



***Aquilaria malaccensis* plantation as a livelihood security in North East India.**



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Introduction:

- Agarwood is a resinous, fragrant wood formed as a result of host-fungus interaction in the heartwood of *Aquilaria malaccensis* L.
- The genus *Aquilaria* has 15 species, of which eight species are known to produce agarwood.
- Most common species in NE India are-
A. malaccensis syn. *A. agallocha*
A. khasiana



Distribution of *Aquilaria* species

India	: <i>A. khasiana</i> , <i>A. malaccensis</i> (<i>A. agallocha</i>)
Nepal	: <i>A. malaccensis</i> (<i>A. agallocha</i>)
Bhutan	: <i>A. malaccensis</i> (<i>A. agallocha</i>)
Burma	: <i>A. malaccensis</i>
China	: <i>A. sinensis</i> , <i>A. yunnanensis</i>
Thailand	: <i>A. crassna</i> , <i>A. hirta</i> , <i>A. malaccensis</i> , <i>A. rugosa</i> , <i>A. subintegra</i>
Laos	: <i>A. crassna</i>
Cambodia	: <i>A. baillonii</i> , <i>A. crassna</i>
Vietnam	: <i>A. baillonii</i> , <i>A. banaensis</i> , <i>A. crassna</i> , <i>A. rugosa</i>
Peninsular Malaysia Singapore:	<i>A. beccariana</i> , <i>A. hirta</i> , <i>A. malaccensis</i> , <i>A. microcarpa</i> , <i>A. rostrata</i>




Tree morphology:



- Tropical evergreen tree of 18-20 m height.
- Sometimes grows up to 40 m height and diameter about 60 cm.
- Leaves simple, 5-9 cm long, oblong lance shaped.
- Flowers bell shaped, off white or green or dirty yellow coloured.
- Fruit capsule, egg-shaped (3-4 cm x 2.5 cm) dark brown coloured seed bears a appendage that is as long as the seed, twisted from the base, tail like and covered with soft short hairs
- Seeds germinate above ground (viviparous).

Tree morphology:



Flowers



Fruit capsule



Capsule with seeds



Leaves

Climate and soil:

- Agar tree grows well in humid temperature, sub tropical climate with annual rainfall of about 1500-6500 mm and a mean annual maximum temperature of 22- 28°C and minimum temperature of 14- 21°C.
- The tree requires lot of sunshine in natural forest, at an altitude of a few meters to about 1000 meters MSL, it grows best .
- Agar tree can be cultivated in a wide range of soil
- It prefers good forest soil of acidic reaction, well drained, sandy loam to clay loam textured with high organic matter content
- Also grown in marginal soil, shallow soil over rocky beds and in hilly slopes.

Bio-prospecting of Agarwood:

The essential oil from agarwood is valued for the following Uses

Religious practices & spiritual life:
 Since ancient times, people of NE India has been using agar wood and bark for writing religious 'puthis'. Agar-candle is also an indispensable part of worshipping a deity. Now-a-days, it is used in all religions viz. Buddhism, Christianity, Islam, Catholicism, Hinduism, Deep meditation, Yoga.

Aroma industry :
 Perfumes, Cosmetics & cosmeceuticals, Toiletries, Flavourings, Fragrances, Incenses, Candles, Aromatherapy preparations.

Medicine :
 Traditional Vietnamese Medicine, Traditional Chinese Medicine, Tibetan medicine, Ayurved & Aromatherapy, Efficacious sedative, Aphrodisiac.

Indoor air improvement & fumigation:
 Air revitalizing solutions help to improve indoor air quality and performance of office works.

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Other uses :
 Ornamentation, Bead strings, Carvings, Wines, Teas, Burial & Cremation (grave-clothes, libation ingredients in funeral pyre), Prayer rugs.

Agar leaves used as tea

Agarwood incense sticks

Agarwood Bracelet

Craft

Benefits of Drinking Agarwood Tea:

- It's a natural detoxifier.
- It's a natural way to remove harmful toxins from the body (such as mercury).
- Agarwood tea is a natural diuretic to get your digestive system on "track".
- It promotes healthy, clear skin.
- It stabilizes blood sugar
- Agarwood tea helps blood flow
- It's caffeine and sugar free

Other Agarwood products:

Body lotion

candle

Shower gel

Soap

Agarwood oil

Perfume

TRADE OF AGARWOOD IN INDIA:

- India does not permit harvest of Agarwood species from the wild. The trade in Agarwood products is limited to import, processing and re-export.
- Indonesia and Malaysia are major contributors of import into India
- Re-export of Agarwood in the form of processed incense chips, oil and dust are permissible with CITES re-export permit.
- Saudi Arabia and UAE are major destinations for exported products from India

MANAGEMENT OF WILD POPULATION:

- Inventory of wild population by the Working Plan Officers of respective forest departments of state Governments
- Inclusions of proper prescriptions for conservation and regeneration of the species in the wild
- Coordinated Legal and policy issues for control over trade between all Agarwood producing states of the country
- NDF Formulation may not be an immediate need for wild population in the country and can be reviewed as information base widens.

MANAGEMENT OF AGARWOOD PLANTATIONS AND NDF :

Creation and proper inventory of plantations

- There are estimated 9-10 million *Aquilaria* trees in North East India on private lands.
- Government owned cultivated trees are reportedly less.
- The trend for cultivation is rising and great interest is generated in the south India also.

Research

- Artificial inoculation
 - Identifying proper strains of causal fungi and inoculation
 - Techniques of inoculation(Injury, time of inoculation etc.)
- Genetic evaluation of *Aquilaria malaccensis* in North Eastern India and establishment of Gene Bank

What can be achieved through research initiatives?

- Series of cultivated species having wider and representative genetic base providing seed security for future plantations through out it's range of occurrence under state control
- Motivating few if not all, private growers to establish preservation plots with R&D support from research institutes and advocating sustainable harvest
- Artificial inducements to avoid indiscriminate harvest of non agar producing individuals
- Promoting research collaboration amongst all agar producing countries

Agarwood Trade:

- Agarwood has become a precious commodity and is comparative to gold .
- The international trade in agarwood involves wood, wood chips, powder, oil and products such as perfumes, incense and medicines.
- The cost of agarwood is extremely high depending on the oleoresin content of the wood.
- Prices range from a **10,000 to 30,000 US dollars** per liter of agar oil.
- Indonesia and Malaysia appear to be the main traders of agarwood in international trade.
- Considering the economic importance and abundance of *Sasi* trees in North East, the trade of agarwood has become a fascinating industry not only in this area, but also in the whole world market.

Agarwood formation:

Agarwood formation is the resinification of accumulated oleoresins due to the action of microorganisms.

The infection of fungus occurs when stem injured or is bored by larvae of a stem borer (*Zeuzera conferta* Walker).

The borer makes tunnels inside the tree trunks. Fungus enters the plant through this vertical hollow sometimes-zigzag tunnel inside the stem, which serves the initial sites of infections.

The fungal infection takes long time to mature and trees about 50 years old have the highest concentration (2.5-5.0 kg/tree).

Natural Resin formation:



Zeuzera conferta Walk.



Oozing out of watery substances from fresh borer hole



Frass at the base of the tree

Keys for Identification of the Infected Agar Trees:



Natural closing of borer's hole



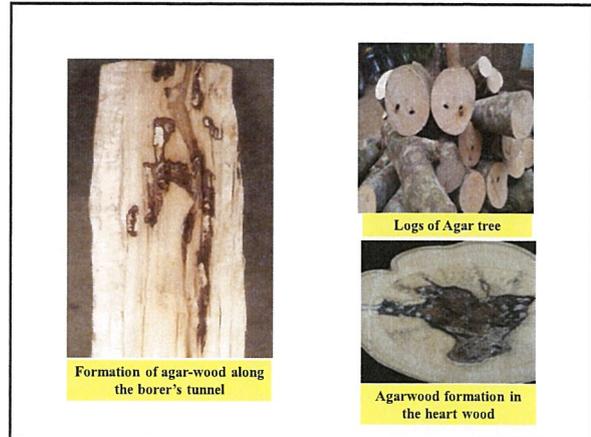
Cracking symptom



Sickly appearance of agar tree is a sign of agarwood formation

External symptoms for identification of agarwood formation in homestead/natural plantation:

- Appearances of borer hole.
- Oozing out of watery substances from fresh borer hole.
- Accumulation of frass at the base of the tree.
- Closing of borer hole by the growth of host tissue leaving a small spindle shaped mark.
- Longitudinal cracks or fissure on the trunk/bole.
- A poor crown with drying and decayed branch and uneven bole with stunted growth.
- Swelling or depression and sometime canker formation on the bole/tree.
- Appearances of hordes of ants in the fissure and formation of ant's nests
- Leaves become smaller and yellowish colour.
- Overall abnormality and ill health of plant distinct from a healthy looking plant.
- Formation of hollow sound when hammered on the trunk.



Artificial Treatment for Agarwood Formation:

- Open wounding with the help of *Dao* (Knife) on the tree trunk of agar tree can induce agarwood formation.
- These injuries provides ready-made infection sites, and also put the tree to undergo a stress condition, which helps in spreading of infection.
- Besides, artificial inoculation technique is found to be effective and reliable method for enhancement of agar formation.
- In this technique, inoculation of dominant fungi species isolated from infected agar tree are carried out in non-infected tree, where agarwood formation starts after 3 months.

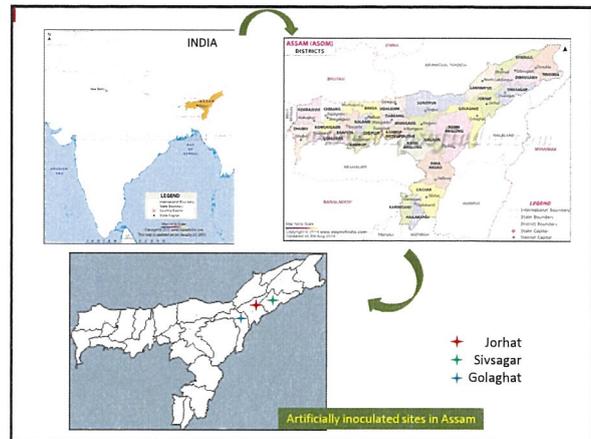
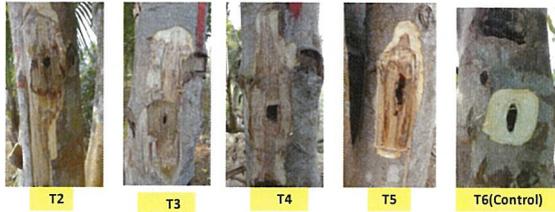
Artificial inoculation of fungi carried out in Tezpur, Assam for inducement of agarwood in agar trees in the month of March, 2011.

Visual observation for deposition of agarwood after 3 months in the month of June, 2011

Visual observation for formation of agar wood after inoculation (September, 2011)

T1 T2 T3 T4 T5

Visual observation for formation of agar wood after inoculation (January,2012)



Economics per hectare:

Heads of exp.	1 st year	2 nd year	3 rd yr	4 th yr	5 th yr	6-8 th yr	9-15 th yr
Cost of fencing & repair	16000	3000	5000	18000	5000	5000	-
L.S	7000	-	-	-	-	-	-
Land preparation	8500	-	-	-	-	-	-
Pit (30×30×30 cm) making 1700×Rs.5/ pit	-	-	-	-	-	-	-
Cost of saplings 1700×Rs.10.00	17000	-	-	-	-	-	-
Planting cost @ Rs.3.00/plant	5100	-	-	-	-	-	-
Compost	10000	10000	9000	10000	10000	-	-
Fertilizers	-	7000	7000	8000	8000	-	-
Application cost Rs.3.00/plant	5100	5100	5100	5100	5100	-	-
After care/year	5000	5000	5000	5000	8000	10,000	35,000
Inoculation @ Rs.1000/tree x 1500	-	-	-	-	-	15,00,000	2,00,000
Misc. exp.	20000	2500	2000	3000	2000	5,000	8000
Total	93,700	32,600	33,100	49,100	38,100	15,20,000	2,43,000

Total Expenditure up to 8th year= **Rs. 20,09,600**

Return:

1. At 7-8th years Boya (150 trees X 25 Kg X @ Rs. 10/Kg) =37,500
2. Dum low quality product (450 trees X 40Kg X @ Rs. 100/Kg) = 18,00,000
3. Dum high quality product (400 trees X 50Kg X @ Rs. 1000/Kg) = 20,000,000
4. Botali maal (500 trees X 0.5 Kg X @ Rs. 5000/Kg) = 12,50,000

Total: **Rs. 2,30,87,500**

Net returns : (2,30,87,500 – 20,09,600) = Rs. 2,10,77,900.

From an established plantation thus a net income of **Rs. 2,10,77,900.**

The average cost of a mature tree in home gardens of upper Assam, ranges from Rs 28,986 (US\$ 580) to 20,08,238 (US\$ 40,165) with an average of Rs 2,49,090 (US\$ 4,982) (Saikia and Khan, 2012)

It shows that agar based home gardens in upper Assam are financially rewarding and can generate significant amount of money for sustaining the economy of the region.



Logs of Agar tree



Agarwood chips



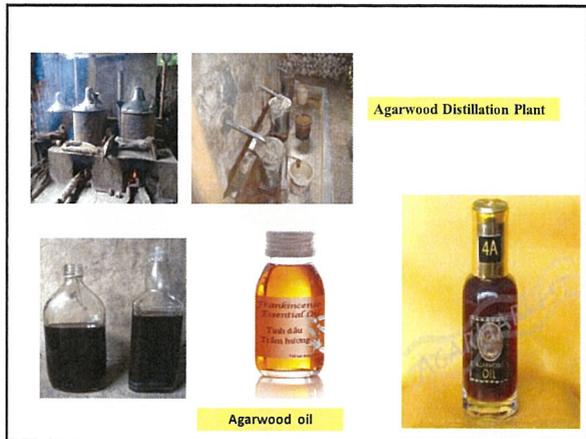
Agarwood chips



Fermented Agarwood chips



Man at work (Preparation of Botali maal)



Agarwood Distillation Plant

Agarwood oil

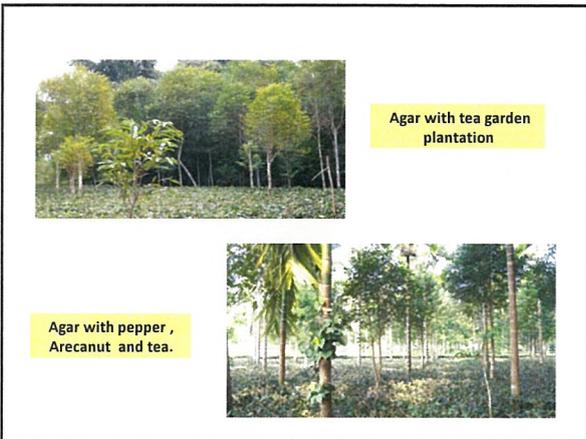
Agar tree in Mixed Plantations:

➤As a mixed crop, agar is planted at wider spacing according to the other companion crops depending upon the situations and purpose of planting.

➤Agar tree has been identified as a potential agroforestry species in homesteads, plantations and in community lands, in combination with patchouli (*Pogostemon cablin*), sarpagandha (*Rouvolfia serpentina*), Jatropha, pepper (*Piper longum*) and with other agricultural crops.

➤Besides, its plantation in the tea gardens of Assam can serve as an insurance against the natural calamities.

➤Turmeric, ginger, pineapple etc. may also be planted leaving about 50 cm around plant base.



Agar with tea garden plantation

Agar with pepper , Arecanut and tea.

RFRI works on *Aquilaria* sp.:

- ❑ Collection and Conservation of *Aquilaria malaccensis* germplasm from North Eastern India.
- ❑ Increasing seed viability in three recalcitrant species – *Dipterocarpus retusus* (Hollong), *Shorea assamica* Dyer. (Makai) and *Aquilaria malaccensis* (Agar).
- ❑ Artificial inoculation technique for formation of agar wood was standardized and multi locational trials were carried out at Tezpur and Rowta. Infected agar samples were subjected to hydrodistillation for extraction of essential oil and droplets of oil were extracted.
- ❑ Development of descriptors and evaluation of artificial inoculation in *Aquilaria malaccensis* Lamk.

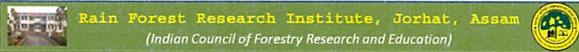
Project title: Development of Descriptors and evaluation of artificial inoculation in *Aquilaria malaccensis* L. (R&D/AS-O1/14)

Study area/ experimental sites: Different parts of Assam and North East India.

Duration : 3 years
Budget: Rs. 27,23,651.70 Lakhs
Date of start: October'2013

Name of Principal Investigator: Dr. Rajib Kumar Borah, Scientist – E
Name of Co- Principal Investigator: i. Shri. Satyam Bordoloi, Scientist - B
 ii. Shri. Hari Ram Bora, Scientist - B

Institute: Rain Forest Research Institute, Jorhat, Assam.



Physical Achievements:

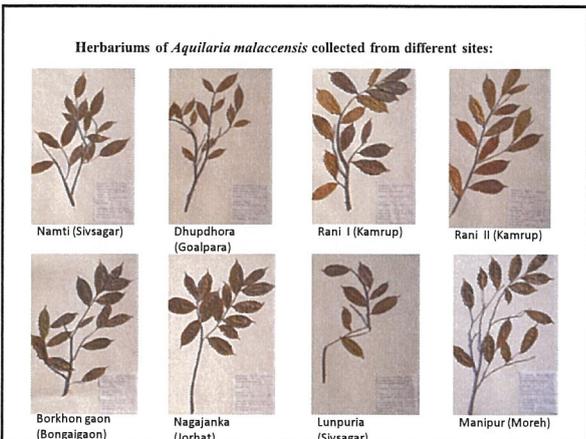
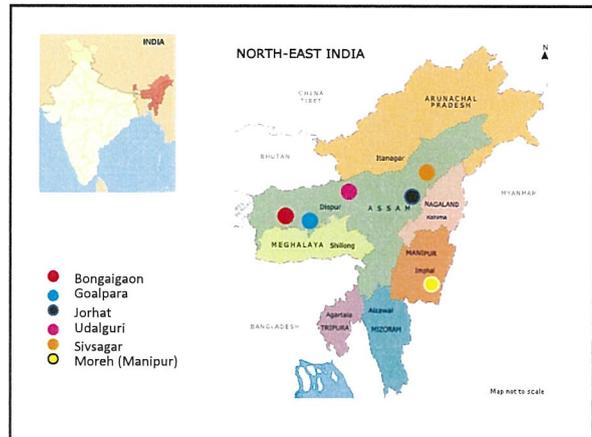
Objective I: Survey, generation of passport data and *ex-situ* conservation of variants/subtypes of *A. malaccensis*

Sl. No.	Project activities	Achievements
i.	Identification of survey sites	•Different <i>A. malaccensis</i> plantation sites were identified in Assam, Manipur and Mizoram states of NE India.
ii.	Collection of information on existing populations of variants	•Information regarding the different population of <i>A. malaccensis</i> in Assam and North East India were collected from various.
iii.	Survey in the identified site for known variants as well as new variants	•Survey has been carried out in different sites of Assam (Rowta, Tezpur, Namti, Ramungia, Titabor, Bongaigaon, Dhupdhora, Dudhnoi, Damra, Rani, Nagajanka), Manipur and Mizoram for collecting information. •Herbarium was prepared.

Physical Achievements:

Objective I: Survey, generation of passport data and *ex-situ* conservation of variants/subtypes of *A. malaccensis*

Sl. No.	Project activities	Achievements
iv.	•Germplasm collections of variants	•Seeds as well as seedlings were collected from Bongaigaon, Rowta, Rani, Boko, Dhupdhora from Assam and Moreh (Manipur).
v.	•Preparation of nursery and ex-situ site •Nursery raising through seed and clonal material	•Agar nursery was raised in RFRI campus for ex-situ conservation.
vii.	•Optimisation of DNA extraction protocol	DNA extraction and purification of different samples is in progress



Physical Achievements:

Objective III: Evaluation of the response differential on variants towards artificial inoculation

Sl. No.	Project activities	Achievements
i.	Trials on artificial inoculation for agarwood formation	• A trial on artificial inoculation for agarwood formation was carried out in 25 nos of Agar trees at Borkhon gaon, Bongaigaon, Assam. • Measurement of increase in infection from the point of artificial inoculation was recorded at regular interval.



Fig : Artificial inoculation of agarwood at Bongaigaon experimental



Fig : Measurement of increase in infection from the point of artificial inoculation

Conclusion:

- The demand of agarwood currently far exceeds the available global supply. Over harvesting and over-exploitation of *Aquilaria malaccensis* L. from the nature for agarwood production has made this plant threatened.
- Employment prospects and improved economic opportunities for rural people are usually regarded as the most important social benefits of agar plantation.
- Thus, low input management, lack of site specificity and intercropping opportunities make the agar tree as the most preferred candidate for home gardens of the region.

