AGAR PLANTATION

(Aquilaria agallocha* Roxb.*)

Family-Thymelaeaceae

Agar oil and agaru or agarwood are the most exalted perfumery raw material obtained from the infected wood of agar tree. This transformed wood due to fungal infection yields agar oil on distillation that has unique fragrance and high export value. The agar oil known in the East as Agar-attar, is one of the perfumery's oldest materials. It is considered one of the costliest perfumery raw materials used in high-class perfumery and as a fixative, imparting a lasting balsamic odour to the product. Its traditional use in India, Middle Eastern and Far Eastern perfumery, both as skin daub and as a fixative, rivals its former usage holy incense by the Hebrews. Agar tree *(Aquilaria agallocha)* is distributed in all the Northeastern States and widely cultivated. It is now rarely found in wild state.

Variation within species

In Assam two types of *A. agallocha* could be identified as '***Jati Sanchi'*** and '***Bhola sanchi*** in the population**.** '*Bhola sanchi'* is comparatively of quick growing but yield is less than that of *Jati sanchi*. It is the *Jati sanchi* that is preferred for commercial cultivation.

Soil and Climate

Agar plant prefers high humid, sub-tropical climate with rainfall 1800-3500 mm per annum. It grows from sea level upto 500-m altitudes. It is a sun-loving plant and requires lot of sunshine.

It prefers well-drained deep sandy loam-to-loam rich in organic matter but can profitably be grown in marginal soils and also in shallow soils over rocky beds with cracks and crevices. It grows well in hill slopes and forest

environment. The traditional agar growing areas show that it prefers acidic soil reaction.

The mycorrhiza and other beneficial fungi which seems to be responsible for oil formation in the agar tree being soil borne requires acid soil for their population build up.

Propagation

Agar is propagated by seeds, which are availabl seed is epigeal, therefore, special care should be taken in nursery management. They are first germinated in sand beds and then transferred to poly bags. Seed has short viability period (7-10 days) .

Transplanted in poly bags

From 25 days onward when the cotyledons just drops down the seedlings are transplanted carefully to poly bags arranged under temporary shade. Normal management practices should be adopted.

After planting young seedlings in poly bags, they are arranged in bed supported by bamboo poles around. At monthly interval the shifting of bags should be done to prevent the penetration of roots into the soil. Shifting of seedlings should be followed by light watering to avoid wilting due to disturbances in the root system. Root trainer may be used successfully.

Field layout

Agar is a long-term plantation crop. A profitable plantati short cycle plantation yields only essential oil or 'agar attar' of low quality (*Boya* oil). The plantation may be planned in two ways: (a) planting at wider spacing along with some suitable intercrops and harvesting at the end of the crop cycle. (b) Planting at comparatively closure spacing and harvested at 2-3 phases. In the second approach about 8-10 years of planting about 40 % selected trees may be harvested with a view to thin out the plantation for better growth and development of the remaining trees and also to get a substantial income.

Planting time

Planting should be done when the plants have the greatest chances of survival. The best time is during the rainy season (May-September).

Planting

Under average condition spacing ranges between 2.5-5 m, (initially accommodating about 1700 plants per hectare) which at later stages i.e., after 8-10 years of growth maintained at 4-5 m by harvesting in phase manner. When the planting is raised with some other forest species the spacing may be given accordingly. The distance for avenues and public places depends upon the situations and purpose of planting which may range between 3-4 m.

Planting of the saplings is done in well-prepared pits of size 50 x 50 x 50 cm made in advance and preferably in the evening time or during the cloudy weather. After planting staking should be done to keep the seedling in upright position and the soil around the plant should be firmly consolidated. Immediately after planting watering is necessary. In no case, the soil around the root be disturbed or removed during planting.

In the open and in public places the newly planted seedlings are to be protected in cages till they grow fairly large. For better and faster growth of the plant, the pits should be weeded and hoed to keep the soil loose and free from weeds.

Agar in Agro-forestry

Agar tree is suitable for growing on field boundaries and for dividing whole plot into sub-plots. Not only this, agar tree is also grown on borders of gardens, school compounds, office compounds, parks and residential sites. The good capacity for pollarding and coppicing has made it suitable to fit in agro-forestry. The canopy of Agar tree is such that it allows sunshine penetration partly. Thus, it can be planted in field boundaries, bunds etc., without affecting the field crops.

Besides, agar tree has been successfully grown for strip planting along banks of ponds, tanks, canals and roads. In hilly areas / *tillas* as in Barak valley it can be planted on poor soils on hill slopes, *tilla* tops. They help in reducing soil erosion and land sliding caused by rushing water during rainy season.

Agar tree could successfully be introduced in Social Forestry and also in afforestation programme.

Agar in Tea garden

Tea growing situation is also ideal for agar tree. The increasing demand of agarwood, it is being introducing as shade tree in tea plantation particularly in Upper Assam with success. Agar tree is evergreen and with spreading canopy it allows partial penetration of sunshine through it. Regular looping of branches above tea bushes is necessary.

Cultural operation

Soil working to a radius of 50 cm is to be done once in 3-4 months. Fertilizer application should also be followed by these operations preferably twice in a year, before and after monsoon from second year onwards.

Agar seedlings are foraged by goats or cattle. To protect plantation, fencing is necessary. Initial 4-5 years period should be protected from farm animals. Trenching around the plantation has also given good success. All the replacements of casualties should be done in the same planting season and if necessary second replacement may be done during the second year using large size seedlings.

Intercropping

Vegetables/pulses or aromatic crops like Patchouli (*Pogostemon cablin*), Sugandhmantri may be cultivated as short season/short term intercrops during first three to five years of plantation. In the later stages shade loving medicinal plants like Sarpagandha (*Rouvolfia serpentina),* long pepper *(Piper longum)* may also be grown for another few years depending on plant population and land type. Ginger/Turmeric may also be planted leaving about 50 cm around plant base. Both the crops are exhaustive in nature for which some special care has to be taken. This type of crops should not be taken more than two seasons.

Manuring

It is not necessary to apply inorganic fertilizers at the time of planting. Fertilizers should be applied after complete establishment and only from second year of planting.

Well-decomposed cowdung/FYM @ 10-15 kg/pit of size 50 cm^3 may be applied in pit and well mixed with soil prior to planting. Undecomposed FYM or fresh cowdung should not be applied in any case. The rhizosphere of Agar tree (0 - 45 cm) exhibits a higher rate of microbial population when organic manures are used.

Fertilizer application

N, P_2O_5 and K_2O at 10 : 10 : 4 ratio as per the following schedule may be applied from second year onward preferably in two splits-

Second year ……	200 g/tree
Third year ……	300 g/tree
Fourth year onward.	500 g/tree

The fertilizers should be applied along with decomposed cowdung/compost @10 -15 kg/tree. In the virgin forestland initially no fertilization is required. Later depending on crop growth fertilization may be resumed accordingly. From 6-7 years of growth nitrogenous fertilizer @ 400-500 g/tree per year may be applied in two splits during pre and post monsoon period. This may help in keeping the tree wood soft, with higher content of cell sap enabling easy insect boring followed by fungal infection and spread of infected area over a larger wood volume ie, higher rate of bioconversion.

Input requirement

Fertilizers per plant	$N;P_2O_5$ & K_2O at 10 :10 : 4 ratio **When P is in the form of SSP**	**When DAP is applied**	
2nd year @ 200 g/plant	Urea	182 g	110 g
	S S P	518 g	-
	MOP	55 g	55 g
	DAP	-	182 g
3rd year @ 300 g/plant	Urea	275 g	166 g
	SSP	781 g	-
	MOP	83 g	83 g
	DAP	-	275 g
4th year onwards till 10th year @ 500 g /plant	Urea	458 g	277 g
	SSP	1300 g	-
	MOP	138 g	138 g
	DAP	-	138 g

(SSP-Single super phosphate containing P_2O_5 -16 %, DAP- Di-ammonium phosphate containing N 18 %and P_2O_5-45 %, and MOP- Muriate of potash containing K_2O -60 %)

Coppicing ability of the tree

Agar tree regenerates freely. This characteristics facilitates (1) harvesting of infected tree leaving the tree trunk for quick regeneration for a second crop and (2) seed production from the coppiced tree once identified as a good mother plant from quality and production point of view.

Coppicing during 10-15 years age the growth of new shoots is at a faster rate and attain harvestable within next 10-15 years with comparatively higher yield of distillable wood. A second coppicing depends on the condition of the growing environment and root system. Higher infestation of woodborer and fungal infection are also observed compared to normal tree.

Best results are obtained during March-May. Coppicing during monsoon and also during winter months gives poor results.

Plant protection measure

In agar plantation no such serious pests and diseases have been observed. However, *Heortia vitessoides* a leaf-eating caterpillar is considered to be the most destructive pest causing damage by complete defoliation of agar plantations and has become a real menace to the plantations in this region. The intensity of attack is more in the trees grown in open than under shade and during drier season (March/April) the infestation is comparatively higher

than rainy months (July/August). The pest found to cause defoliation twice in a year being first in May/June and second in August/September. The intensity of attack is more severe during May/June and can cause death of well-grown trees due to complete defoliation.

Control

1) Hand collection and destruction of the young caterpillars while in clusters.
2) At severe attack spraying with Ekalux EC 25, Endosalfan 35 EC Thiodan), Fenitrothion 50 EC (Sumition) or Nuvacron 40 EC is done twice at 10-15 days interval. While plant protection measures by pesticide application is resorted to, it is to be remembered that the beneficial insect borer associated with agar formation is not affected particularly in the later stages of growth.
3) Severe infected tree should be treated with an extra dose of nitrogen.

Formation of agar oil and 'agaru'

The infection of fungi occurs when stem injured or is bored by a larvae of a stem borer mainly *Zeuzera conferta* Walker. It is seen that the larvae of *Z. conferta* bore the standing tree trunk of *A. agallocha* Roxb. and make 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. Later on infections spread on all sides slowly and gradually and ultimately a larger wood volume gets infected. More insect infestation in the infected area, more is the chances to form agar wood in 7-8 years time after infection. Agarwood formation is the resinification of accumulated oleoresin due to the action of microorganisms.

Infections may also occur due to mechanical or natural injuries on the stem but it is very much localized. Due to infections oleoresins are accumulated in the infected wood and later become odoriferous. At the initial stage infections appear as brown streaks in the tissue. Accumulation of oleoresins goes on increasing with the increase of infection rate as well as aging of infection. As more of oleoresins are deposited the intensity of colour of the infected wood increases and finally it becomes black due to increase in concentration. For agaru formation the hollow tunneling inside the trunk/stem of the living tree seems to be necessary.

The fungal infection takes long time to mature and trees about 50 years old have the highest concentration (2.5 - 5.0 kg/tree). Sometimes all the tissues under the bark of the tree may be found synthesizing oil and also agarwood. True agarwood is heavier than water.

If the infection starts at a young age say at the age of 5 – 6 years, then a total 10 years age may be sufficient to get commercial agarwood or agaru in a plant. Without infection century old tree may not bear a microscopic piece of agarwood. Based on the intensity of attack

the trees can be grouped as healthy, slightly attacked, moderately attacked and severely attacked trees. In a natural population about 25 to 30% of the trees may get infected and thus productive.

Cultural treatment to augment oil formation

Formation of agarwood can be initiated by the creation of open wound on the trunk of agar tree. It is a common practice now a day to apply mechanical injuries in the stem, branches at regular intervals for early infection. This is done just before breaking the dormancy i.e. before spring by giving a deep slanting cut with a sharp *Dao* (a multipurpose heavy knife) *or* Axe. These injuries are to provide ready infection sites and also to push the tree to undergo a stress condition, which helps in spreading of infection. This practice yields better result where there is already built up microbial population in soil and also the climate is warm and humid. These cut injuries serve the initial sites of fungal infection.

The '*Dum type'* product obtained out of this treatment for oil extraction is locally known as "*Ghap mal"*. A 20 years old tree that may produce only 5-10 kg of '*Dum*' without any treatment (which is due to natural injuries and mostly obtained at the junctures of broken branches) when treated by mechanical injuries is found to yield more than 30 kg in about 2 years.

Artificial inoculation

Artificial inoculation technique already developed and standardized in lab scale is found to be most effective and reliable method for enhancement of agar production. Works on commercialization are in progress and expected to make available for general use in the field.

Detection of productive trees

Since agar is located deep within the trunk, its detection from outer appearance is not easy. Generally, such trees are distinguished by certain external features whether or not the tree harbours precious agar oil or agaru deposits. These include:

(a) a poor crown, decayed branches, and uneven bole;

(b) swelling or depressions and cankers on the bole;

(c) the appearance of hordes of ants in the fissures;

(d) a distinctly yellowish to brownish tinge in the wood under the outer bark; and

(e) signs of ill-health particularly a die-back symptoms of the top and outer branches and a yellow tint to the woody tissues.

The visible wounds, cankers on the bole, stem distortions, smaller leaves and the rotten branches provide evidences of agaru deposits within a tree. Wood assumes distinctly yellowish tinge when agar formation takes place. The normal wood in the healthy trees is of pale brown buff colour. The change can be observed by removing the bark of the tree. Sometimes screw augers are

driven inside at various depth and samples are drawn for examination. Finally the odour on examination by drawing samples with the help of screw augurs. The disease or the fungal infection usually takes some time to make it manifest, hence agaru is hardly found in young shrubs.

Harvesting

The physical age, growth rates and / or wood volume or physiological maturity do not govern the harvesting age of agar tree for commercial purpose. It is the infected tree and whose further growth is arrested due to physiological imbalance is harvested and yields agarwood and oil.

Generally, the bad and deformed trees attain harvestable first unlike other forest species. The healthy trees are left to undergo stresses or subject to infection either naturally or artificially to induce oil formation. The harvesting is done on selection and continues for a longer period from a plantation raised at the same time.

Harvesting time

Although the collection of agar trees for oil extraction as well as for agaru 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. During this period maximum concentration of oil with less waxy substances is obtained. When stress is more bio-molecule concentration is also more. The extracted oil during dry season possesses the finest odour and note compared to that obtained during rainy season when the plant remain active in growth.

Yield

The yield of commercial products of agar tree is not uniform in all productive trees. It varies greatly and is almost unpredictable. After 10 years of planting with intensive management each infected tree may yield about 30-40 kg '*Dum* type' to *Kolagachi'* product for oil extraction, depending on infection intensity. Therefore, quality of oil varies depending on types of wood used for distillation.

Agar processing

Two types of commercial products are obtained from a harvested agar tree (a) agaru or agarwood that is used as incense and (b) Essential oil or agar oil or agar attar. Agaru 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.). Thereafter, the logs are splitted to separate out the infected and non-infected woods. The agarwood of any grade if detected is first separated out with the help of indigenous tools like hacksaw blade and '*Batali*' and graded them based on the oleoresin impregnation, colour density, specific gravity

and finally the odour. These are then dried, 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 special type of distillation unit. Distillation is continued for 5-10 days or more using firewood as the energy source.

Economics per hectare

Heads of exp.	1st yr	2nd yr	3rd yr	4th yr	5th yr	6-8th yr	9-15th yr
Cost of fencing & repair L.S	15000	-	3000	-	5000	5000	7000
Land preparation	5000	-	-	-	-	-	-
Pit (30x30x30 cm) making 1700xRs.2/pit	3400	-	-	-	-	-	-
Cost of saplings 1700 x Rs.5.00	8500	-	-	-	-	-	-
Planting cost @ Rs. 2.00/plant	3400	-	-	-	-	-	-
Compost	9000	8000	8000	8000	8000	-	-
Fertilizers	-	5000	6000	8000	9000	-	-
Application cost Rs.2.00/plant	3400	3400	3500	3500	3500	-	-
After care/year	5000	5000	5000	5000	6000	20,000	30,000
Inoculation @ Rs. 100/tree x 1500 trees	-	-	-	-	-	1,50,00	50,000
Misc. exp.	1300	1600	1600	1600	1500	3,000	7000
Total	54,000	23,000	27,000	27,000	33,000	1,73,000	87,000

Total expenditure upto 8th year = Rs. 3,37,000

Next 7 years = Rs.87, 000

Total Rs. 4,24,000

Anticipated yield and income

Assuming 1500 Nos. 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 Nos. trees) would be done at 15th year.

Assumptions

Yield: 1) Yield of distillable wood (low quality Dum or Boya) from 8-10 years old tree approx. 20 kg/tree @ Rs. 10.00/kg

2) Yield of *Dum* at 15th year = 50 kg /tree @ Rs. 50.00/kg

3) Yield of *Kalagachi/Batali mal* (agarwood)=0.5 kg @ Rs. 2000/kg from about 500 trees.

Return

Gross return	= 1. At 7-8 th years Dum 600 x 20 x 10	= Rs. 1,20,000
	2. At Final harvest Dum 900 x 50 x 50	= Rs. 22,50,000
	3. Agarwood 500 x 0.5 kg= 500 x 2000	= Rs. 10,00,000
	Total	Rs. 33,70,000
Net returns:	(Rs.33, 70,000 – Rs. 4,24,000)	= Rs. 29,46,000

From an established plantation thus a net income of Rs. 25-30 lakhs after 15 years may be generated giving an average of Rs. 1,96,400/year/ha. Intercropping in the early stages of growth can generate extra income.

-000-