Tk. 1,300 respectively. For the 2nd year after care/year and miscellaneous cost were Tk. 5,000 and Tk. 1,600 respectively and total cost Tk. 6,600. Cost of 3rd year cost of fencing and repair, after care/year and miscellaneous cost were Tk. 5,000 and Tk. 1,600 respectively and total cost Tk. 9,600. For the 4th year cost of after-care/year and miscellaneous cost Tk. 5,000 and Tk. 1,600 respectively and total cost Tk. 6,600. For the cost of 5th year cost of fencing & repair, after care/year, miscellaneous cost was Tk. 5,000, Tk. 6,000, Tk. 1,500 respectively and total cost Tk. 12,500. For the cost of 6-8th year cost of fencing & repair was Tk. 5,000, cost of fencing & repair was Tk. 20,000, inoculation cost Tk. 15,000, miscellaneous cost Tk. 3,000 and total cost Tk. 33,000. For the cost of 9-15th year cost of fencing and repair was Tk. 7,000, cost of care per year was Tk. 30,000, the inoculation cost was Tk. 20,000and miscellaneous cost was Tk. 7,000. And total cost was Tk. 37,000 (Table-3). Total expenditure up to 8th year =Tk. 1,28,800. Next 7th years =Tk. 37,000; Total Tk. 310800.

Anticipated Yield and Income of the Respondents

Assuming 1500 numbers of trees at 8th year out of the total, we may harvest about 40% of the selected trees i.e., 600 with a view to thin out the population for the remaining 900 trees for further growth and development. The final harvesting of 900 trees would be done at 15th year. The investigation showed that yield of distillable wood from 8-10 years old tree approx. 20 kg/tree @ Tk. 10.00/kg and yield of 15th year was 50 kg/tree @ Tk. 50.00/kg. Yield of Batali mal (Agar wood) was 0.5 kg @ Tk. 2,000/kg from about 500 trees. That's why gross return for 7-8th years was Tk. 1,20,000, from final harvest Tk. 22,50,000 and Agar wood was Tk. 5,00,000 and finally total Tk. 28,70,000 (Table-3). After 15th years net return was (Tk. 28,70,000 – Tk. 310800) = Tk. 2559200.

Evaluation of Intertemporal Budget for Agar Cultivation

The cultivation system showed that the cash flow at the 1st - 5th year was negative, but it became positive from the 7th and 8th year was Positive. Again in 9-14 years were negative and in 15th year it was positive. The discounted -cost ratio (5.99) indicates that if a farmer invests Tk, the benefit-cost ratio indicates. 100, he will get return of Tk. 650. (Table-3).

The relationship between yield and farmer's experience is positively significant at 5 percent level. There is no significant relationship between yield and education status. The calculated value of the co-efficient of correlation was 0.051 which was smaller than the tabulated value at 5 percent level of significant. Relationship between yield and family size is positive significant at 5 percent level. , The relationship between yield and Planting materials (seedling), is positive significant at 1 percent level. The relationship between yield and Maturity symptoms (Round hole with black color) is positive significant at 1 percent level. There is no significant relationship between yield and Problems faced during Agar cultivation. The calculated value of the coefficient of correlation was 0.051 which was smaller than the tabulated value at 5 percent level of significant (Table-4).

Table 1. Socio-economic characteristics of the respondents

Characteristics	Dakshinbhag	Patharia	Sujanagar
Age (Mean) year	43.70	50.30	48.60
Household size (Mean) head or person	5.7	6.7	4.9
Literacy rate	49%	54%	45.5%
Per household landholding (ha) (Mean)	0.56	0.60	0.52
Distribution of households by religion			
- Muslim	44%	61%	71%
- Hindu	56%	34%	26%
- Others	0%	4%	3%
Households' main income sources			
- Agriculture	60%	78%	52%
- Wage labor	17%	18%	20%
- Business	3%	12%	15%
- Unemployment	0%	0%	2%
- Remittances	20%	0%	11%
- Others	0%	0%	0%

Table 2. Major characteristics of the participants in the study area

Parameters	Status and Trends
Farmers Literacy rate	49.5%, Improving slowly
Children literacy rate	79%, Sharply improving
Micro-credit and easy loan facilities	39%, Slightly improving
Financial support received from program	71%, Slightly progressing
Farmers received scientific training	68%, Satisfactory
Farmers social relationships with other community	Moderate, gradually improving
Household infrastructure and physical assets	Brick wall and tin roof, shift from raw/mud with sun-grass roof, Increasing physical assets
Road infrastructure to farm and markets	Average, Improving
Livestock small (e.g., chicken)	3.4, Increasing
Livestock big (e.g., cow, goat)	0.8, Slightly improving
Food sufficiency of the household members throughout the year	10 months, Increasing
Program creating health awareness	64.7%, Improving
Tree stock in household premises	27, Improving
Program improving soil	Partially, slightly improving
Alternative livelihood options	Exist, Increasing

Table 3. Cost of production, total income, and net income of Agar Plant in hectare per

Heads of Exp.	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	5th Yr.	6-8th Yr.	9-15th Yr.
Cost of Fencing & Repair	1500	-	3000	-	5000	5000	7000
Land Preparation Pit (30cm x 30cmx30cm) Making	3400	-	-	-	-	-	-
Cost of Seedlings 1700 x Tk.5.00	8500	-	-	-	-	-	-
Planting Cost @ Tk. 2.00/Plant	3400	-	-	-	-	-	-
Compost	9000	-	-	-	-	-	-
Fertilizer	15000	-	-	-	-	-	-
Irrigation	5000	-	-	-	-	-	-
Application Cost Tk. 2.00/Plant	3400	-	-	-	-	-	-
After Care/Year	5000	5000	5000	5000	6000	20000	30000
Inoculation @ Tk. 100/Tree of 1500 Trees	-	-	-	-	-	15000	20000
Miscellaneous Cost	1300	1600	1600	1600	1500	3000	7000
Land Value	250000						
Total Tk. (15 Yr.)	305500	6600	9600	6600	12500	33000	37000
Returns from Agar tree (TK)	1-6th Yr.	7th Yr.	8th Yr.	9-14th Yr.	15th Yr.		
Distilled Wood	-	50000	70000	-	2250000	-	-
Agar Wood	-	-	-	-	500000		
Gross Return (After 15 Yr.)	2870000						
Total Cost Tk	410800						
Net Income	2459200						
BCR (Benefit Cost Ratio)	5.99						

*Total income of trees was calculated in the yearly basis, TK (Bangladeshi Taka) = 85 USD.

Table 4. Relationship between the Dependent and Independent Variables

Dependent Variables	Independent Variables	Co-efficient of Correlation	Tabulated Value at	
			0.05 Level	0.01 Level
Yield (kg)	Farmers Experience	0.285*	0.2348	0.2751
	Education	0.051NS		
	Family Size	0.223*		
	Planting Materials (Seedling)	0.750**		
	Maturity Symptoms (Round hole with black colors)	0.893**		
	Problem faced during Agar tree cultivation	0.113NS		

NS = Not Significant, ** = Significant at 1% level, * = Significant at 5% level

Discussion

According to the current study, the number of landless and large farms is low. This indicates a large number of medium-sized farms. The majority of agar farmers leads a mediocre existence. The number of trees on the farmland indicates the predominance of medium-sized farmers. The majority of the farmers here have crossed the primary boundary. One of the main obstacles to the expansion of this export-oriented sector is a scarcity of educated farmers. Farmers with a higher secondary education account for 18% of the population. They are primarily involved in the export trade of Agar. The number of medium-sized families is higher than the number of small families among agar farmers. Agar farmers own significantly more land than the average farmer in the country. According to the current study, the number of landless and large farms is low. This indicates a large number of medium-sized farms. The majority of agar farmers leads a mediocre existence. The number of trees on the farmland indicates the predominance of medium-sized farmers.

Agar growers are less prone to use of fertilizers and pesticides. Most of the fertilizer users mainly use cow dung as fertilizer. We can also call it Eco-Friendly Cultivation System. In our research, we have seen that farmers do not get enough advice from agricultural extension officials. Many farmers have also cited the inadequacy of marketing and inadequacy of credit facilities as a problem for agar cultivation. Lack of arable land, lack of training, low price of manufactured goods, and lack of technical knowledge are some of the obstacles in developing this potential sector. 77.5% of the agar wood is used in perfume production. Besides, the use of agar wood outside agarbati production is very little in our country. Agar is a perennial plant. To get good quality fruits, you must take care of agar tree for about 15 years. As we have seen the cost of production, the highest cost is in the first year. Maintenance costs also increase as the tree grows larger in the 14th and 15th years. In addition, a small amount of money must be spent throughout the year to maintain the tree. The major portion of invested capital of 14-15 year returns in the 15th year. A little distilled wood is available in 8-10 years which is very little compared to the total return. Also, in our Benefit of Cost Ratio, we find that agar cultivation is a productive and economic system.

Conclusion

Agar tree though known in Bangladesh is highly demand as commodity and the premiums it commands today not only in the local market but also in the international markets. From this experiment, assuming 1500 number of trees at 8th year out of the total, we may harvest about 40 % of the selected trees i.e., 600 with a view to thin out the population for remaining 900 trees for further growth and development and also to generate an interim income. The final harvesting (900 trees) would be done in the 15th year. Production of Agar is a long-time process and it's about fifteen years to get raw materials.85% respondents used nursery seedling for Agar production. Marketing is a good problem for Agar production. The discounted benefit cost ratio (5.99) clearly indicated that Agar tree cultivation system was productive and economical. There is a need to boost up its production, identifying the week points for furthering the returns. There was a significant positive correlation between maturity symptoms and Agar production. For the improvement of this potential sector, some recommendation is given bellow:

1) Agar wood cannot be stored for many days because the dried wood chips decreasing oil production. So, storing mechanism should be studied.
2) Further research on the quality of Agar chips, Agar wood is to be conducted.
3) Proper propagation method (seeding by traditional or tissue culture method) are introduced through research for maximum production.
4) Leaflet, poster and reports are to be prepared for wide scale adaptation, cultivation of *Aquilaria malaccensis* among the farmers.
5) Institutional credit facilities should be made available to farmers on easy terms and conditions.

Acknowledgment

The authors are grateful to Department of Agroforestry & Environmental Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh for laboratory supports.

Authors' Contribution

Conceptualization, NA and NN; Methodology and Investigation, NA and RH; Supervision, HA; Formal analysis, NA and NN; Writing - original draft preparation, review and editing, NA, MMR and HA.

All authors have read and agreed to the published version of the manuscript.

Conflict Interest: The authors declare no conflicts of interests.

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